SCOTTISH ENVIRONMENT PROTECTION AGENCY

Scotland's Water Environment Review 2000-2006

Foreword

Our environment is important to us. We depend upon it for the air we breathe, the water we drink and the food we eat. There is an increasing recognition of the role of our environment as a recreational resource and in supporting biodiversity. It is important to the economic success of our country, and quality of life of its citizens and visitors.

We have come a long way in the last 150 years since the days when sewage pollution was a significant threat to the health of a large proportion of the population. Improvements have been achieved through planning and expenditure on infrastructure carried out at a rate judged to be proportionate to the risks posed and affordability. For the last few decades, another factor determining the rate of improvements has been European legislation, delivered through the implementation of various directives agreed by the European Union as a whole.

With a population continually seeking a better quality of life, and new areas being developed for housing and industry, significant expenditure and work is required just to maintain environmental quality. Most pollution abatement measures have some energy demand and resource cost. A balance must be struck between expenditure made and benefits delivered. This report provides some feedback on overall progress made in respect of our fresh and marine waters.

It is good news that during the last decade or so, sustainable urban drainage schemes (SUDS) have become the norm for new developments in Scotland. SUDS have prevented the further deterioration of many urban watercourses. All too often in the past, improvements in effluent quality have been offset by new problems from urban run-off or unsatisfactory combined sewer overflows elsewhere.

This report focuses on the chemical and biological quality of our water environment.
It is on balance a ‘good news’ story, but inevitably with some caveats. It shows what has been achieved. Past legislation concentrated on water quality and flood defence rather than physical habitat, so improvements relate to water quality. As illustrated in the forward looking Significant Water Management Issues (SWMI) reports produced recently by SEPA, other things – working with others, engineering and abstraction pressures – are at least as important in determining the overall quality of our aquatic environments.

Good, clean water flowing in a stream piped in a culvert flowing underneath a development has no real environmental value. Open that stream out, with green areas alongside to constrain floods, and it can become a refuge for wildlife and a recreational resource. It is far better if people have a pleasant walkway in their neighbourhood than having to drive to find somewhere more pleasant to take the daily exercise we should all have.

The work and improvements outlined in this report are the culmination of a lot of effort made by many people and organisations, and to which we have all contributed through water charges. I hope you find this backward look interesting and encouraging in respect of what should be delivered in the future. The success of the new River Basin Management Planning system which SEPA and the Scottish Government have put in place as part of the EU Water Framework Directive implementation, will be crucial to maintaining and enhancing Scotland’s water environment.

Dr Chris J Spray MBE
Director of Environmental Science

Executive Summary

SEPA has a duty to protect, and improve as necessary Scotland's water quality. This report provides a summary of information held by SEPA on water quality in rivers, canals, estuaries, coasts, lochs and groundwaters for the period from 2000 to 2006. A more detailed report is available on the SEPA website (http://www.sepa.org.uk/publications/index.htm)

The assessment of water quality and trends is a substantial task. The information in this report is based upon sampling and analysis results from over 4,000 riverine sites, approximately 1,500 coastal and estuarine sites, 200 loch sites and over 250 groundwater sites spread across Scotland. Data from 1999 form the baseline year against which progress is measured, although longer datasets are used when possible.

Overview

Water quality in Scotland is generally good and continues to improve. In recent years there have been major investments in sewage treatment and greater control of other sources of pollution from individual sites. Although diffuse pollution originating from farmland and urban areas is being reduced, it remains a significant issue and is now the largest source of pollution to Scotland's aqueous environment. Other pressures include fish farming, acidification, forestry and agricultural point sources. The increasing environmental awareness shown by the public and ease of reporting incidents has also helped tackle local environmental issues.

Water quality targets

SEPA first set water quality targets in 1997 on the basis of water quality classification data for 1996. The targets represent planned reductions in the combined length of 'poor' or 'seriously polluted' waters. In 2000 SEPA repeated the target setting process. Based on 1999 results, targets were set to further reduce the extent of affected waters by 2006. The process was phased with Scottish Water's capital investment programmes which specify the investment timetables for improvement of its assets (i.e. sewerage and sewage treatment works).

Headline figures

SEPA classifies over 25,000 km of **rivers and canals** in Scotland. In 2000 the target was set to reduce the length of poor and seriously polluted rivers from 1,169 km to 818 km by 2006. This target represented a 351 km (30%) reduction. The target was achieved. At the end of 2006 Scotland had only 734 km of these waters, a reduction of 37% since 2000.

SEPA classifies over 800 km^2 of **estuaries** in Scotland. In 2000 the target was set to reduce the area of unsatisfactory and seriously polluted estuaries by 6.5 km^2 (20%) from 32.5 km^2 to 26 km^2 by 2006. Although there were improvements, the target was not achieved. New data and assessment methods applied to the Montrose Basin resulted in the downgrading of this estuary.

SEPA classifies almost 12,000 km of **coasts** in Scotland. In 2000 the target was set to reduce the length of unsatisfactory and seriously polluted coastal waters from 322 km to 176 km by 2006. This target represented a 145 km (45%) reduction. This target was comfortably achieved. At the end of 2006 Scotland had only 90.5 km of these waters, a reduction of 72% since 2000.

SEPA classifies almost 200 of Scotland's **lochs**. In 2000 the target was set to achieve no deteriorations in loch water quality by 2005 and specifically to improve water quality in Loch Gelly, Fife. Final figures for the state of Scotland's lochs will be available in early 2008 but Loch Gelly is known to have improved.

Contents

1	**Introduction**	**6**
2	**River water quality 2000-2006**	**7**
2.1	Overall picture	7
2.2	General issues relating to river water quality, 2000-2006	10
2.3	River water quality around Scotland	11
2.4	Other river quality issues across Scotland	29
3	**Estuarine water quality 2000-2006**	**33**
3.1	Overall picture	33
3.2	General issues relating to estuarine water quality, 2000-2006	35
3.3	Estuarine water quality around Scotland	35
4	**Coastal water quality 2000-2006**	**49**
4.1	Overall picture	49
4.2	General issues relating to coastal water quality, 2000-2006	51
4.3	Coastal water quality around Scotland	52
5	**Loch water quality 2000-2006**	**65**
5.1	Overall picture	65
5.2	General issues relating to loch water quality	68
5.3	Selected case histories illustrating loch water quality	69
5.4	Blue-green algal monitoring	74
6	**Groundwater quality**	**76**
6.1	Proposed UK groundwater classification scheme	76
6.2	Monitoring to comply with EU directives	76
6.3	General issues relating to groundwater quality, 2000-2006	79
6.4	Case studies relating to groundwater quality, 2000-2006	79
7	**Conclusions**	**81**
8	**Future Quality Assessments**	**82**
9	**References**	**83**
10	**Abbreviations and acronyms**	**85**
11	**Glossary of terms**	**86**

List of tables

Table 1:	Scottish river quality classification, 1999-2006 (DRN)	7
Table 2:	Clean-up schemes at abandoned mines, 2000-2006	31
Table 3:	Scottish estuarine water quality classification, 1999-2006	33
Table 4:	Improvements to the major discharges into the Forth Estuary	47
Table 5:	Scottish coastal waters classification, 1999-2006	49
Table 6:	Length of Class C and D coastline in Ayrshire coast in 2000 and 2006	54
Table 7:	Loch water quality classes	65
Table 8:	Loch classification for 1995 and 2000	66
Table 9:	Lochs selected for detailed study for this report	69

List of maps

Map 1:	River water quality classification for Scotland, 2000	8
Map 2:	River water quality classification for Scotland, 2006	9
Map 3:	Clyde Estuary classification, 2000	37
Map 4:	Clyde Estuary classification, 2006	37
Map 5:	Forth Estuary classification, 2000	44
Map 6:	Forth Estuary classification, 2006	44
Map 7:	Moray coastline classes, 2000 and 2006	59
Map 8:	Lochs classified as fair, poor or seriously polluted in 2000	67
Map 9:	Nitrate concentration in Scottish groundwater, 2000-2006	78

List of figures

Figure 1:	River class totals, 2006	10
Figure 2:	Ammonia content of Levern Water before and after Neilston STW improvements	14
Figure 3:	Annual average dissolved oxygen pattern (including long-term trend) in River Clyde at Tidal Weir, Glasgow city centre, 1970-2006	15
Figure 4:	Annual average ammonia (including long-term trend) in River Clyde at Tidal Weir, Glasgow city centre, 1970-2006	16
Figure 5:	Ammonia levels downstream of the Stonehouse STW	17
Figure 6:	Annual TON levels in the River Ythan at Ellon, 1980-2006	20
Figure 7:	Annual TON levels in the River Ythan at Ellon, 1996-2006	20
Figure 8:	Trace metal concentrations in East Tullos Burn sampled every 15 minutes following a storm event on 20 January 2006	23
Figure 9:	Oil concentrations in East Tullos Burn sampled every 15 minutes following a storm event on 20 January 2006	23
Figure 10:	Estuarine class totals, 2006	34
Figure 11:	Annual totals and three-year rolling average for Class C and D estuarine waters	35
Figure 12:	Dissolved oxygen levels in the Clyde Estuary, 1970-2006, as five-year mean values (as 95th percentile)	38
Figure 13:	Dissolved oxygen levels in the Forth Estuary at Alloa, 1988-2006, as five-year daily mean values (as 95th percentile).	47
Figure 14:	Annual BOD inputs and three-year means for the Forth Estuary, 1981-2006	48
Figure 15:	Coastal class totals, 2006	50
Figure 16:	Annual totals and three-year rolling average for Class C and D coastal waters	51
Figure 17:	Total phosphorus levels at Creinch in the south basin of Loch Lomond	70
Figure 18:	Atrazine concentrations in the Dumfries aquifer, 2002-2006	79

Annexes

Annex A - River water quality classification scheme
Annex B - Overall River Class results 2000-2006
Annex C - Estuarine water quality classification scheme
Annex D - Coastal water quality classification scheme
Annex E - Loch water quality classification scheme

Supplementary Material

Case Study 1 – The Kelvin's water quality is improving!
Case Study 2 – Steady improvement in water quality of the River Almond
Case Study 3 – The Mouse Water – a success story!
Case Study 4 – Changes combine to boost water quality in the Clyde Estuary

1 Introduction

The Scottish Environment Protection Agency (SEPA) was set up in 1996 and is responsible for environmental regulation and improvement in Scotland. The Environment Act 1995 gave SEPA numerous duties in respect of maintaining and improving the water environment via regulation and other means. SEPA has fulfilled this duty through regulatory actions and improvement programmes planned to protect and enhance the quality, quantity and conservation value of our rivers, freshwater lochs, estuarine/transitional waters, coastal waters and groundwaters. In addition, SEPA is responsible for monitoring and reporting on the condition of these waters across Scotland for national reporting and, increasingly, to demonstrate compliance with European environmental directives.

One of SEPA's early actions was to set water quality targets for rivers, coasts, estuaries and lochs for the year 2000.

Before 2000, river lengths were hand measured from Ordnance Survey (OS) maps. This method was inconsistent across Scotland as different sizes of streams were measured in different parts of the country. The measured lengths were also neither verifiable nor repeatable. In addition, most of the length of the river network (i.e. thousands of remote tributaries, often in the headwaters of catchments) had never been specifically monitored. They were always assumed to be of top quality and traditionally recorded as such. Improved and more extensive monitoring strategies have since demonstrated that this assumption of good quality in remote streams is not always valid. Problems such as sheep dip pollution or acidification have been found in some unpopulated areas.

In conjunction with a new set of targets for 2006, SEPA introduced an improved system for describing river water quality in 2000. The classification criteria remained unchanged but were now based on a computerised Digitised Rivers Network (DRN). This network included the same river systems as the previous method plus island rivers, all of which could be displayed using geographical information systems (GIS). This ensured consistency throughout SEPA, enabled river lengths to be measured automatically and made river quality information more accessible (see SEPA's website at http://www.sepa.org.uk/rqc/map.asp). SEPA also embarked on a programme to extend the monitored network each year to include previously unclassified minor watercourses. Many of these are now covered by one-in-three year ecological monitoring.

Since 2000, SEPA has reported river classification outcomes using the DRN scheme and progress against the 2006 targets was based on this consistent network. Coastal and estuarine waters were also digitised during this period but, for these waters, the effects of this change on the length and areas involved was less marked than with rivers and streams.

This report examines trends in water quality since 2000 (longer where datasets are available) for rivers, estuaries, coastal waters, lochs and groundwater. It presents details of the most significant quality changes, starting in the south-west of Scotland and working clockwise around the country. The report also looks at whether SEPA has achieved its 2006 targets to improve water quality in Scotland. Finally, it considers future issues likely to apply to SEPA's monitoring strategies and anticipated outcomes for Scotland's water environment. Terms used in the report that are defined in the glossary are shown in blue at their first mention.

2006 is the last year that SEPA will use the classification schemes reported here (and in previous years' reports). From 2007 onwards, entirely new Water Framework Directive (WFD) quality classification schemes will be applied to all waters. http://www.sepa.org.uk/wfd/. Other methods will be used to enable long-term water quality trends to be tracked across the changeover from SEPA to WFD methods.

2 River water quality 2000-2006

2.1 Overall picture

The summary of the annual classification for rivers, streams and canals presented in Table 1 indicates that SEPA met its 2006 river quality target. The Scottish River Classification Scheme is explained in Annex A.

Table 1: Scottish river quality classification, 1999-2006 (DRN)

Length	Year	A Unclassified	A1 Excellent	A2 Good	B Fair	C Poor	D Seriously Polluted	Total
km (%)	1999	n/a	n/a	N/A	2,577.0 (10.1)	1,077.7 (4.2)	91.2 (0.4)	25,381.8 (100)
km (%)	2000*	12,815.6 (50.3)	3,171.5 (12.5)	6,087.2 (23.9)	2,453.2 (9.6)	853.9 (3.4)	73.4 (0.3)	25,454.6 100.0
km (%)	2001	11,960.1 (46.9)	3,874.5 (15.2)	6,324.9 (24.8)	2,339.1 (9.2)	929.4 (3.6)	82.5 (0.3)	25,510.5 (100)
km (%)	2002	7,987.9 (30.5)	5,279.4 (20.1)	8,655.5 (33)	2,562.7 (9.8)	902.9 (3.4)	56.3 (0.2)	25,444.7 (100)
km (%)	2003	5,903.3 (23.2)	6,815.2 (26.8)	9,540.4 (37.5)	2,373.8 (9.3)	750.8 (3.0)	52.6 (0.2)	25,436.1 (100)
km (%)	2004	3,806.5 (15)	7,659.9 (30.1)	10,612.5 (41.7)	2,587.6 (10.2)	716.6 (2.8)	50.6 (0.2)	25,433.8 (100)
km (%)	2005	2,126.4 (8.4)	8,003.9 (31.5)	12,053.1 (47.4)	2,469.8 (9.7)	723.6 (2.8)	52.3 (0.2)	25,429.1 (100)
km (%)	**2006**	**2,075.9 (8.2)**	**7,861.3 (30.9)**	**12,333.2 (48.5)**	**2,424.8 (9.5)**	**698.8 (2.7)**	**35.12 (0.1)**	**25,429.1 (100)**

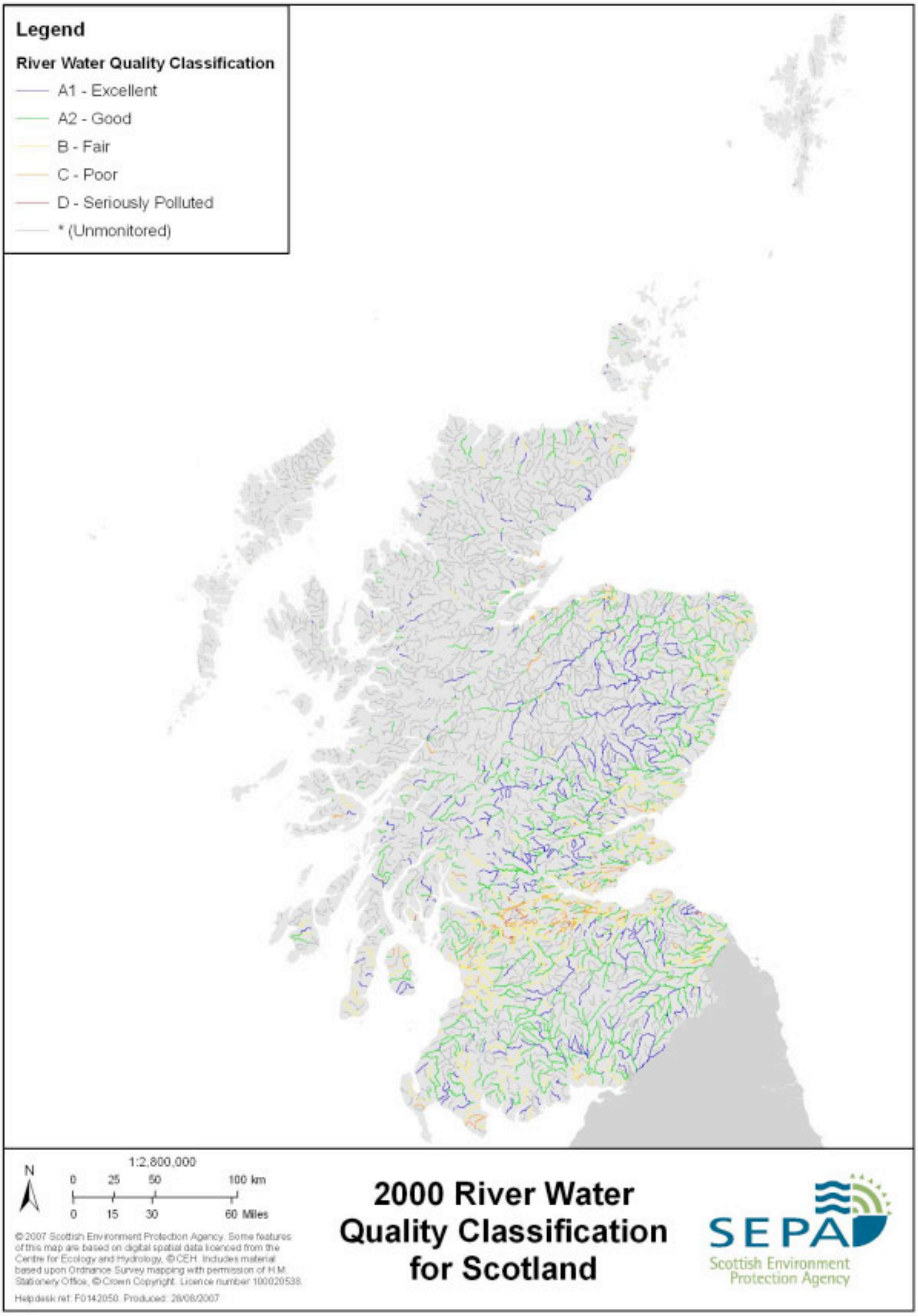
Actual length of Classes C and D in 1999	**1,169 km**
Actual length of Classes C and D in 2006	**734 km**
Target length of Classes C and D by end 2006	**818 km**
Actual change in length of Classes C and D 1999 to 2006	**–435 km (–37%)**
Target change in length of Classes C and D 1999 to 2006	**–351 km (–30%)**

*Figures for 2000 are slightly amended from those previously reported due to inclusion of toxic substances classification previously accidentally omitted in one area.

Map 1 shows the river water quality classification for 2000 with the inevitable, poor water quality around cities and many unclassified streams. The situation for 2006 is shown in Map 2; this shows improvement (though still with the poor water quality around cities) and an extended river network (i.e. fewer unclassified rivers).

The predominance of excellent and good quality Scottish rivers is illustrated in Figure 1, which shows the percentage totals for 2006.

Map 1: River water quality classification for Scotland, 2000



Map 2: River water quality classification for Scotland, 2006

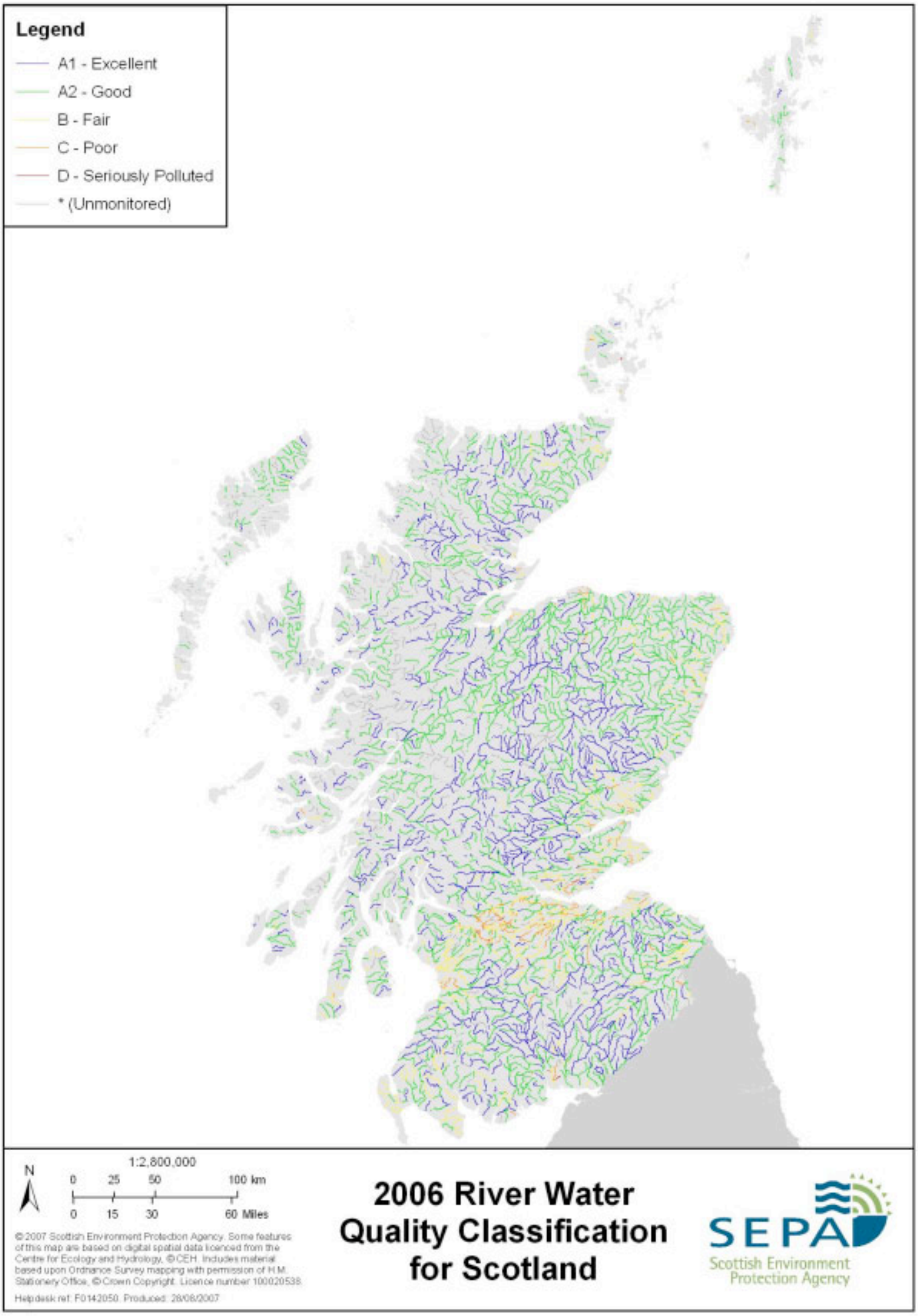
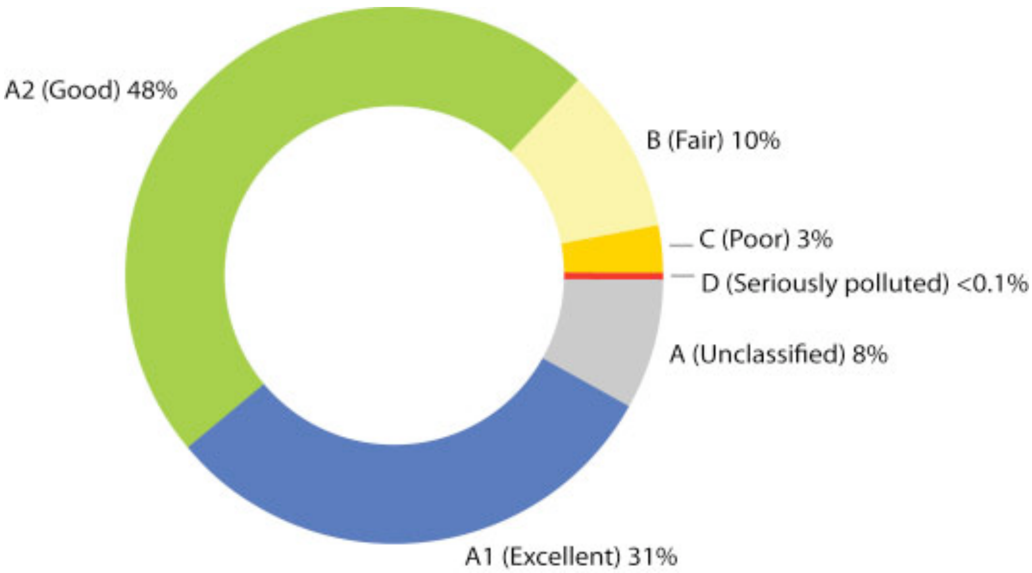


Figure 1: River class totals, 2006



SEPA's target for the period 2000-2006 was to reduce the length of poor and seriously polluted waters (Class C and D) by 351 km, equivalent to 30%. As shown in Table 1, the steady improvement resulted in a national reduction of these rivers over the period of **435 km (37%)**. This exceeded the target.

There was also a six-fold increase (equal to an additional 10,000 km) of classified rivers and a doubling of Class A1 (excellent) and Class A2 (good) rivers. This represents a remarkable achievement over the time period.

Most of the previously unclassified stretches now fall into the upper classes; only a handful fall into Classes C or D. Many of the previously unclassified stretches were remote water bodies whose ecology is now monitored once every three years. Any of these sites whose water quality was classed as Class of B or worse was investigated to determine the cause and revisited each year until the quality improved.

The complete detailed list of monitored rivers and streams in Scotland, together with overall classification score from 2000 to 2006 can be found in Annex B.

2.2 General issues relating to river water quality, 2000-2006

Most of the specific quality improvements expected by 2006 have been achieved and work on the remainder is continuing.

In addition, numerous improvements have been achieved for watercourses which, when the targets were set in 2000, were not expected to improve by 2006. These include welcome work by the Coal Authority to intercept and treat previously polluting minewater arisings prior to their discharge to watercourses. There has also been significant upgrading of wastewater infrastructures and industrial premises, with some significant step changes in water quality due to the closure of sewage treatment works (STWs) and diversion of effluent to newer or larger works elsewhere.

The main mechanism to address pollution caused by sewage is through investment in Scottish Water's sewers and treatment works. Investment is delivered via a public planning process called Quality and Standards (Q&S), which determines the investment objectives in the context of Ministerial decisions on the scale of charges that can be afforded by customers. Q&S I covered a two-year period from April 2000 to March 2002, but tackled only the larger discharges. In the four years of investment during Q&S II (April 2002–March 2006), over £1.8 billion was invested. Further investment is planned in the next stage of the capital investment programme, Q&S III, which started in 2006 and will run to 2014. Scottish Water is currently investing approximately £500 million annually on improving its sewage treatment network.

There are many places where river quality is affected by a combination of several different point and diffuse sources of pollution. In order to deal with these more complex cases, SEPA often develops specific Environmental Improvement Action Plans (EIAPs – also known as Action Plans), which aim to identify:

- the exact nature of polluting sources and their relative impacts;
- the range of actions needed to secure the required improvements in water quality.

Actions can be varied, ranging from working with farmers on land management issues to advising local authorities on changes in land use planning policies that might be required.

Although water quality totals can show significant variations from year to year, the overall trend is one of improvement between 2000 and 2006. There was a particularly large improvement in 2003, which may have been helped by reduced diffuse pollution during the dry summer. To have maintained and consolidated progress in subsequent years is particularly encouraging. Many of the improvements are a direct result of infrastructure investments made by Scottish Water, SEPA actions and work with other organisations such as the Coal Authority and the farming community.

Over the period from 2000 to 2006, there have been both improvements and deteriorations of particular rivers and streams throughout Scotland. Examples of key issues and impacts on river water quality over the period are examined below, starting in the south-west and moving clockwise around Scotland.

2.3 River water quality around Scotland

Dumfries and Galloway

The main rivers in this area (Nith, Annan, Dee and Cree) have been maintained in a good or better condition throughout the period apart from continuing concerns about acidification in some headwaters. This success was achieved by detecting and eliminating local pollution sources without allowing them to become chronic problems.

In September 2006, SEPA was alerted to a sewage fungus problem in the Tacher Burn to the east of Kirkcudbright. The cause of the fungus, which led to a downgrade from Class A2 (good) to Class C (poor), was found through investigations initiated by SEPA to be liquor (thick liquid) from a farm midden. The farmer agreed to install a new effluent tank to collect the liquor and thus rectify the problem. A recent visit confirmed that a new 20,500-litre tank had been installed to collect drainage from the midden and to protect the watercourse from this polluting run-off.

The quality of a long length (12 km) of the Abbey Burn near Dundrennan on the Galloway coast fell in 2004. The downgrade was due to a problem with a farm silage effluent; new fencing had punctured a perimeter drain, allowing the effluent to enter a ditch rather than going to the effluent tank. SEPA contacted the farmer and the situation was remedied immediately. The river has since recovered to good status, but SEPA remains concerned that the river may also have suffered a toxic incident – suspected to be a discharge of sheep dip.

The STW serving Castle Douglas previously discharged treated sewage and partially screened storm sewage to the Tarry Burn, a small ditch tributary (feeder) of the Carlingwark Lane. This small waterbody offered limited dilution and dispersion of the sewage and, like the Carlingwark Lane, the water classification was Class C. Castle Douglas STW was upgraded in Q&S II, improving storm effluent quality and removing unsightly sewage debris. In addition, discharge of the final effluent volume from the STW has been transferred from the Tarry Burn to the River Dee some 3.5 km away, where greater dilution and dispersion ensures all environmental standards are met. This pumped discharge is currently being commissioned and initial issues with trapped air within the transfer pipe are being resolved.

Significant improvement has been seen in the Buittle Burn between Castle Douglas and Dalbeattie. The watercourse had been affected by the presence of sewage fungus across its width, leading to a downgrade under the aesthetics component of SEPA's classification regime. On inspecting the watercourse, SEPA considered the likely cause of the sewage fungus to be an agricultural source. As part of the national Diffuse Agricultural Pollution Environmental Improvement Action Plan, farms in the area were audited and issued with the Prevention of Environmental Pollution from Agricultural Activity (PEPFAA) code of practice [1]. These farm visits highlight any measures needed to reduce run-off and any other environmental impact. Further farm inspections are planned in the catchment, but there has already been some improvement with the Buittle Burn upgrading in 2006 to Class A2 (good).

A number of coastal streams, including the Pinminnoch, Caldons, Monrieth, Sandmill and Pouton Burns, have seen a steady improvement in quality over recent years. SEPA has worked with the agricultural community to reduce diffuse impacts to watercourses.
Farms were audited against the requirements of the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil)(Scotland) Regulations 2003 [originally 1991] (SSAFO) [2]. The main areas of concern were the appropriate storage of farm effluent, run-off from fields and livestock having direct access to watercourses. Pro-active engagement with, and education of, the farming community by SEPA resulted in remedial measures at non-compliant units. Overall, the co-operation from the agricultural community was excellent with most farmers attempting to achieve compliance.

Direct benefits from this work are reflected by the improvements in the Piltanton Burn and the Wigtownshire and Machars coastal streams. So much so, that by 2006, Class C and D rivers were almost eliminated in the Galloway area – an area stretching over 130 km from Dalbeattie to Stranraer.

Ayrshire, Arran and Bute

In Ayrshire, many catchments have been improved since the introduction of the national Diffuse Agricultural Pollution Environmental Improvement Action Plan. 2005 was particularly notable, being the first season ever that all designated bathing waters on the south-west coast met mandatory European standards. However, some Ayrshire rivers still alternate between good and fair water quality and are therefore of concern to SEPA.

In South Ayrshire, the upper reaches of the Pow Burn have improved as a result of enhanced sewage treatment at Hansel Village. However, the catchment is adversely affected by diffuse farm run-off in the upper areas. Farm inspections undertaken in recent years seem to be having a positive effect, though a first-time rural sewerage scheme for the Bogend Toll area would also help; a pollution incident in August 2005 highlighted how easily the watercourse can drop into the lower water quality classes. The lower reaches of the Pow Burn go into a culvert under Prestwick International Airport and the A79 road, and are polluted by urban run-off.

Also in South Ayrshire, near Tarbolton, high ammonia concentrations in spring 2004 downgraded part of the Water of Fail. This pollution was attributed to the nearby landfill site and subsequent action has prevented recurrence.

There is particular interest in the Cessnock Water, a small river draining an intensive livestock agricultural area that it is at risk of not meeting future water quality objectives. The river is a tributary of the River Irvine and lies some 25 km upstream of a designated bathing water. There are no significant sewage treatment works or combined sewer overflows (CSOs) discharging to the Cessnock, but it does suffer from sporadic pollution events particularly during wet spells. Sources of faecal indicator bacteria arise primarily from agriculture and septic tanks. In wet weather, the Cessnock Water can have a major impact on the quality of the coastal bathing water at Irvine. In addition, the dissolved oxygen (DO) content of this watercourse can drop during summer low flows, which exacerbates any impacts from diffuse pollution sources. SEPA recently installed storm event auto-sampling and soil moisture meters to assess the loading of pollutants from the catchment and to check whether measures to mitigate diffuse pollution have been successful. The Cessnock Water is also a nutrient sensitive area designated as eutrophic under the Urban Wastewater Treatment Directive (UWWTD). The eutrophic designation means that there is evidence that high nutrient levels have caused an undesirable disturbance in the river's ecology. This status will drive improvements via European directives and partnership working within the agricultural community to increase awareness.

The Earn Water was badly polluted by silt-contaminated surface water run-off from M77 motorway construction work in 2004. One of the construction contractors was prosecuted for the damage caused. Since completion of the motorway in May 2005, the watercourse has shown good signs of recovery.

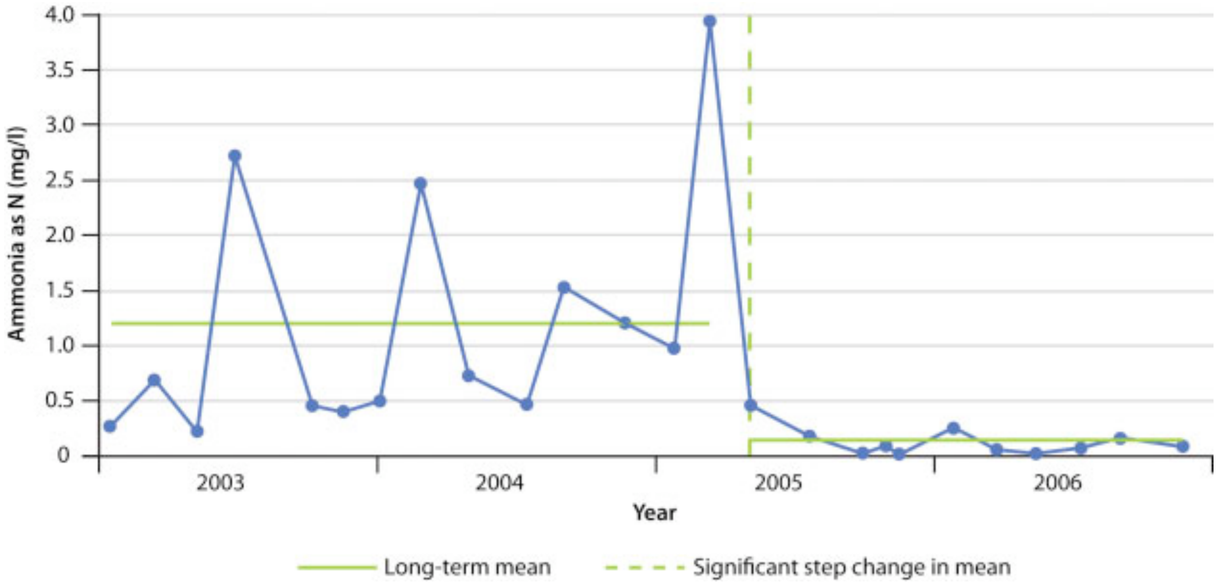
Greater Glasgow Area

The River Kelvin catchment has seen considerable improvements in water quality in recent years. The River Kelvin and its tributary rivers have benefited from the successive removal of sewage treatment works in its watershed. Almost 25 km of poor or seriously polluted waters have upgraded since 2000 in the most polluted stretches of the River Kelvin, Luggie Water and Bothlin Burn. For more information on the improvements in this catchment see the River Kelvin case study.

The downgrading of the Garnqueen Burn (at the top end of the Bothlin Burn) is a long-standing issue. The watercourse is polluted by elevated levels of ammonia, a large volume of which is thought to originate from the former unlined Kilgarth landfill site. Levels of 90 mg/litre have been recorded in this discharge and up to 30 mg/litre in the river. Another possible source is from a resurgence of minewater downstream (d/s) of this site. The ammonia/iron resurgence (rising) manifests itself via a small loch, which spills into the watercourse.

Work was completed in October 2005 to upgrade the sewage treatment works serving the settlement of Neilston in the Renfrew and Inverclyde area. This involved upgrading the surface aeration plant (secondary treatment), installing auto de-sludging (removal of sludge) and refurbishing all tanks. The improvement in the Levern Water, which receives the effluent from the works, was immediate – as illustrated by the ammonia data presented in Figure 2. The result is an enhancement of 2.4 km of the Levern Water with potential for further improvement in the future.

Figure 2: Ammonia content of Levern Water before and after Neilston STW improvements



Water quality in the lower reaches of the Black Cart Water (Renfrew) improved considerably at the end of 2004. Under Scottish Water's Q&S II investment programme both Johnstone STW and Linwood STW closed in December 2004; both effluents are now diverted to the Clyde Estuary via the new Erskine STW. Almost 4 km of the Black Cart Water downstream from the former discharges has shown an improvement in water quality.

Unsatisfactory combined sewer overflows (uCSOs) have been a problem in the Paisley Area. Work in relation to the Candren Burn was initiated in 2005 and more than half of this watercourse (almost 3.5 km) has since been reclassified from Class C (poor) to Class B (fair).

The River Clyde has remained mainly fair/good quality throughout most of its length, but its condition still deteriorates as it passes through Glasgow city centre. Despite this, the Clyde continues to have a run of salmon and other game fish in the autumn, which spawn in the larger tributaries of the Avon Water and the River Nethan. Salmon returned to the Clyde in the 1983 after a century of absence and numbers have slowly increased since that time, though are still below optimal levels [3].

Basic long-term data analysis of the lower Clyde has shown that average levels of oxygen are increasing (Figure 3) and levels of ammonia are correspondingly decreasing (Figure 4). The site used is downstream of all the major sewage discharges to the freshwater River Clyde.

Figure 3: Annual average dissolved oxygen pattern (including long-term trend) in River Clyde at Tidal Weir, Glasgow city centre, 1970-2006.

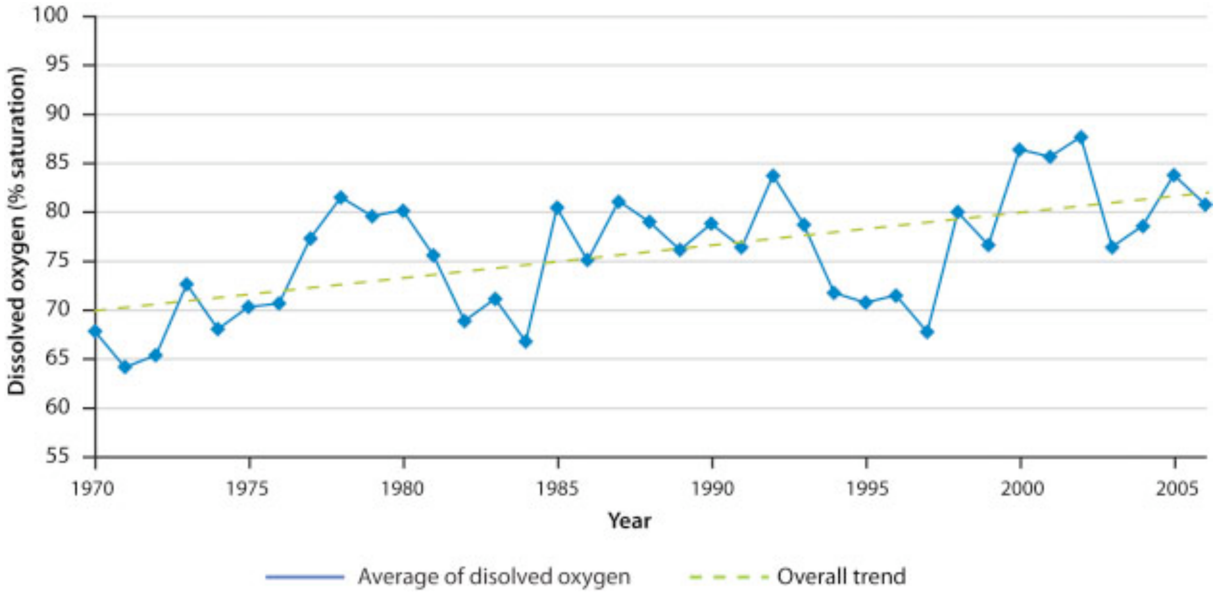


Figure 3 shows the annual average levels of dissolved oxygen in the river water column, as percentage saturation. The data has had seasonal variations removed, and shows the overall trend is an increase in dissolved oxygen (an improvement in water quality).

Figure 4: Annual average ammonia pattern (including long-term trend) in River Clyde at Tidal Weir, Glasgow city centre, 1970-2006

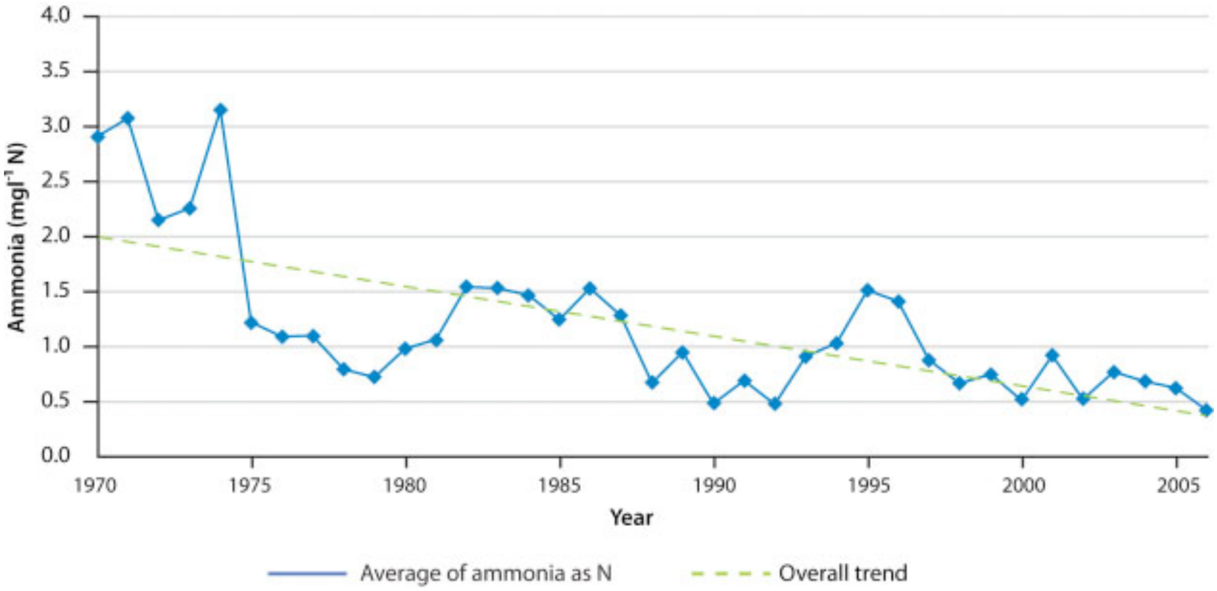


Figure 4 shows the annual average levels of ammonia in the river water column. The data has had seasonal variations removed, and shows the overall trend is a decrease in ammonia (an improvement in water quality).

Much of the improvement in water quality illustrated is due to investment in sewage treatment and hence less polluting effluent discharges. The closure of three STWs at Motherwell and Orbiston (closed October 1995) and Airdrie (closed December 1998) with diversion of flows to Daldowie STW have contributed to water quality improvements in the catchment.

Daldowie STW began nitrification (the removal of nitrogen) of its sewage effluent in August 1999. Since then average levels of ammonia in the effluent have fallen ten-fold, average levels are now around 2 mg/litre. The ammonia levels in the river downstream of Daldowie STW also fell at the same time.

The removal/improvement of these discharges has consequently raised oxygen levels in the water, allowing an increased number and variety of fish to live.

The European ban on dumping sewage sludge at sea that came into force on 31 December 1998 meant that sludge had to be further processed at a larger STW or at regional sludge treatment centres. Daldowie's sludge treatment centre became fully operational around late 2002 and now processes all greater Glasgow's sludge. Although this led to improvements in coastal water quality, it has brought with it numerous complaints about smell nuisance downwind of the plant.

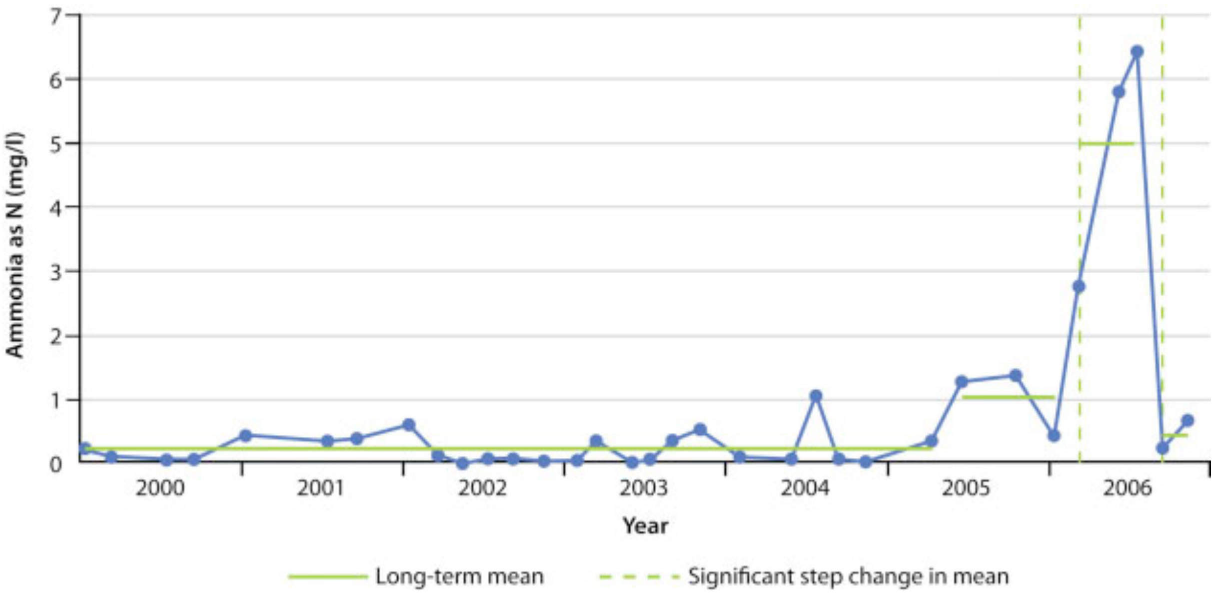
Seasonality trends show the Clyde suffers from ammonia 'spikes' caused by CSOs triggered by only moderate rainfall, and associated summer dips in dissolved oxygen. In these conditions, the river fails to comply with European standards to support freshwater fish life. In the summer of 2000, SEPA installed a network of continuous on-line water quality stations to provide real-time water quality data, 24 hours a day. The data have been used for operational and pollution control purposes.

Discharges from uCSOs continue to cause or threaten pollution of many urban watercourses in west central Scotland. This general problem is being tackled through a major study with Scottish Water, which is additional to the ongoing Quality and Standards work.

Lanarkshire

In South Lanarkshire, much of the Cander Water (a tributary of the Avon Water) has been of fair/good quality for a number of years. However, water quality in the final stretch has degraded recently due to increasing levels of ammonia from the Stonehouse STW (Figure 5.)

Figure 5: Ammonia levels downstream of the Stonehouse STW



Coupled with these increasing ammonia levels, there was also a significant reduction in the amount of dissolved oxygen in the river; this may be adversely affecting local fish life. Overall water quality downstream of Stonehouse STW has fallen to its lowest level since 2000. SEPA is discussing the situation at Stonehouse with Scottish Water and hopes the planned improvements at the works will be given increased importance in the Q&S III priority list.

The sewerage system in East Kilbride is mostly a separate system whereby only sewage goes via the foul sewer to the sewage treatment works and surface water is discharged to watercourses. However, these two systems often run side-by-side. This has caused serious pollution of the urban watercourses due to:

- blockages in the foul sewer causing discharges of sewage to the surface water sewer;
- wrong connections of foul drainage into the surface water sewer;
- rogue discharges and spills in industrial areas to the surface water sewer.

The water quality and ecology of East Kilbride's rivers have been significantly downgraded. Watercourses in the area have shown only slight improvements in recent years despite considerable expenditure by Scottish Water including:

- sealing of common access manholes;
- installing sewer 'switches' to surface water outfalls;
- dye testing to determine wrong connections.

These urban rivers continue to be under pressure, especially at times of high rainfall. SEPA and Scottish Water now carry out joint inspection work in the area and have formed a rapid response team with the aim of minimising the impact of any polluting discharges into the watercourses.

The Kittoch Water is unfortunate to also receive effluent from Philipshill STW, which serves almost half of East Kilbride's population (68,000 people). The problems associated with Philipshill STW will be addressed under Q&S III. Options include relocating the discharge to the River Clyde, as has already been done with the treated effluent from Allers STW which serves the other half of East Kilbride. An early-start project is underway with Scottish Water to assess future environmental requirements for Kittoch Water and White Cart Water with a view to developing an appropriate solution.

In North Lanarkshire, the South Calder Water (a considerable tributary of the Clyde) continues to be borderline Class B/C. Long lengths of this river are ecologically downgraded and upper stretches of the South Calder Water are consistently also Class C chemically. Because the reasons for the continued poor quality are not fully understood, the entire catchment will be the subject of an SEPA Environmental Improvement Action Plan in 2007 to determine the source(s) of the problem.

The closure and flooding of many former deep coal mines in Scotland has left a legacy of pollution from the resulting resurging minewater. There are still many stretches in the south-west of Scotland, especially in Ayrshire and Lanarkshire, which are adversely affected by resurgence from past mining activates. The Coal Authority has completed two minewater remediation systems at Mouse Water and Dippool Water (upper Clyde, Lanark), which have dramatically improved water quality in these catchments. SEPA has been working closely with the Coal Authority at a national level to ensure that treatment schemes are set up to tackle the most environmentally damaging minewater discharges first. For more details, see the minewater section.

West Highlands and Argyll (including Skye, Mull, Islay and Jura)
SEPA has extended its routine water quality monitoring network in the area over recent years. This first-time monitoring has detected instances of agricultural diffuse pollution in water previously thought to be of at least good quality. It is difficult to determine whether these findings represent a real degradation of Class A1 waters or merely improved understanding of the extent of diffuse pollution problems.

Western Isles
On the Isle of Lewis, the installation of a detention tank at a landfill site has improved the Abhainn a Ghlinn Mhoir (west of Stornoway). The tank ensures that landfill leachate is discharged at an even rate throughout the day rather than the previous batch discharge system.

Also on the Isle of Lewis, a considerable length of the Abhainn Eirearaigh has unfortunately downgraded in quality. This is thought to be the result of an increase in the stocking density of fish at the Barvas Hatchery following a change of ownership.

North of Scotland
The Gillock Burn in Caithness has shown steady improvement following a successful Action Plan in 2003/2004 when Scottish Water installed a reed bed to provide additional treatment for the effluent from the Gillock septic tank.

In Sutherland, a clean-up of the Clachan Burn in Bettyhill by the Highland Council has ensured the upgrade of some 3.5 km.

At Wick Airport, three watercourses have shown marked improvements following the construction of collection tanks which receive surface water from the runway and release it slowly to sewer.

The Murkle Burn, near Thurso, had experienced a reduction in water quality. Inputs to the burn are from diffuse agricultural sources, individual septic tanks and a larger Scottish Water communal septic tank serving Murkle. A SEPA Action Plan successfully identified problems. A leaking silage effluent tank has since been replaced and Scottish Water has upgraded its STW at Murkle by adding reed bed treatment. In addition, SEPA has insisted that any new houses have a biological treatment plant installed and that the effluent is discharged to a soakaway rather than direct to the Murkle Burn or any of its tributaries. As a result of these combined actions, the Murkle Burn recovered to Class A2 in 2006.

Dingwall
Between 2000 and 2001, the Dornoch Burn on Scotland's north-east coast upgraded from poor to fair quality. This watercourse received sewage effluent from Camore STW until its closure in late 2000. Sewage is now diverted to another STW at Dornoch, where it receives secondary treatment before being discharged to the Dornoch Firth via the Black Burn. Improvement in the Dornoch Burn is particularly welcome since it flows into an EU designated bathing water.

In the Grampian area, the water quality of the Allt na Frithe downstream of Tomatin Distillery fell to Class C in 2005 due to a breach of the Environmental Quality Standard (EQS) for copper. The reasons were initially unclear as all wastes are tankered off-site and spread to land. However, a recent investigation by the distillery's operators detected a leakage that could contain copper and which was finding its way into the drainage system and then onto the Allt na Firthe. Repairs have been carried out and the most recent samples show improvement.

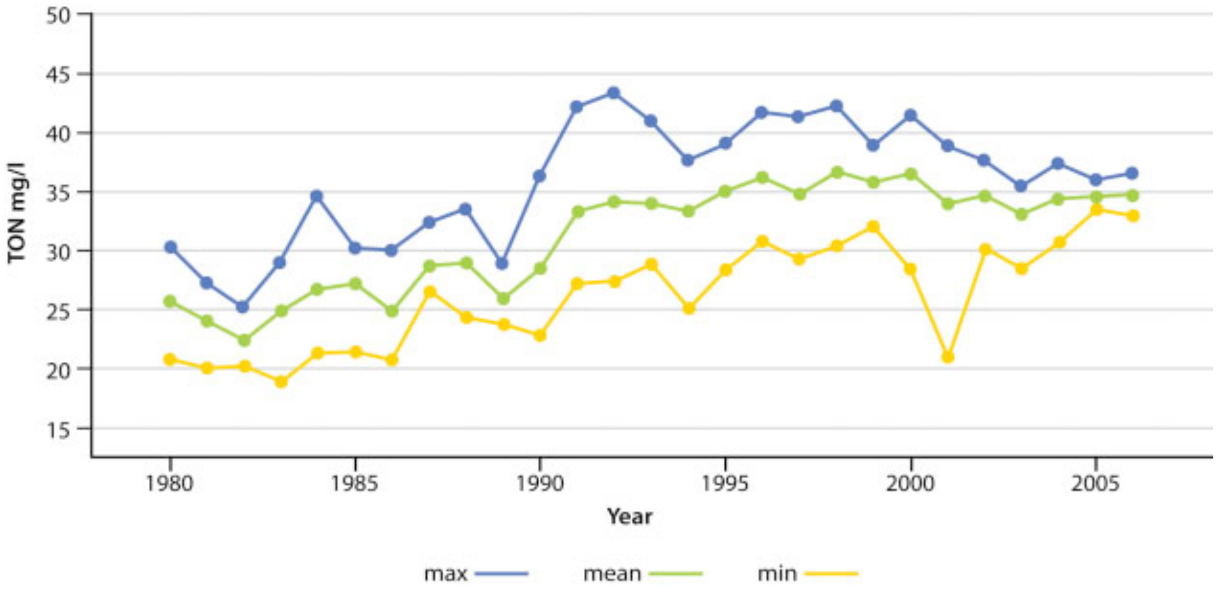
Elgin
The main rivers (Nairn, Findhorn, Spey) flowing northwards into the Moray Firth have remained in good or excellent quality throughout the period. Occasional problems have been detected in smaller tributaries, but none have been persistent.

Aberdeenshire: River Ythan
The River Ythan and its estuary are situated to the north of Aberdeen and drain a catchment area of 690 km^2, much of which is agricultural land. The Ythan Estuary is a nationally important conservation area for various bird populations but has shown signs of eutrophication. For more on the Ythan Estuary, see the Estuary chapter.

Water quality in the Ythan deteriorated during the 1980s and 1990s, with the estuary in particular showing signs of eutrophication. Increasing levels of nitrates in the river and estuary waters have been the most prominent problem and are believed to have contributed to the increase in algal blooms observed within the estuary. Algal blooms can have a negative effect on bird populations because they reduce the quantity and availability of the small mud-dwelling invertebrate animals that are a prime food source for the birds. Studies during the 1990s indicated a decrease in the number of birds, related to an increase in macroalgal biomass in the Ythan.

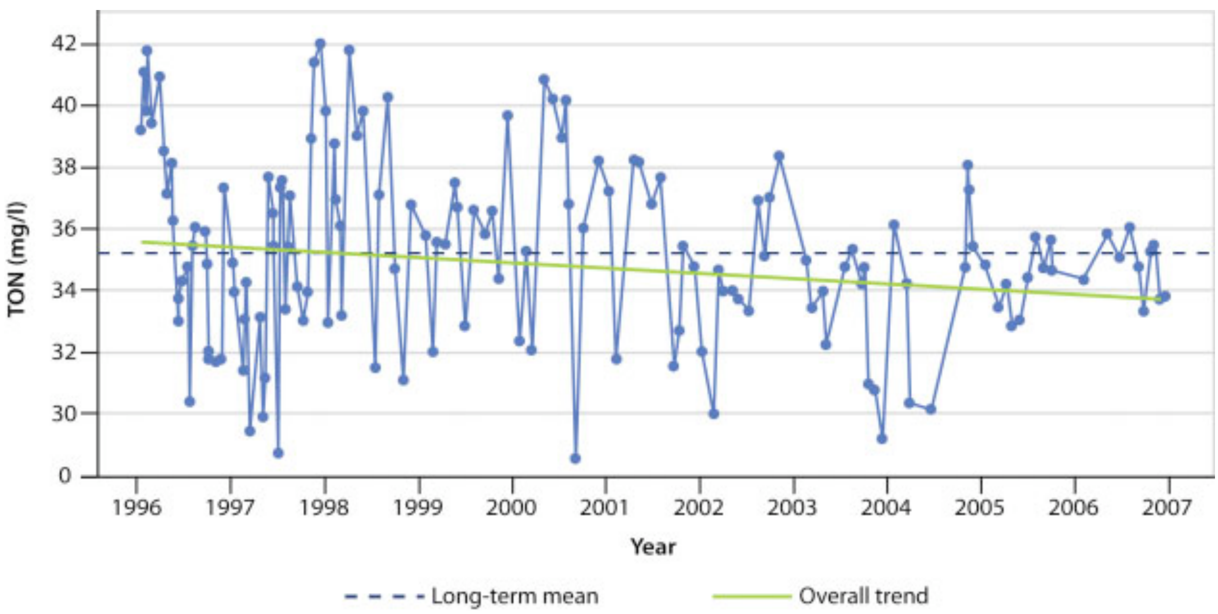
After showing an increasing trend over a period of nearly 20 years, total oxidised nitrogen (TON) levels in the River Ythan at Ellon have at least stabilised (see Figure 6). TON is an indicator of the amount of nitrogen readily available for plant (algal) growth.

Figure 6: Annual TON levels in the River Ythan at Ellon, 1980-2006



A closer look at the last 10 years shows that nitrate (TON) levels are actually beginning to drop (Figure 7).

Figure 7: Annual TON levels in the River Ythan at Ellon, 1996-2006



The River Ythan is part of the Aberdeenshire, Banff, Buchan and Moray Nitrate Vulnerable Zone (NVZ), designated in 2000. The eutrophication effects observed were attributed primarily to the elevated nitrogen levels within the catchment, which mainly come from diffuse agricultural sources. The NVZ plan for the Ythan limits the amounts and timing of nitrogen fertiliser application in the catchment. Such inputs can affect nitrogen levels in the underlying groundwater as well as impacting surface waters directly via run-off. Measures implemented as a result of the Scottish Government's work with local farmers to ensure that NVZ requirements are met are expected to lead to long-term improvements in water quality within the catchment.

Phosphate levels within the catchment are also high. Phosphate levels in the lower part of the River Ythan as well as the Youlie Burn, which feeds directly to the estuary, resulted in these freshwaters being designated in 2006 as Sensitive Areas (eutrophic) under the EU Urban Waste Water Treatment Directive (UWWTD).

SEPA has demanded various improvements to sewage treatment and other discharges along the river and estuary. Nutrient stripping (removal of nitrogen and phosphate from the discharge) has been in place at Ellon STW since 2004. This is by far the largest of the sewage works within the catchment and is located towards the bottom end of the river. Discharges from Newburgh STW, which until recently went directly to the estuary, ceased in 2005. Planned projects will further reduce nutrient inputs from sewage works discharging to the river further up the catchment.

With EU assistance, the Ythan LIFE Project was set up in 2001 with the aim of involving local people in protecting, restoring and enhancing the Ythan catchment. The project ran until 2005 and made considerable strides in:

- raising awareness of diffuse pollution issues (local community events);
- helping improve farming practices (including installing buffer strips, management of slurry spreading);
- carrying out river restoration work.

Such work helps to address water quality and habitat issues, though it may be several years for any resulting improvements in water quality to be seen in the Ythan catchment.

To the west of Aberdeen, the ‘3Dee Vision’ project ran from April 2003 until September 2006 with the aim of improving the quality of the Elrick Burn, Tarland Burn and Loch Davan.

The mainly culverted Elrick Burn suffers from contaminated surface water run-off and domestic sewage inputs from numerous unauthorised cross-connections throughout the catchment. The ecological status of the watercourse has improved through the establishment of a sustainable urban drainage system (SUDS) wetland and investigation of the surface water sewerage system draining to the burn.

The Tarland Burn has benefited from the installation of a new STW serving the village, the creation of buffer strips (reducing run-off to the river) and the establishment of a small community wetland. Although full analysis of the Tarland catchment is yet to be completed, recent data show a reduction in phosphate levels downstream of the created wetland area.

The conservation status of Loch Davan is threatened due to eutrophication and increased sedimentation rates. Sediment inputs were identified and reduced through farm water audits and a programme of remedial works to address diffuse pollution issues. This included the installation of over 30 cattle watering areas as an alternative to cattle entering watercourses to drink (and pollute). Physical barriers were also used to protect the banks of watercourses from erosion, while buffer zones or filtration were provided to field run-off. Monitoring of diatoms (microscopic algae that can be used as indicators of water quality) in the catchment of the Dinnet Lochs (Davan and Kinord) suggests improvements (i.e. lower nutrient levels) since these works were undertaken.

For more information on the 3Dee Vision project see SEPA's website (http://www.sepa.org.uk/publications/sepaview/html/35/3Dee_vision.html).

Also in Aberdeenshire, a significant length of the Tuach Burn – once a poor quality waterbody – has improved. Much of the improvement can be attributed to the recent closure of the Kintore Knackery.

The East Tullos and West Tullos Burns are small watercourses that lie just south of the city of Aberdeen. Both watercourses flow through culverts under a large industrial estate for most of their length. In 2004, a continuous water quality monitoring station was installed by SEPA in the East Tullos Burn to monitor diffuse urban pollution. This was part of a national Diffuse Agricultural Pollution Environmental Improvement Action Plan which sought to characterise the pollutant loadings from arable, livestock and urban catchments. East Tullos was chosen to represent urban pressures on water quality; Figures 8 and 9 show pollutant concentrations monitored during one storm event. During the initiative, SEPA collaborated with local businesses on the industrial estate, providing them with information on water quality and identifying potential unauthorised discharges.

Figure 8: Trace metal concentrations in East Tullos Burn sampled every 15 minutes following a storm event on 20 January 2006

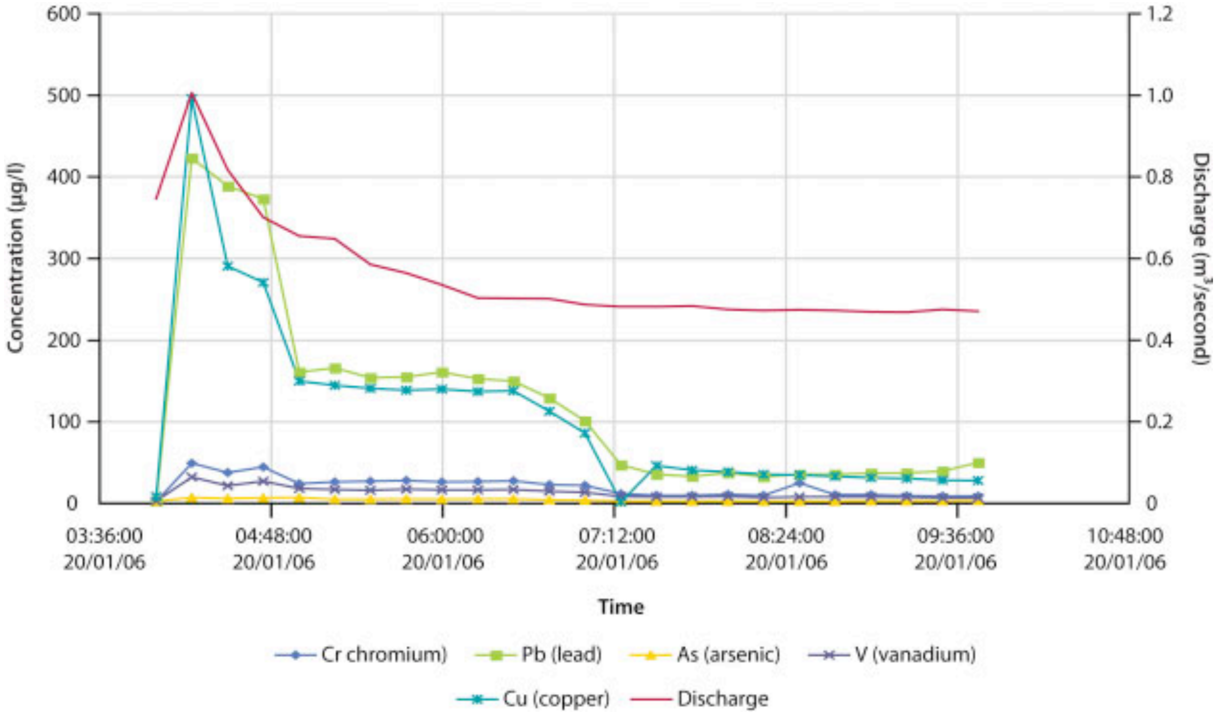
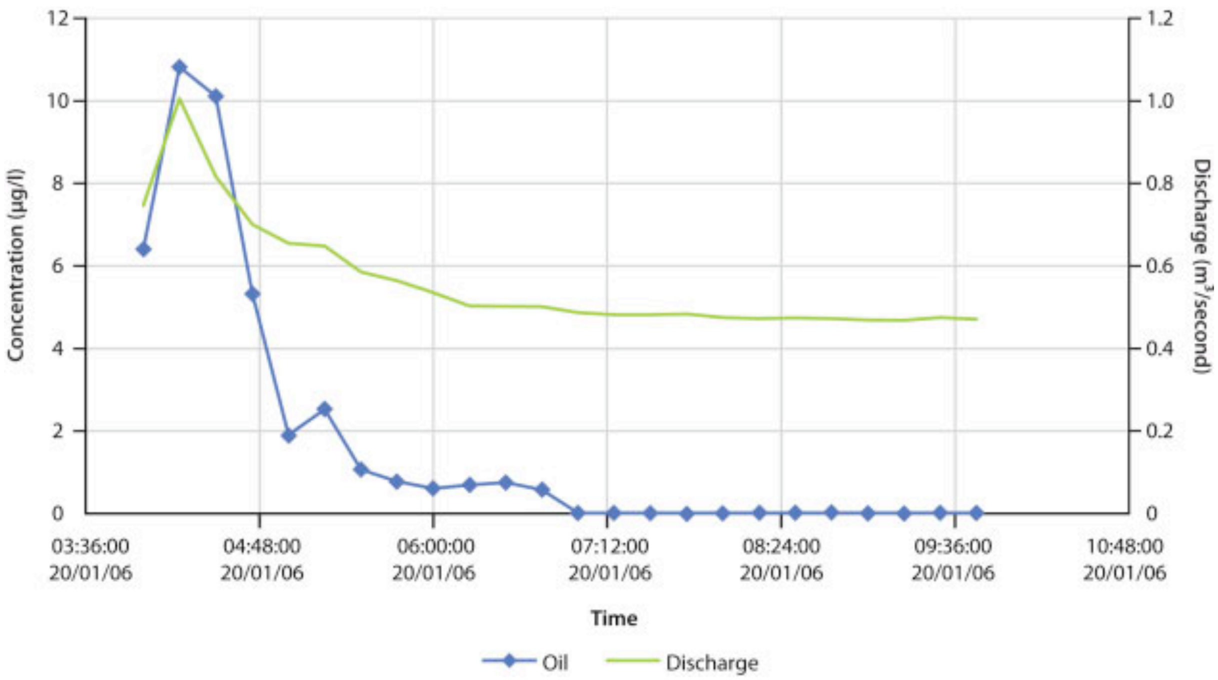


Figure 9: Oil concentrations in East Tullos Burn sampled every 15 minutes following a storm event on 20 January 2006



Figures 8 and 9 clearly show that, following this period of heavy rain, the river flow responded and the concentrations of both trace metals and oil increased dramatically. The polluting run-off occurred rapidly and most was washed off-site within the first hour of the event. The monitoring shows the effect from the industrial estate.

SEPA has maintained continuous monitoring on the East Tullos Burn which recently resulted in the successful tracing of a severe chronic pollution problem. In conjunction with Aberdeen City Council and Scottish Water, SEPA is also developing an Action Plan to gain further improvements to the surface water run-off from the East Tullos Industrial Estate and to improve the habitat of the East Tullos Burn downstream of the site, where it flows through a public park.

The West Tullos Burn, at the entrance to the Dee Estuary, has shown steady improvement since 1999 when it was Class D (seriously polluted). This positive trend in water quality is due to ongoing regulation and improved working practices on the West Tullos Industrial Estate.

To the south of Aberdeen, the Burn of Findon flows to the east coast through the village of Portethlen. The upper stretches of the watercourse are generally of good quality, but deterioration occurs as the river flows through two industrial estates and then under both the A90 trunk road and the main railway to Aberdeen. An Action Plan commenced following serious water quality issues in 2000. Companies within the industrial estates were inspected, potential pollution sources tackled and operators given advice on better drainage practice. The response from commercial industry and the public was encouraging and risks to the watercourse fell. SUDS are now required by all new developers on this site but a proposed wetland at Burnside Park was never realised due to its cost and engineering complications. Despite the fact that the ecological quality remains poor, recent trends suggest improvement in general water quality.

Angus and Dundee

Staying in the east but moving further south to Angus, intensive agriculture is still the dominant land use, but urban problems also arise. The Treacle Burn is a largely culverted watercourse flowing underneath Forfar. It is often polluted by high levels of ammonia and biochemical oxygen demand (BOD). Investigations have been undertaken in conjunction with Scottish Water and some engineering works have taken place to remedy cross-connections in the sewerage system. This work was expected to result in improved water quality but, as the problems have persisted, investigations are still being carried out to track down all the discharges into the burn.

The Brothock Water, which drains into the coastal town of Arbroath, had flood prevention maintenance undertaken on it in 2003 by the local authority. This involved dredging the riverbed in the town leading to stripping of habitat, which had a short-term affect on the ecology. Subsequent monitoring and analysis of ecological parameters has shown that recovery and re-colonisation has begun. Activities such as this highlight the conflict between maintaining flood prevention structures and protecting habitat.

In the city of Dundee, SEPA has targeted efforts on improving the water quality of the Dighty Water. Farm inspections in the upper catchment revealed problems with silage effluent and the disposal of waste chemicals. Following discussions, farmers agreed to changes in farm management practices. As a result, water quality improved for a couple of years but have since declined. The Dighty Water is identified as an ‘at risk’ watercourse and improvements will be sought under Water Framework Directive. http://www.sepa.org.uk/wfd/

Significant lengths of the Buddon Burn in Dundee improved from 2002. A reduction in diffuse inputs – a result of raising awareness during farm inspections – has contributed to these improvements. Nutrient inputs from Wellbank STW are still of concern; the STW has been identified for phosphate removal in Q&S III with completion by 2012.

River Tay catchment

The River Tay has the greatest flow of all rivers in Britain; it is very important for its salmon run, and remains in good or excellent quality throughout its length. This high quality has been maintained by paying attention to actual or potential problems in its many tributaries.

The completion of improvements at Methven STW saw an upturn in water quality in the East Pow Burn. The cessation of timber treatment at a nearby timber site may also have had an influence on the improvement, though the site has still to be fully cleaned up.

The improvement recorded in recent years in the Lunan Burn immediately downstream of the Loch of Butterstone is attributed to the removal of fish cages from the loch.

The Frenich Burn, which begins in the hills south of Loch Tummel, has been historically contaminated by zinc discharges originating from the operational Foss Barytes Mine. Although the burn is normally low in toxic substances, sporadic incidences of high zinc levels are recorded. In 2004, which was a relatively wet year, 13 zinc results exceeded the target EQS of 8 μg/litre and the stretch was downgraded to Class C (poor) quality. The watercourse improved the following year, though this may have been partially weather related. Real upgrades came after improved management of the settlement ponds at the mine. Work is also being carried out to gradually infill opencast areas, which may be a source of zinc pollution.

The reduced river flows in 2003 are likely to have contributed to the reduction in biological quality of the Burrelton Burn near Coupar Angus. As a consequence, low dilution was provided by the river to the discharges from Wolfhill STW and Burrelton STW. Treatment of sewage at Wolfhill STW improved in 2004 with the installation of a membrane treatment plant. This has reduced the nutrient (ammonia) input to the river and hence improved water quality. The river is now classed by SEPA as fair in quality. The lower reaches of the Burrelton Burn still contain elevated levels of nutrients and there is a risk that it may become eutrophic. SEPA is monitoring algal coverage and diatom levels as part of a long-term action plan. The reduced water quality in the area appears to be from diffuse agricultural sources.

Fife

There has been a significant improvement, from a rather poor baseline, in the water quality of the generally small rivers and streams in the Fife area. Remediation of a failed soakaway resulted in the upgrading of 6.6 km of the Cairnsmill Burn (a tributary of the Kinness Burn, St Andrews).

Early on after 2000, the upgrading of the sewerage infrastructure in the Ore Valley led to an improvement in a large length of the River Ore. In 2003, more than 20 km of the River Ore and tributaries improved in quality due to further sewerage improvements including work at Strathkinness STW. However, the River Ore at Thorton was downgraded in 2005 due to a drop in dissolved oxygen. It is possible this was due to leakage from the Ore Valley sewer. This sewer had been in a very poor condition due to corrosion at a number of points along the river and, depending on the river flow, leakage could have detrimental effect on water quality. Scottish Water contractors began extensive refurbishment of the sewer in mid-2006 and three long sections of the sewer at Thornton Golf Course, Thornton and Cluny Mains have been upgraded. This removed the threat of leakage and catastrophic failure of the corroded pipework. Phased remedial upgrading work continues, but the most serious known problem sections of sewer have been addressed.

Two sections of the Ceres Burn in the River Eden catchment near Cupar returned poor ecological scores and dropped to Class C (poor) in 2004. This downgrade was due to several unsatisfactory discharges in the area. Three significant operational upgrades have since been completed. Pitscottie STW has been improved and now provides secondary treatment. Ceres STW was also upgraded to improve final effluent and storm discharge quality. The Kemback Bridge septic tank was replaced with a pumping station to convey the sewage upstream to an upgraded septic tank at Kemback in Dura Den. However, the River Eden itself is still affected by surface water outfalls in the Cupar area, and agricultural nutrients.

The Lochgelly Burn in Cowdenbeath remains seriously polluted downstream of the town's sewage pumping station. During 2003, there were several overflows of sewage into the burn due to equipment failure. These, combined with long periods of low flow, exacerbated the situation. Extensive remedial works at the pumping station have taken place but its performance remains unacceptable, especially during periods of heavy rain. The burn will remain polluted until Scottish Water provides an upgraded sewage disposal system for Cowdenbeath. This is currently being designed under Q&S III with improvement earmarked for the 2006-2010 expenditure period.

The Wilkieston Burn catchment is primarily agricultural land and sheep farming activities, in particular sheep dipping, are a concern. It is possible that the stretches experiencing problems in 2004 were subject to intermittent pollution by sheep dip.

Water quality in the Kilrenny Burn has recovered following the adverse effects of a housing development in the small coastal town of Kilrenny. The nearby watercourses, the Dreel Burn and Balmonth Burn, also upgraded in 2006. In both cases this upgrading is viewed as a return to their more expected classification after unexpected drops in 2005, which were ascribed to diffuse agricultural pollution.

East Central Scotland

The improvements noted in the Stirling area in 2003 were not solely due to the drier weather experienced. Improvements along the Black Devon are accredited to improvements at Saline STW that year, which included the installation of new filter beds and proper use of storm tanks that had previously remained full of storm sewage for long periods.

The Duchray Water, River Forth and Annet Burn have all had time to recover from previous farm pollution incidents. The River Forth and Annet Burn have both improved to Class A1 (excellent), resulting in an improvement of more than 20 km of the local riverine environment.

In the Falkirk and West Lothian area, a very recent improvement has occurred in the Sauchinford Burn. This may be attributable to the current upgrading of Plean STW, even although the majority of the upgraded parts are not yet operational. Future monitoring will show if the upgrade seen in 2006 is maintained.

The River Carron catchment near Falkirk has benefited from £12 million of investment to upgrade sewer systems at Larbert and Cauldhame to resolve unsatisfactory CSOs. The work was completed in 2004 with resulting ecological upgrades the following year.

The improvement to large stretches of the Barbauchlaw Burn can be attributed to the completion of the Armadale STW upgrades. This watercourse has gone from being mainly class C in 2001 to completely class B – an overall improvement in length of almost 10 km.

The Bonny Water has a tendency to fluctuate in class and, like other watercourses in the area, is subjected to both urban run-off and sewage discharges. The biology is known to deteriorate in wet weather and this appears to have been the case in 2004. The improvement of the Bonny Water stretch from Banknock to Bonnybridge in 2006 is possibly surprising given that there were problems at Dunswood (Cumbernauld) STW, with industrial effluent knocking out the works in May/June 2006. Since then the sewage works has maintained good compliance with its licence conditions.

The whole length of the Red Burn, a tributary of the Bonny Water, is impacted by surface water run-off from Cumbernauld's residential and industrial areas. The impacts extend throughout the Bonny Water and into the River Carron for a total of 17 km. Of most concern is the oil pollution, which can smother the riverbed and kill sensitive macro-invertebrates and fish.

Near Falkirk, the Logie Water has improved following closure of a paper mill. However, the Bainsford Burn still suffers from chronic oil pollution. Pressures from sewage, combined with the fact that it is culverted for most of its length and runs under an industrial estate, suggest it is not likely to sustain much biological life. There is often oil and silt present where it emerges near the outfall. SEPA spent a considerable amount of time on this problematic watercourse in 2006. It transpired that the siphon at the outfall was acting like an interceptor, collecting oil which then flushed out during every storm event. As yet it has not been included by the local authority on a maintenance programme to get it emptied periodically.

In 2006, more than 3 km of the Couston Water showed ecological deterioration. An investigation attributed the problem to Bathgate STW, which had discharges in May and June 2006 with elevated BOD levels which breached its licence conditions. These exceedances were attributed to defective sand filters at the STW, which have since been repaired, and licence compliance has been restored.

The River Almond is a significant watercourse flowing east from the outskirts of Lanarkshire to the Firth of Forth near Edinburgh. During dry weather a third of its flow is treated sewage effluent. Additional tertiary treatment was introduced at all the main STWs by 1998 and, more recently, work has been completed to further improve the final effluent and reduce overflows at East Calder STW in Livingston. Recorded water quality downstream of the works improved in 2006, but problems still remain after heavy rainfall when the STW's storm overflows can impact on the river. The dry weather in 2006 means there may have been fewer storm events, thus reducing organic inputs and improving the classification. See the case study for more information on the River Almond improvement story.

The improvement in 2006 of a 6 km stretch of the Gogar Burn may be the result of the closure of some polluting piggery units. In the same area, the expected large improvement in the classification of the Swine Burn upon the closure of Scotmalt Maltings in 2003 was eventually realised in 2006.

Urban drainage from the city of Edinburgh has contributed in the past to downgrading in the Water of Leith. A significant pollution incident occurred in March 2002 on the Water of Leith resulting in a 10 km downgrade of the watercourse. The insecticide permethrin was found in the water and traced to Katesmill surface water outfall serving Redford Army Barracks. Operations at the barracks were investigated and modifications suggested. While the pollution was never conclusively linked to a particular operation, the modifications have been successful in preventing any recurrence of this problem.

The Swanston Burn lies at the headwaters of the Burdiehouse Burn, south of Edinburgh. Within the last two to three years, a number of septic tanks within this catchment have been connected to the main sewerage system and their discharge removed. The watercourse has recently shown some improvement; the upgrade of almost 4 km in 2004 is likely to be due to the removal of sewage in the catchment. However, two stretches of the same river showed a downgrade in quality in 2005. Scottish Water has since taken action to rectify two problematic wrong connections in the Swanston Estate area. In addition, there are proposals to divert the Swanston Burn out of its culvert under the A720 road across a field to the east and, in doing so, to connect a further septic tank to the adjacent foul sewer. These developments are likely to make a positive contribution to the chemical quality of the watercourse.

In 2006, stretches of the West Peffer Burn in East Lothian that had previously suffered chronic long-term water quality problems improved. Performance at Fenton Barns STW improved last year following the commissioning of a new trade effluent treatment plant. However, the catchment is very agricultural and thus subject to problems associated with crop spraying and abstractions of water for irrigation. The water quality in the lower end of this catchment has been fluctuating over the past ten years.

Borders

The River Tweed is the ultimate conduit of most rainfall run-off in the area. It continues to be of dominantly good quality with important salmon fisheries, but good control of nutrient inputs from farming and the smaller contribution from STWs is necessary to maintain this.

In 2002, diffuse pollution from agriculture contributed to water quality problems in the Leet Water (10 km), Otter Burn (4 km) and Glensax Burn (11 km). The Glensax Burn in Peebles may also have been affected by a pollution incident from the Bonnycraig water treatment plant. Since then, all have recovered and improved in quality.

The impact of some poultry units north of Peebles was responsible for a 2.5 km section of the Eddleston Water dropping in quality. These previously unlicensed units now come under Pollution Prevention and Control (PPC) regulation and thus their impacts will be dealt with by SEPA through PPC permits.

The Manse Burn, rising on the Raecleugh and Flass farms, has a history of water quality problems mainly due to the high density livestock policy adopted by Flass farm. The owner of Flass farm purchased Raecleugh farm in late 2003 and changed it from a low density livestock unit into one heavily stocked with cattle and sheep.

SEPA initiated an Environmental Improvement Action Plan to study the cause/effect of intensive stocking of the farm with sheep and cattle. In 2004, this work and routine monitoring recorded the effects of severe diffuse agricultural pollution and soil erosion. The wet weather that year no doubt exacerbated the problem by increasing run-off. The situation continued into 2005 with high numbers of cattle entering and polluting watercourses and causing river bankside erosion. Successful enforcement action was brought against the farmer concerned in 2006. A cross-compliance audit with the Scottish Government took place in 2006 with the farmer agreeing a number of actions including fencing of watercourses to reduce animal access. Implementation measures will take place in 2007. SEPA's Action Plan will continue to ensure these improvements take place and that any further deterioration is prevented.

In the nearby catchment, results in 2006 showed the Kelloe Burn to be of poor quality. Initially no specific reason could be given for the downgrade and SEPA began work with Scottish Water and companies within Duns Industrial estate to resolve the problem. Various contaminated surface water drainage and problematic cross-connections were identified and resolved. However, a survey in late 2006 indicated that a significant impact remained immediately below the outfall from the industrial estate. The SEPA Action Plan will continue into 2007/2008 in order to eliminate the pollution pressures on this waterbody.

In 2001, the top end of the Gala Water was significantly impacted by sheep dip pollution. More than 7 km of this watercourse, which eventually runs through Galashiels, dropped from excellent quality to fair and remained so until 2005. Water quality has since shown a slow improvement, although SEPA will remain vigilant as there are concerns about a recurrence.

In 2004, almost 10 km of Spittal Burn near Biggar improved from poor quality to fair. Unfortunately this improvement was not sustained and, in 2006, the river reverted back to Class C (poor). The ecological downgrade is believed to be due to diffuse pollution from agriculture. It is possible the downgrade is related to periodic dredging, as no organic inputs were identified through monitoring during autumn/winter 2005/2006. The Spittal Burn will be the subject of an SEPA Environmental Improvement Action Plan, with the aim of identifying causes of pollution issues in the catchment.

The Biggar Burn, a tributary of the Biggar Water, had been a Class A1 (excellent) watercourse until recent years when poor water quality was recorded. The dramatic drop in ecological quality in 2004 is thought to be due to the toxic effect of pesticide input. In addition, the invertebrate community may still be recovering from a re-sectioning of parts of the river. SEPA initiated an Environmental Improvement Action Plan to identify the source of pollution and to return the river to better quality. No specific sources were identified through monitoring, but a series of farm visits and community liaison work were undertaken to raise awareness of the issue. Since the end of the Action Plan in March 2006, good water quality has returned and no further problems have been identified.

2.4 Other river quality issues across Scotland

Acidification

Acidification is a continuing problem in some geologically sensitive areas in the west and north of Scotland. On the west coast, the Isle of Arran has many streams, especially in the northern part of the island (totalling approximately 30 km), which are still affected by low pH levels. Many of these rivers have remained classified as fair (Class B) for a number of years.

Minewater impacts

Several watercourses in Scotland are now being affected by resurgent (rising) minewater as result of historical deep coal mining. The most affected areas include Fife, Lothians, Clackmannanshire, Lanarkshire and Ayrshire.

These mines could be hundreds of metres deep, with workings well below the water table, and groundwater had to be actively pumped from the mine shaft. As the deep mines closed (the last being Longannet in 2002), groundwater pumping stopped or was reduced resulting in the rebound of groundwater within the abandoned workings. Eventually, rising water levels lead to discharges of iron-contaminated water from mine entries, outcrop zones and discharge pipes. Once the minewater reaches the surface, it comes into contact with air and a chemical reaction takes place causing small particles of iron (more commonly known as ochre) to form from solution.

Ferruginous (iron-bearing) minewater from these abandoned mines has a pronounced turbidity and the fine particles can smother the riverbed, killing fish and invertebrates. The rising iron-bearing water can also contaminate overlying or adjacent aquifers preventing their use as a source of drinking water or water for industrial processes.

In 1994 the Coal Authority was formed with a remit to deal with the legacy of pollution from abandoned coal mines. This remit was strengthened when powers to deal with the issue were included in the Water Services etc. (Scotland) Act 2005 (http://www.opsi.gov.uk/legislation/scotland/acts2005/20050003.htm). SEPA and the Coal Authority have developed a priority list of discharges to rivers from abandoned mines that require treatment, tackling the most environmentally damaging minewater discharges first.

Successful treatment installed at a number of Scottish sites has resulted in almost 24 km of river being cleaned up (Table 2). For a detailed list of minewater treatment schemes currently in operation in Scotland, visit the Coal Authority website (http://www.coal.gov.uk).

The preventative schemes in the Lothians and Fife are stopping deleterious impacts before they occur. This pro-active approach is welcomed by SEPA.

Active treatment is the enhancement of water quality by methods that require pumping of minewater. These schemes are not the Coal Authority's preferred way of treatment as they are expensive to construct and maintain, and have a high visual impact. Passive systems are preferable as these have no long-term maintenance or energy costs. Schemes can have both active and passive elements, with pumping and dosing at the start of the process while still passing the water through reed bed cells for final cleansing.

Table 2: Clean-up schemes at abandoned mines, 2000-2006

Scheme name	Location	Date completed	Build cost (£ million)	Scheme type	River	Length improved
Cuthill	West Lothian	Dec 2003	0.9	Pumped/ passive	Breich Water	2 km
Frances	Fife	Sep 2003	0.8	Pumped/ active	n/a	Preventative scheme
Kames	Ayrshire	Aug 2001	0.5	Passive	Garpel Water/ River Ayr	3 km
Lathallan Mill	Fife	Sep 2003	0.5	Passive	Cocklemill Burn	2 km
Mains of Blairingone	Clackmannan-shire	Mar 2003	0.1	Passive	River Devon	1 km
Minto	Fife	Sep 1998	0.3	Passive	River Ore	3 km
Monktonhall	East Lothian	July 1998	0.5	Pumped/ active	Cairnie Burn	Preventative scheme
Mouse Water	Lanarkshire	Nov 2004	0.8	Passive	Mouse Water	8.6 km
Polkemmet	West Lothian	1999	0.5	Pumped/ active	White Burn	Preventative scheme
Pool Farm	Lanarkshire	July 2004	0.5	Passive	Dippool Water	4.3 km

Two minewater remediation systems completed in Mouse Water and Dippool Water (upper Clyde, Lanark) have dramatically improved water quality in the catchment; almost 13 km of watercourse has improved since the completion of these schemes (Table 2). For more details on the work in this catchment see the Mouse case study.

As a result of improvements carried out by West Lothian Council in 2002 to the water treatment system at Seafield Bing, almost 4 km of the Lochshot Burn upgraded from Class D to Class B and just less than 1 km from Class B to Class A2.

The Lochty Burn in Fife showed improved water quality due to reduced ammonia levels in 2006, but is still affected by the ferruginous discharge from the former Kinglassie pit. The Coal Authority is carrying out a feasibility study into treating this discharge. The Den Burn at Cardenden in Fife is also impacted by ferruginous discharges and ferruginous minewater discharges from the Fordell Day level are still polluting lower reaches of the Keithing Burn in Fife. Unless the upstream minewater discharge is treated, it is not expected that any improvement will be seen in the Keithing Burn.

In West Lothian, the tributaries of the Foulshiel Burn and the Bickerton Burn were all downgraded due to high iron and ammonia levels. There was significant historic mine working in this area, which has left iron-rich spoil. Point sources have been identified and investigated alongside the Coal Authority, but diffuse seepages throughout the catchment are also a possibility. Ammonia can arise as a natural source from mine workings and this is considered likely to be the case here, as other sources have been eliminated

A Coal Authority improvement scheme at Cuthill was completed in December 2003. An adit (former mine entrance) is now intercepted and the discharge pumped to a treatment system. It was hoped that the Breich Water would show a subsequent improvement in quality, but iron levels have remained above 2 mg/litre (on average) and have been as high as 5 mg/litre in the summer months

Despite these advances, some serious problems related to elevated iron levels in Scotland’s rivers remain. Further action depends on the Coal Authority receiving funding. The improvements described above cost over £5 million. However, funding has been limited in recent years with no Scottish schemes constructed since 2004. There is currently no guarantee that future funding for this programme will be made available. Furthermore, funding is required to allow the Coal Authority, in collaboration with SEPA, to initiate work to provide treatment for polluting non-coal mines.

Forth and Clyde Canal

During late 2000 and most of 2001, many sections of the Forth and Clyde Canal were subject to engineering works as part of the Millennium Link project. Dredging and bank reinforcement took place during 2001 and, in some places, much of the water was removed from the canal. As a result, dissolved oxygen fell as low as 40% saturation, threatening fish life. The project was completed by 2003 and has succeeded in allowing craft to sail the extent of the canal from Grangemouth in the east to Bowling in the west (some 55 km). The fish population in the canal has improved in recent times and SEPA even has reports that otters have been seen. These are most welcome outcomes of improved water quality.

3 Estuarine water quality 2000-2006

3.1 Overall picture

Since 1999 Scottish estuaries listed by the Scottish Government under the Urban Waste Water Treatment Directive (UWWTD) have been classified using a scheme developed by the former river purification boards (see Annex C).

A relatively small unit of resolution of 0.1 km^2 is used in the classification scheme and affected areas smaller than 0.01 km^2 are ignored. There are seven assessment criteria covering aesthetics, biological and chemical quality, and four quality classes – A (excellent) through to D (seriously polluted). The scheme is default based, so a given area of estuary is classified by assessing all criteria and then allocating it to the poorest class.

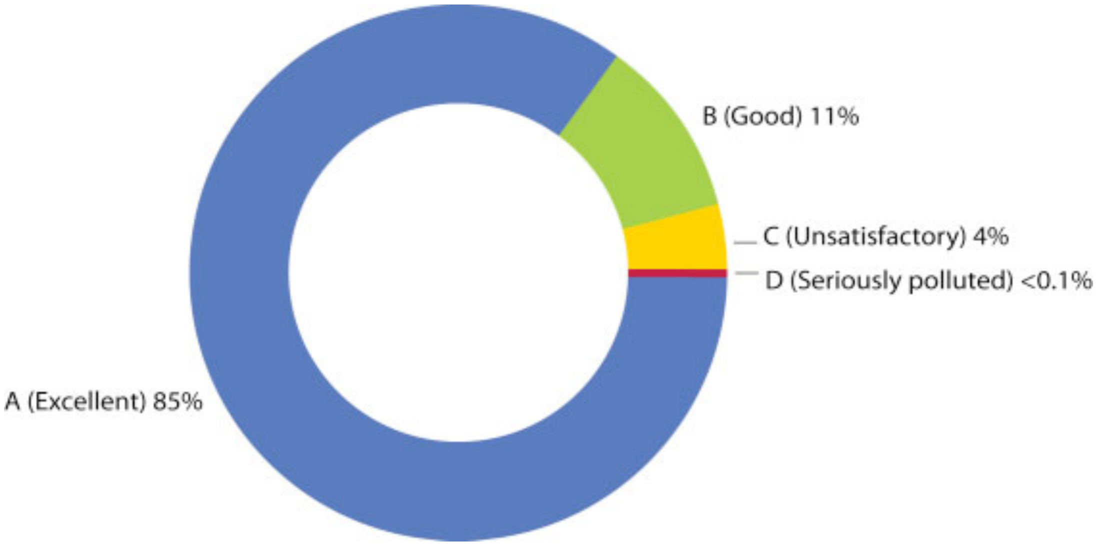
A summary of the annual classification for estuaries from 1999 to 2006 is given in Table 3. The class percentages for 2006 are shown in Figure 10.

Table 3: Scottish estuarine water quality classification, 1999-2006

Area	Year	A Excellent	B Good	C Unsatisfactory	D Seriously Polluted	Total
km^2 (%)	1999	633.3 (78.2)	143.6 (17.7)	31.6 (3.9)	0.9 (0.1)	809.4 (100)
km^2 (%)	2000	637.0 (78.7)	132.9 (16.4)	38.2 (4.7)	1.2 (0.1)	809.3 (100)
km^2 (%)	2001	661.1* (81.7)	115.5* (14.3)	31.8* (3.9)	1.1 (0.1)	809.5 (100)
km^2 (%)	2002	644.7* (79.6)	140.7 (17.4)	23.1* (2.9)	0.8 (0.09)	809.4 (100)
km^2 (%)	2003	651.1* (80.4)	121.9* (15.1)	35.5* (4.4)	0.9 (0.1)	809.4 (100)
km^2 (%)	2004	687.7* (85.0)	92.3 (11.4)	29.3* (3.6)	0.2 (0.02)	809.5 (100)
km^2 (%)	2005	684.0* (84.5)	95.0 (11.7)	30.1* (3.7)	0.2 (0.02)	809.5 (100)
km^2 (%)	**2006**	**693.8 (85.7)**	**86.1 (10.6)**	**29.5 (3.6)**	**0.2 (0.03)**	**809.5 (100)**
Actual area of Classes C and D in 1999					**32.5 km^2**	
Actual area of Classes C and D in 2006					**29.7 km^2**	
Target area of Classes C and D by end 2006					**26.0 km^2**	
Actual change in area of Classes C and D 1999 to 2006					**–2.8 km^2 (–8.6%)**	
Target change in area of Classes C and D 1999 to 2006					**–6.5 km^2 (–20%)**	

* Figures for 2001-2005 have been corrected relative to earlier SEPA publications to take account of the decision to retrospectively downgrade Montrose Basin to Class C as a consequence of the 2006 Oslo and Paris (OSPAR) Convention and UWWTD reviews of the Basin. This has led to 8.5 km^2 being downgraded from Class A/B to C between 2001 and 2003, and 8.4 km^2 being downgraded from Class A to C in 2004 and 2005 (0.1 km^2 was classified separately from 2004 onwards). The Montrose Basin classification before 2001 has been left as Class A (8.5 km^2).

Figure 10: Estuarine class totals, 2006



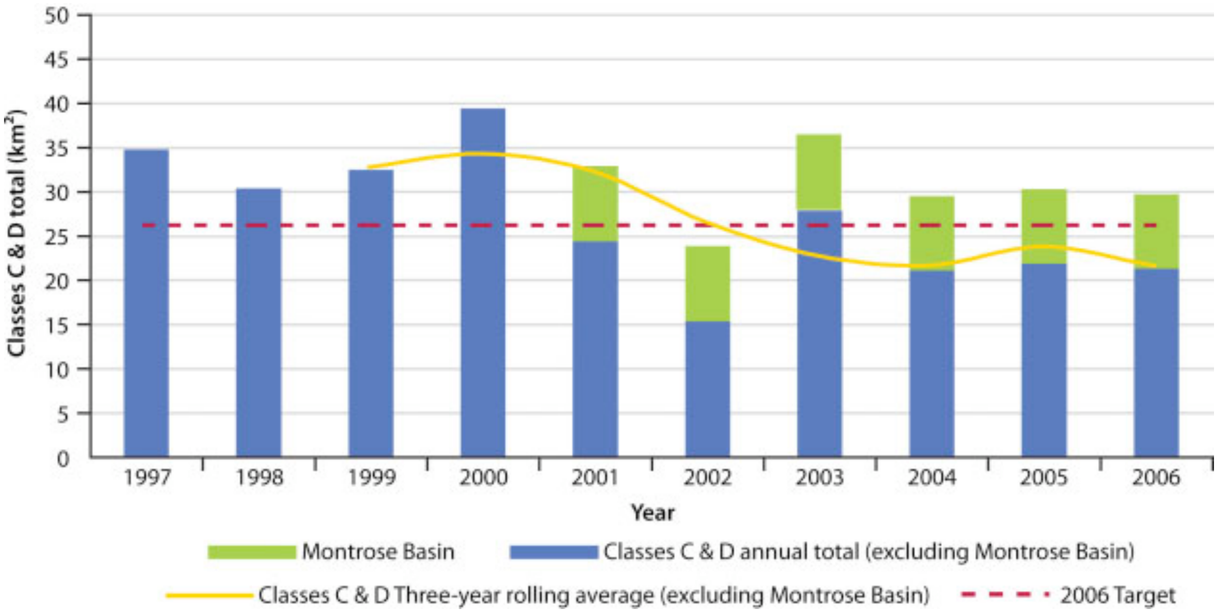
The data show that Scotland's estuaries are dominantly of excellent quality. The main areas of downgrading are in the heavily urbanised Clyde and Forth estuaries, which receive many effluent discharges. Better treatment of these discharges is gradually improving environmental quality. However, the sediments of these estuaries carry a burden of organic matter and some toxic contaminants from historic discharges. These will remain for many years to come and continue to influence the classification of parts of these estuaries.

SEPA's target for the period 2000-2006 was to reduce the length of poor and seriously polluted estuarine waters (Class C and D) by 6.5 km^2, equivalent to 20%. As shown in Table 3, estuarine water quality totals have varied each year during this period. This has meant an overall decrease of only 2.8 km^2 (8.6%) of Class C and D estuaries. But if the Montrose Basin is excluded (owing to the changes in its classification which affect the baseline against which progress is measured[1]), a total area of 11.2 km^2 improved from Classes C and D to Classes A and B between 1999 and 2006 – ahead of the target of 6.5 km^2.

As noted in previous annual water quality reports, the weather can have a significant impact on the classification of estuarine waters. Wetter weather, as in 2002, results in higher river inflows to the major estuaries and consequent higher dilution and greater mixing. This in turn improves oxygen levels and potentially the estuary's water quality. These weather-induced changes mean that the three-year average figure of the total area of Class C and D estuarine waters gives a clearer picture of change in these waters over time (see Figure 11).

[1] See footnote to Table 3 and the more detailed explanation in the section on the South Esk Estuary under in Section 3.3.

Figure 11: Annual totals and three-year rolling average for Class C and D estuarine waters



The 2002 improvement was assisted by the very wet summer of that year and, as expected, the dry weather of 2003 reversed this trend. The summer of 2004 again brought wet weather and this aided estuarine water quality. Plotting a trend line depicting a three-year rolling average reduces these annual fluctuations.

3.2 General issues relating to estuarine water quality, 2000-2006

The water quality of Scotland's two major estuaries, the Forth and Clyde, is significantly dependant on weather-influenced river flows and historically polluted sediments. The dry summers of 2003 and 2006, which reduced the rate of water exchange throughout the Clyde and Forth estuaries, led to poor quality in parts of these estuaries. This contributed to the overall net downgrading of quality of Scotland's estuaries.

Continuing investment by both Scottish Water and industrial dischargers is resulting in estuarine waters with lower contaminant concentrations. As a result, the longer term trend is one of significant improvement. Further improvements are expected as the contaminant load from diffuse sources carried by inflowing rivers (e.g. nutrients from agricultural activities) is reduced by measures arising from implementation of European directives.

3.3 Estuarine water quality around Scotland

Details of the most significant quality changes around Scotland are presented below, starting in the south-west.

Inner Solway Firth

The entire Solway Firth extends from Gretna at the English border to the Mull of Galloway in the west covering an area of almost 2,000 km^2. In terms of estuarine water quality, this section considers only the Inner Solway Firth, taken as the area east of an imaginary line from Southerness Point on the Scottish side to Dubmill Point on the English side.

The Inner Solway Firth (or Solway Estuary) receives inputs from several rivers (some with significant flows), which drain intensively farmed agricultural areas in both England and Scotland. The inner area of the Solway Estuary is designated as a Site of Special Scientific Interest (SSSI). The extensive intertidal sands are very productive, with a good variety of invertebrates living in the sediments and providing the food for the wading birds that are a feature of this area.

The Inner Solway Firth is mainly unpolluted and therefore mostly Class A (excellent). However, there are concerns that both the Solway and Clyde estuaries are at risk from increasing levels of nutrients from mainly variable diffuse sources. Therefore plankton growth in the Inner Solway Firth is monitored but is not cause for significant concern at present.

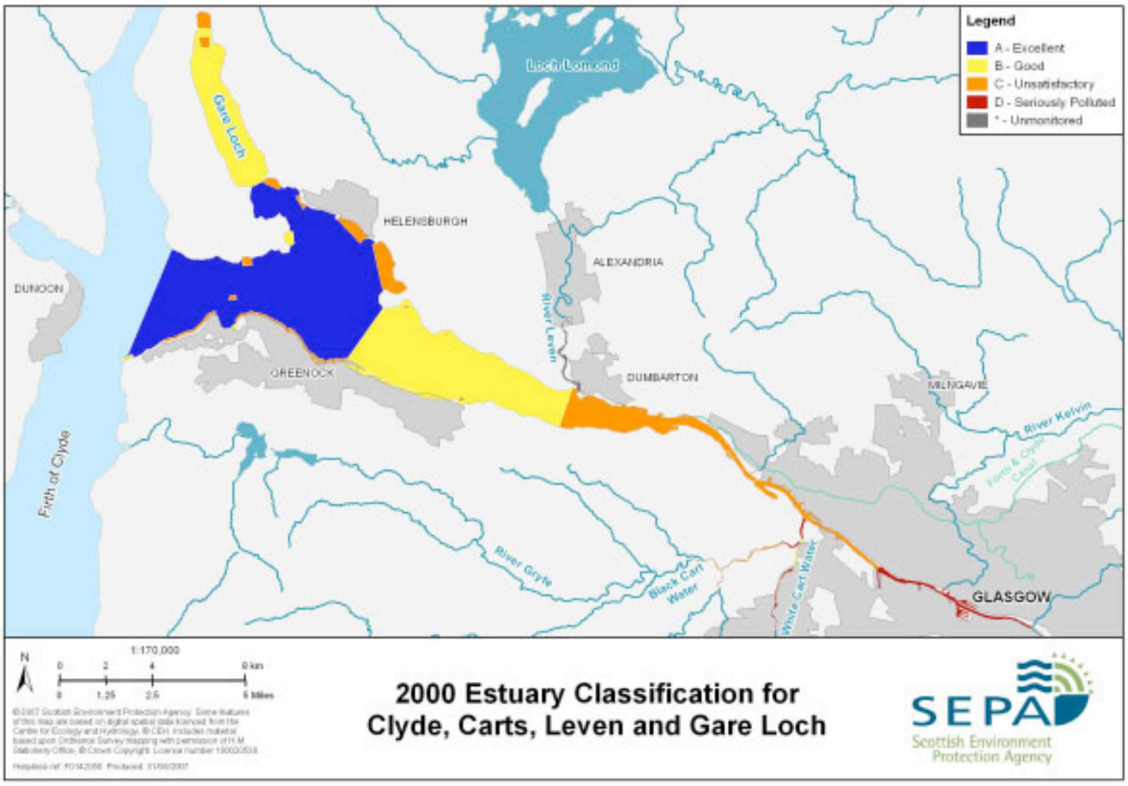
Ayrshire estuaries
Estuaries on the Ayrshire coast have remained in the upper quality classes for a number of years. In 2004, the aesthetic condition of the Ayr Estuary improved due to the removal of CSOs in the town.

Clyde Estuary
The Clyde Estuary extends 42 km westward from the Tidal Weir in the centre of Glasgow to an administrative boundary between Barons Point and Cloch Point. This large area of almost 90 km^2 includes the Gare Loch. There are over two million people living and working in the total catchment area and the estuary receives, directly or via tributaries, the sewage and industrial effluents from this large area.

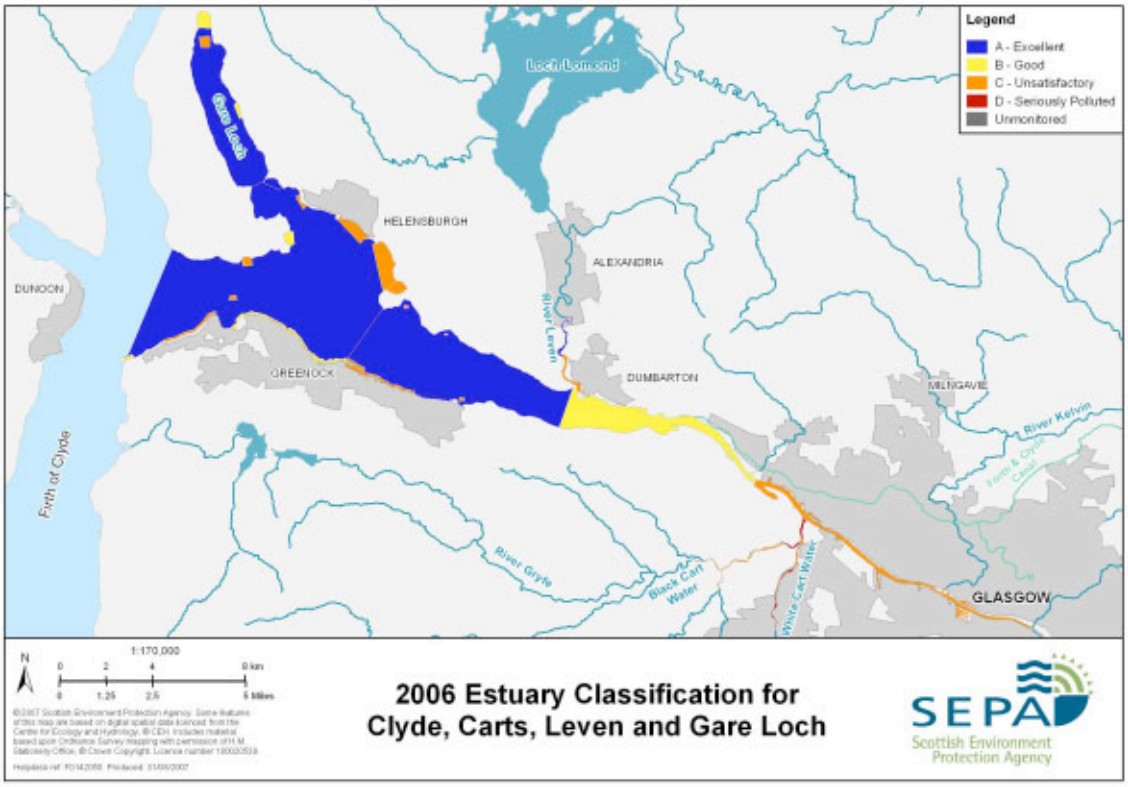
The Clyde Estuary is a complex hydrodynamic area where freshwater from the River Clyde and its tributaries mixes with seawater from the Firth of Clyde. The water quality further from Glasgow has improved in recent years, reducing the area classed as poor water quality. However, the inner estuary retained its Class C (poor) quality designation in 2006 due to low dissolved oxygen levels and aesthetic/litter problems. These trends are illustrated in Maps 3 and 4.

An improvement in the aesthetic condition of the Clyde Estuary between Erskine and Milton has enabled an area of 2.6 km^2 to be upgraded. This improvement resulted from an upgraded system at the Bowling STW where sewage is now screened (to collect debris) and transferred via a pumping station. High flows were reflected by much improved dissolved oxygen levels in the middle estuary between Dalmuir and the Leven confluence. In addition, the foaming problem at Dalmuir STW has recently declined, resulting in the upgrading of a further 0.7 km^2 of the estuary.

Map 3: Clyde Estuary classification, 2000

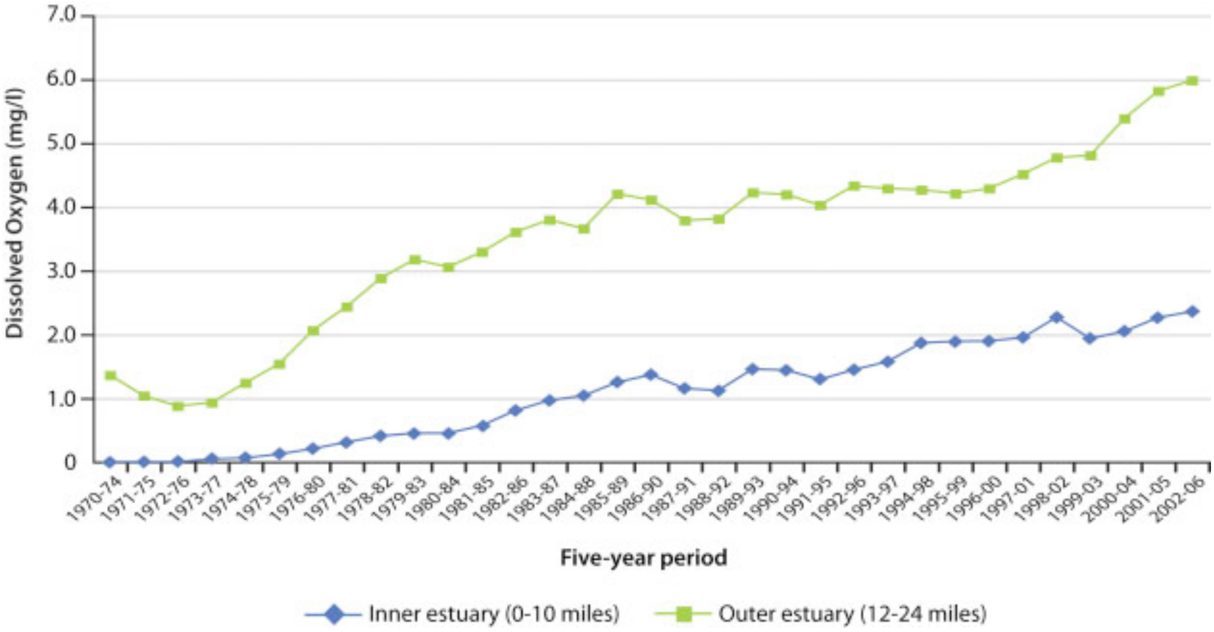


Map 4: Clyde Estuary classification, 2006



The improvement in water quality in the Clyde Estuary over the years is illustrated further by the gradual but steady increase in dissolved oxygen in the estuary. Figure 12 shows dissolved oxygen levels as five-year mean values for the two parts of the estuary. The water quality in the inner estuary can be described as ‘poor’ (>2.0 mg/litre but <3.0 mg/litre) while, in the outer estuary, it is ‘good’ (>5.0 mg/litre).

Figure 12: Dissolved oxygen levels in the Clyde Estuary, 1970-2006, as five-year mean values (as 95th percentile)



A number of pressures (both current and historic) mean the improvement in water quality in the inner estuary is more modest than that of the outer estuary. The general improvement is a consequence of:

- decline of ship building and other industry on the Clyde;
- better integrated pollution control;
- improvements to the surrounding sewerage systems.

The inner estuary from Glasgow to near Erskine was completely devoid of oxygen at certain seasons during the 1970s. The steady improvement in the 1980s coincided with the return of salmon to the Clyde in 1983 after an absence of over 120 years. This marked the culmination of a century of effort to restore to health one of the worst polluted river basins in Britain [3].

Hostile biological conditions near the estuary bed (sulphide levels and deoxygenation of the sediments) can still result from low summer oxygen levels due to low flow or higher summer temperatures. These deleterious effects on water quality can be shown by the dips in dissolved oxygen content in 1984, 1995 and 2003 (Figure 12); these coincided with sustained periods of dry and warm weather.

See the Clyde Estuary case study for more details on other areas of environmental improvement in the Clyde Estuary.

Gare Loch

The Gare Loch, which is part of the outer Clyde Estuary, has also seen improvements to its water quality (Maps 3 and 4). Overflows of sewage from Rhu are now screened, with real-time telemetry present at sewage pumping stations allowing operators to monitor performance. Less screenings are now discharged to the Clyde Estuary from these upgraded CSOs although, as a downside, more screenings are passed to the Craigendoran pumping station (collects and pumps on to Helensburgh STW), which has caused an increased frequency of chokes in the station pumps. Scottish Water hopes to resolve this issue during 2007.

Fewer aesthetic problems have been recorded at Rhu Narrows, leading to a small upgrade in the area. The improvement is due to the fitting of an innovative valve diffuser at the most southerly Shandon tank, which prevents tidal ingress and washout of solids from the tank. Scottish Water intends to upgrade all other tanks where tidal and/or surface water ingression is an issue.

Cart Estuary
The Cart Estuary consists of riverine water from the White Cart Water and Black Cart Water mixing with the waters from the Clyde Estuary.

Chemical sampling via survey boat is difficult in the narrow Cart Estuary and biological classification of low salinity waters is difficult, as the indices used in marine waters do not apply. The first biological classification survey of the Cart Estuary was carried out in 2000 by assessing the invertebrate fauna dwelling in riverbed sediments. The survey found that the fauna of the Black Cart Water above Inchinnan Bridge was composed entirely of freshwater fauna species.

An attempt was made to classify the Cart Estuary using the River Invertebrate Prediction and Classification Scheme (RIVPACS) programme. However, this programme is not designed for estuarine waters and it over-estimates the predicted taxa and Average Score per Taxon (ASPT) scores compared with the actual scores. This means the software may give a lower ecological class than expected (especially the taxa scores) such that, when Ecological Quality Indices (EQIs) are calculated (i.e. actual/predicted score ratios), all sites would be classed as D. The actual ASPT scores alone (0–2 = Class D; > 2 < 3.5 = Class C; ≥ 3.5 = Class B) appear more helpful and discriminate impact around the Paisley STW discharge. Hence this report, and the Maps 3 & 4, uses the actual ASPT scores to provide a provisional biological classification of the Cart Estuary.

The Cart Estuary is mainly Class C (poor) or D (seriously polluted) throughout and remains heavily impacted from benthic disturbance, aesthetic problems from the Paisley STW and associated CSO discharges. Waters of the White Cart are still heavily impacted through modified invertebrate fauna and poor aesthetics.

A recurring foaming problem at Paisley STW adversely affected the estuarial receiving water, but was resolved in 2004. A major oil spill from Glasgow International Airport in 2004 further stressed the estuary, pushing some areas into a lower class status that persisted for over a year.

Dead plant life along the banks of the Cart Estuary (downstream of the M8 motorway flyover) following the oil spill at Glasgow Airport, 2004

Leven Estuary
Biological monitoring of the riverbed invertebrate fauna of the Leven Estuary in Dunbartonshire was undertaken for the first time in 2002. Four stations were sampled along a stretch of about 2 km in the lower estuary between Dumbarton Common and Leven mouth. As expected the fauna was dominated by species characteristic of freshwater or low salinity, including many oligochaetes and larval insects. A provisional classification was attempted using the ASPT method with the same thresholds as used as for the Cart Estuary in 2000. (scores 0–2 = Class D; > 2 < 3.5 = Class C; ≥ 3.5 = Class B).

A small area of the Leven Estuary has since upgraded due to the closure of a distillery. However, most of the Leven Estuary (0.5 km^2) remains Class C due to poor aesthetics, benthic impact and low oxygen levels. An area of the Leven Estuary near Dumbarton Common was recently downgraded due to complaints of sewage near the barrage.

Ythan Estuary
The area of poor quality estuary in the Ythan Estuary (Aberdeenshire) was the same in 2006 as in 2000. Improvement is not expected in the short term.

Some 2.33 km^2 (82%) of the estuary was poor quality primarily due to diffuse pollution from agriculture in the intensively farmed River Ythan catchment. The nutrient enrichment caused by high inputs of nitrogen to the estuary leads to excessive algal growth. The eutrophication effects observed in the estuary resulted in the designation in 2000 of the entire catchment as a Nitrate Vulnerable Zone (NVZ). The estuary was also designated a ‘Sensitive Area (eutrophic)’ under the UWWTD in 2000 and has been identified as a ‘Problem Area’ under the Oslo and Paris (OSPAR) Convention.


Algal blooms in the Ythan Estuary, August 2003

A recent review of the Ythan Estuary found total oxidised nitrogen (TON), phosphate and chlorophyll *a* levels to be above the Sensitive Area assessment criteria for coastal waters [4].

With EU assistance, the Ythan LIFE Project was set up in 2001 with the aim of involving local people in protecting, restoring and enhancing the Ythan catchment. Such work helped to address water quality and habitat issues, though it may be several years for any resulting improvements in water quality to be seen in the Ythan catchment.

The NVZ Action Plan for the Ythan limits the amounts and timing of nitrogen fertiliser application in the catchment. Measures implemented as a result of the Scottish Government's work with local farmers to ensure compliance with NVZ requirements are expected to lead to long-term improvements in water quality.

In addition, SEPA has demanded various improvements to sewage treatment and discharges along the river and estuary. These improvements and planned projects will further reduce nutrient inputs from sewage works discharging to the river further up the catchment.

See the River quality chapter for more information about the River Ythan.

Cromarty Firth
Levels of tributyl tin[2] (TBT) in the Cromarty Firth around Invergordon have fallen in recent years. In 2004, around 2 km^2 of the Cromarty Firth improved in quality following the replacement of several untreated sewage outfalls with a single discharge from a new STW.

In 2005, a small portion of the Cromarty Firth adjacent to the Dalmore Distillery in Alness was unexpectedly downgraded from excellent to poor. This was due to contamination of the distillery cooling water discharge with effluent from other sources on the site. The problem is being addressed but has not yet been remedied.

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[2] Toxic anti-fouling compound used on boats. See the entry for Loch Ryan in Section 4.3 for more information.

Moray Firth
By the end of 2000, commissioning of the new Allanfearn STW further along the coast led to a recovery in quality by 2 km^2 of the Inverness Firth (part of the Moray Firth, east of Inverness) in the vicinity of the former sewage outfall at Longman Point. A further 5 km^2 of the Inverness Firth at Longman Bay improved to achieve excellent status in 2001. This was again attributed to the improvement of sewage treatment in the area. In the same year, around 3 km^2 of the Beauly Firth immediately to the west of Inverness improved following improvements to the sewerage infrastructure in the Inverness area.

Lossie Estuary
Quality of the estuary around Lossiemouth improved in 2004 following completion of the new STW at Oakenhead Wood. All the Lossie Estuary was at the highest possible status in 2006.

River Dee Estuary (Aberdeen Harbour)
Within the Dee Estuary, an area of 0.52 km^2 was classed as poor in 2000 due primarily to oil spills in the harbour. Effective regulation of ship fuelling operations, together with SEPA actions and work undertaken in 2001–2003 with the co-operation of the Aberdeen Harbour Board, gave rise to an improvement in water quality over a large area of the harbour.

In 2004, the quality of 0.36 km^2 of this area around Aberdeen Harbour improved due to improved aesthetics in relation to discharges from the city centre sewer overflows and less oil pollution from vessels using the harbour. However, the remaining area of 0.16 km^2 of the estuary around the inner harbour and commercial quay is still classed as poor quality. Unfortunately, the causes of the remaining sewage problems are such that any improvement work will involve a great deal of expense as well as major upheaval within the city centre.

South Esk Estuary (including Montrose Basin)
In late 2001, a secondary treatment plant and screened combined sewer overflows (CSOs) at Montrose became operational and the previous discharges of unscreened sewage to the South Esk Estuary ceased. This resulted in the narrow neck of the South Esk being upgraded in 2002.

Environmental monitoring showed no impact from the discharge of effluent to the South Esk from the GlaxoSmithKline pharmaceutical factory. The effluent is discharged on the ebb (receding) tide to prevent entrainment into Montrose Basin and is dispersed rapidly by the strong tidal currents in the estuary.

The Montrose Basin, which covers an area of 8.4 km^2, was downgraded from Class A to Class C in 2006. This followed SEPA reviewing its eutrophication status in 2006 for OSPAR and UWWTD reporting purposes. These reviews, which used recently available Water Framework Directive criteria rather than the SEPA classification scheme, showed that the Montrose Basin should be regarded as moderate to poor, and hence Class C. This was because eutrophication criteria were being exceeded based on the level of nutrients, algal cover, algal biomass and secondary effects on invertebrate populations. The presence of nitrate promotes this growth, with the River South Esk being the main source of nitrate to the basin. The area surrounding the basin was designated a NVZ in 2003. Levels of nitrate and other pollutants coming from the catchment should decline in the coming years following implementation of NVZ measures by the Scottish Government. The OSPAR review also identified the Montrose Basin as a Problem Area (i.e. an area with elevated nutrient levels but not yet classed as ‘sensitive’) on the basis that nutrients, algal cover and biomass exceed OSPAR eutrophication criteria. This brings the classification of the Montrose Basin in line with the Ythan Estuary, which is also Class C on the basis of exceeding eutrophication criteria.

The OSPAR review was based on survey work which started in 2001. SEPA has therefore taken the decision to retrospectively downgrade Montrose Basin to Class C all the way back to 2001, although there is no evidence that quality in 2001 was different from the 1999 baseline year.

Re-examination of SEPA's historical (pre-2001) algal data shows marked stability in the status of the basin based on algal cover since 1991. Although only one component of the assessment criteria (others include algal biomass and secondary influences on the macro-invertebrate populations), the constant level of algal cover (~23%) since 1991 is sufficient to justify a retrospective reclassification of the Montrose Basin as Class C back to 1991.

The expected biodiversity along Montrose Beach front and at the mouth of the estuary was significantly reduced as a result of the replenishment of beach sand in 2002. The last Montrose Beach/South Esk estuary survey in September 2003 reported a slight recovery of the intertidal fauna. SEPA is awaiting evidence of further recovery and stabilisation of the fauna. As a result, 0.1 km^2 of the South Esk remains Class B for the moment.

Tay Estuary
This estuary extends westwards from a line from Buddon Ness to Tentsmuir, to the tidal limit at Perth.

In 2003, almost 20 km^2 of the lower Tay Estuary between Dundee and Newport-on-Tay was considered to be of fair/poor quality. Water quality improved following the completion of the Tay Wastewater Scheme in 2002 and, in 2004, SEPA found that this entire area was of excellent quality.

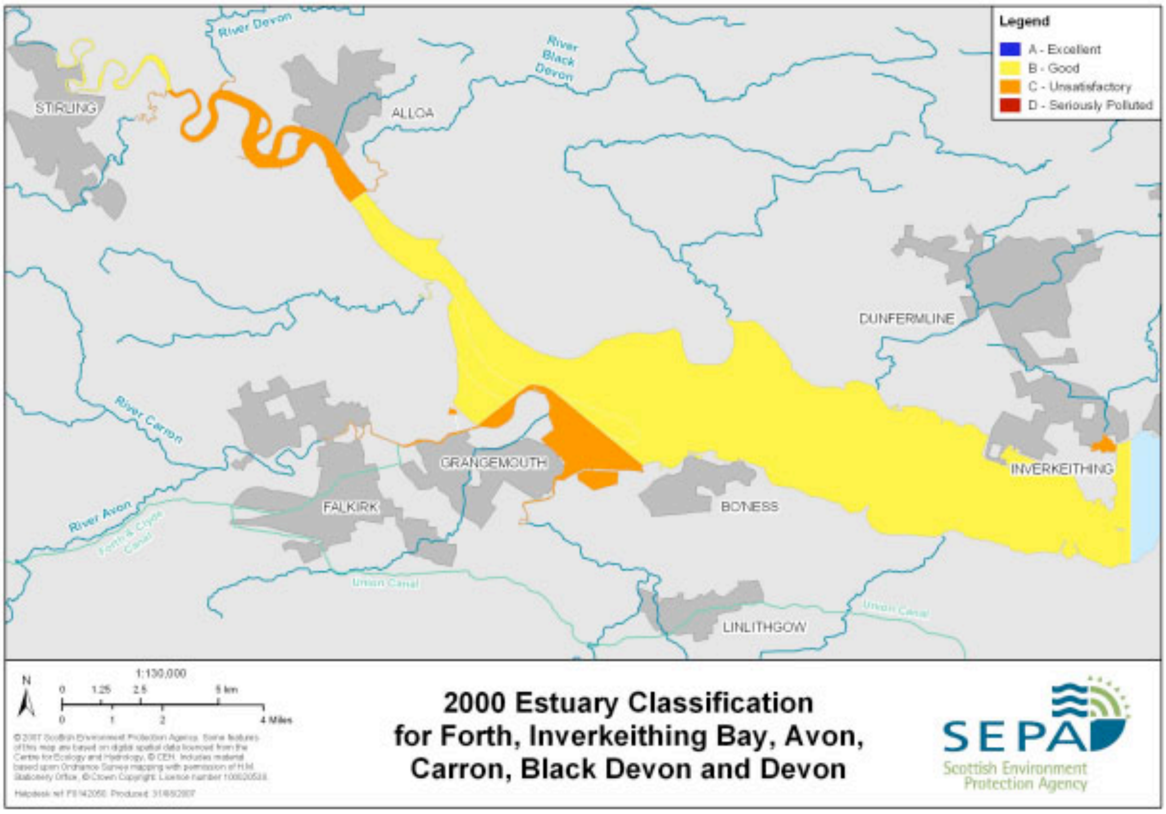
Impacted stretches remain along the north shore from Invergowrie Bay to Monifieth (15 km) and along the southern shore from Wormit at the southern end of the Tay Bridge to Tayport (10 km). The north shore is currently downgraded on the basis of sewage aesthetics. The south shore is downgraded by the discharge of preliminary treated sewage at Tayport and primary treated effluent at Newport, which gives rise to sewage debris.

The new Tayport STW is due to be commissioned in 2007. Scottish Water has completed remedial works to stop the problem of untreated sewage discharges in the Wormit/Newport area and it is anticipated that an upgrade along the north and south shores of the Tay estuary may be possible following these improvements.

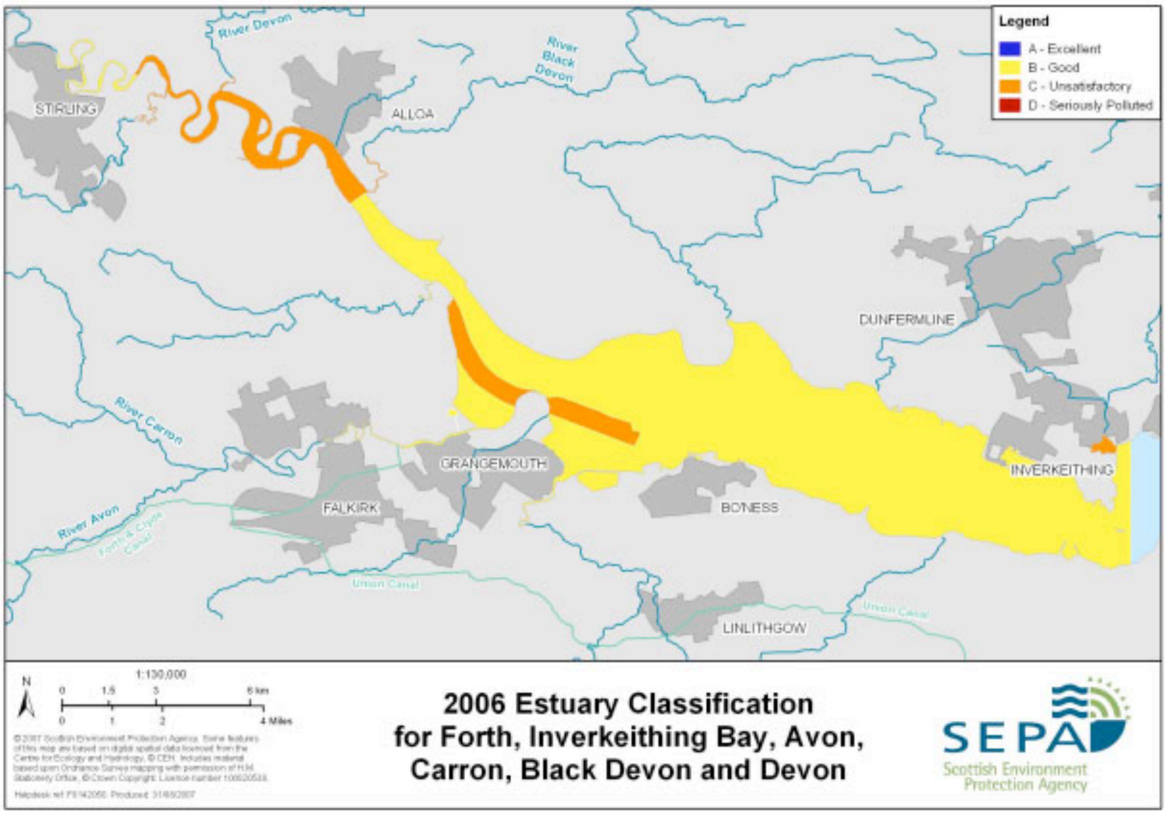
Eden Estuary
The classification of the Eden Estuary has remained unchanged at Class A since full effluent treatment began at Guardbridge Paper Mill in 1992 and the completion of sewage treatment works to serve Balmullo, Leuchars and Guardbridge in 1995.

Forth Estuary
The Forth Estuary is now largely Class B (good), with some intertidal areas downgraded to poor as a result of historic discharges. There is also an area of Class C in the upper estuary resulting from low dissolved oxygen concentrations during summer 2006. The Forth Estuary is not expected to achieve excellent status because of its intrinsically turbid nature and the number of industrial and domestic wastewater discharges it receives. However, there have been areas of improvement between 2000 and 2006 as shown in Maps 5 and 6.

Map 5: Forth estuary classification, 2000



Map 6: Forth estuary classification, 2006



The most significant improvement within the Forth Estuary occurred in 2002 when, following the very wet summer, over 6 km^2 upgraded from poor quality. Most of this upgrading came about in the upper reaches from the Black Devon confluence to Longreach due to a reduction in the discharge of organic waste to the estuary and relatively high river flows. Unfortunately, this was not sustained in 2003 due to the dry hot weather leading to a reduction in dissolved oxygen. The area from Black Devon to Longreach returned to Class C, where it has remained. In this part of the estuary, tidal scouring produces high levels of suspended particulate matter and bacterial degradation of the organic matter removes oxygen from the water column. The long-term aim is to achieve Class B in the upper estuary.

There is evidence that the dissolved oxygen status of the upper estuary is improving as a result of the decrease in discharges of organic waste. Nitrification at Stirling STW is expected to contribute to this trend.

Both the lower and mid Forth Estuary were still Class B in 2006. Sediments and fauna in the lower estuary contain elevated concentrations of trace metals and trace organic contaminants as a result of current and historic discharges to the area. A review of trace metals in mussels collected in the Forth Estuary revealed that mercury in mussels at Grangemouth was twice the national background concentration. Dissolved oxygen concentrations were depressed upstream of Kincardine Bridge as a result of the discharge of organic waste and mixing with oxygen-depleted waters from the turbidity maximum zone. South Queensferry STW, which discharges to the Forth Estuary, was upgraded from primary treatment to secondary treatment at the end of 2006. This will contribute to further water quality improvements in the future.

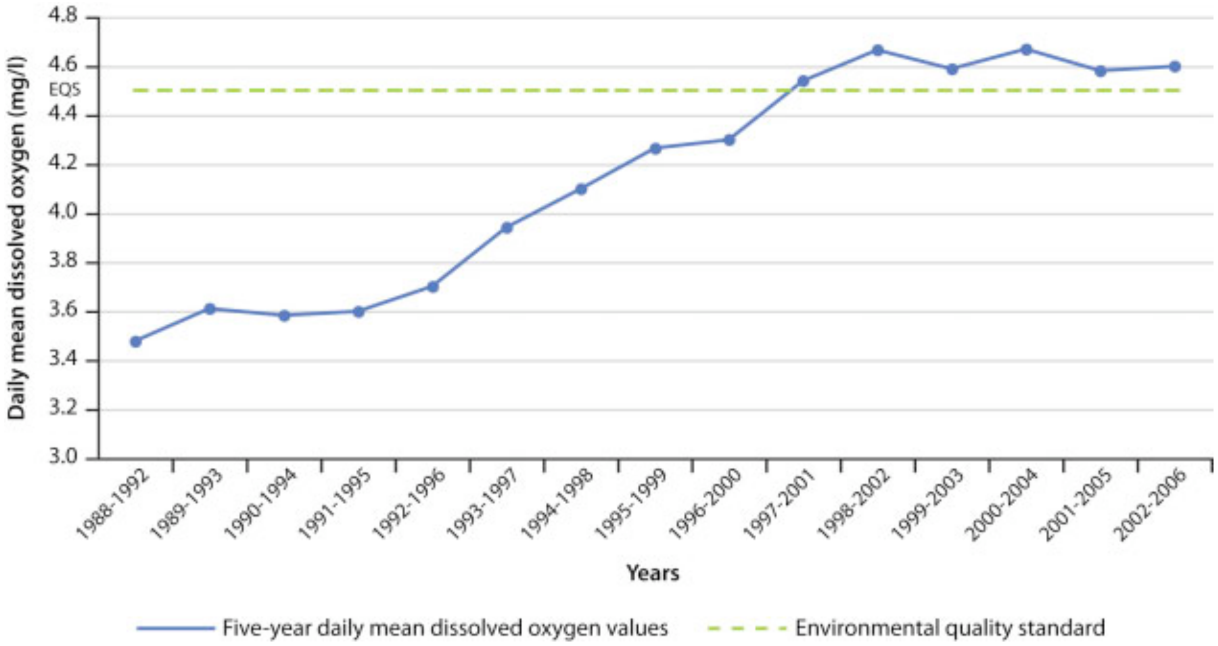
The quality of estuary around Grangemouth has remained Class C between 2000 and 2006 due to organic enrichment (although areas and boundaries have changed). The biological status has stabilised following improvements to effluents discharging in the area. Further improvements in biological status are required for this area to become Class B. There has been no evidence to support an earlier predicted upgrade from Class C to Class B made following the improved fauna observed after the Grangemouth refinery commissioned its biological effluent treatment plant in 1991. Recent evidence gathered as part of the Forth Estuary environmental assessment programme suggests that the biological status has stabilised, as any improvements are very small and masked by natural variability.

There are now no longer any Class D waters in the Forth Estuary, reflecting the success of the sustained programme of improvement in the treatment of discharges. Inverkeithing Bay remained Class C in 2006, having previously upgraded from Class D in 1999 due to a substantial reduction in the discharge of suspended solids and BOD from the treatment of paper mill waste. This resulted in decreased organic enrichment of the sediments and consequent improvement in the fauna. The discharge ceased in 2003 following the closure of the paper mill. Further improvements in benthic fauna are expected, but this is a slow process which depends on the decomposition of the paper fibres in the sediments.

An automatic water quality monitoring station at Alloa has recorded the daily mean oxygen level in the Forth Estuary since 1988. As shown in Figure 13, the five-year rolling daily mean has shown a steady improvement from 3.5 mg/litre (1988 to 1992) to above the EQS of 4.5 mg/litre (1997 to 2001). Since 2001, it has remained steady at around 4.6 mg/litre.

A more detailed analysis of the data indicates that the daily mean dissolved oxygen (DO) concentration can drop below the Environmental Quality Standard (EQS) of 4.5 mg/litre each summer. However, there is no evidence to suggest that these occasional low DO conditions pose a problem for fish.

Figure 13: Dissolved oxygen levels in the Forth Estuary at Alloa, 1988-2006, as five-year daily mean values (as 95th percentile)



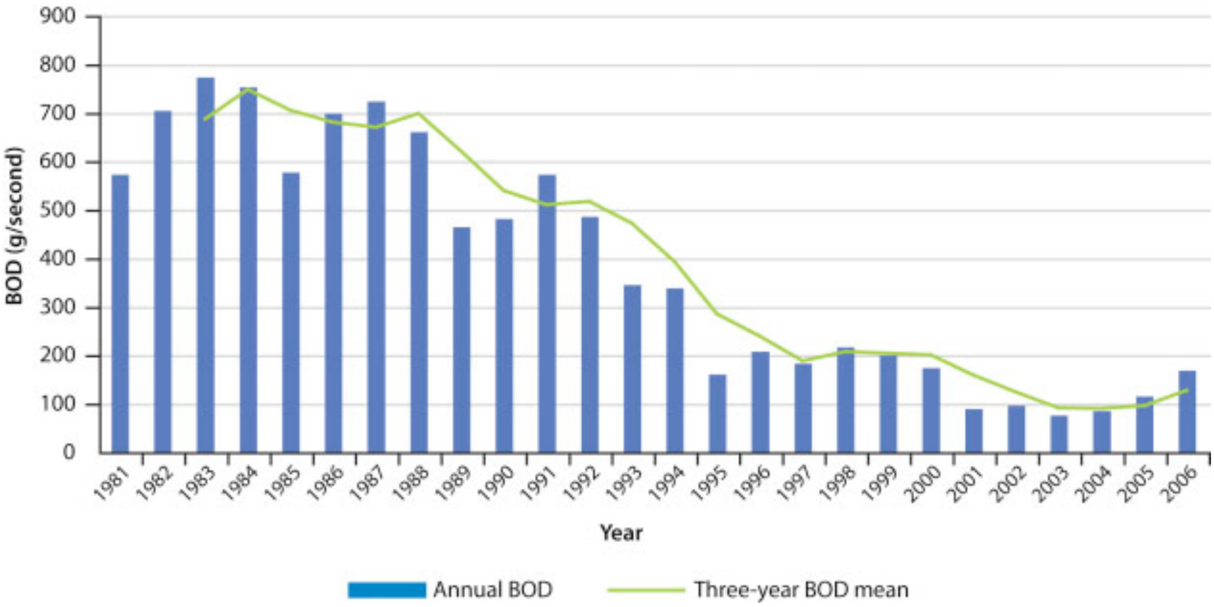
In addition, Figure 14 shows that discharges of organic waste to the upper estuary have fallen substantially since 1981. This reduction was achieved mostly through improvements to the treatment of both domestic sewage and industrial effluents (see Table 4). The increase in BOD in recent years shown in Figure 14 is thought to be due a large chemical factory now receiving effluent from a third party. The factory is still within the conditions of its discharge consent, but SEPA is investigating both this arrangement and the performance of the treatment plant.

Table 4: Improvements to the major discharges into the Forth Estuary

Site	**Nature of improvement**	**Year**
Stirling STW	Secondary treatment	1987
Grangemouth Refinery	Secondary treatment	1991
Alloa STW	Secondary treatment	1993
Cambus Distillery	Site closed	1993
Quest International	Biological treatment	1995
Dunfermilne STW	Secondary treatment	2000
Avecia (Kemfine)	Biological treatment	2000
South Queensferry	Biological treatment	2006

A new nitrification plant at Stirling STW should be operational in 2007. This will reduce the nutrient loading to the estuary and help to further improve in oxygen levels.

Figure 14: Annual BOD inputs and three-year means for the Forth Estuary, 1981-2006



Tyne Estuary
The River Tyne opens to the Berwickshire coast near Dunbar. There are no major discharges in the area, although high nitrate concentrations in the River Tyne may result in increased algal growth in the intertidal area. The whole estuary is currently at the highest status available.

4 Coastal water quality 2000-2006

4.1 Overall picture

The quality of Scottish coastal waters has been classified each year using a scheme developed by the former river purification boards (see Annex D).

The scheme has four quality classes from Class A (excellent) to Class D (seriously polluted) and four assessment criteria – aesthetic, bacteriological, biological and chemical condition. The scheme is default-based, i.e. the class is based on the poorest outcome of the four criteria.

A summary of the annual classification for coasts from 1999 to 2006 is given in Table 5. The class percentages for 2006 are shown in Figure 15.

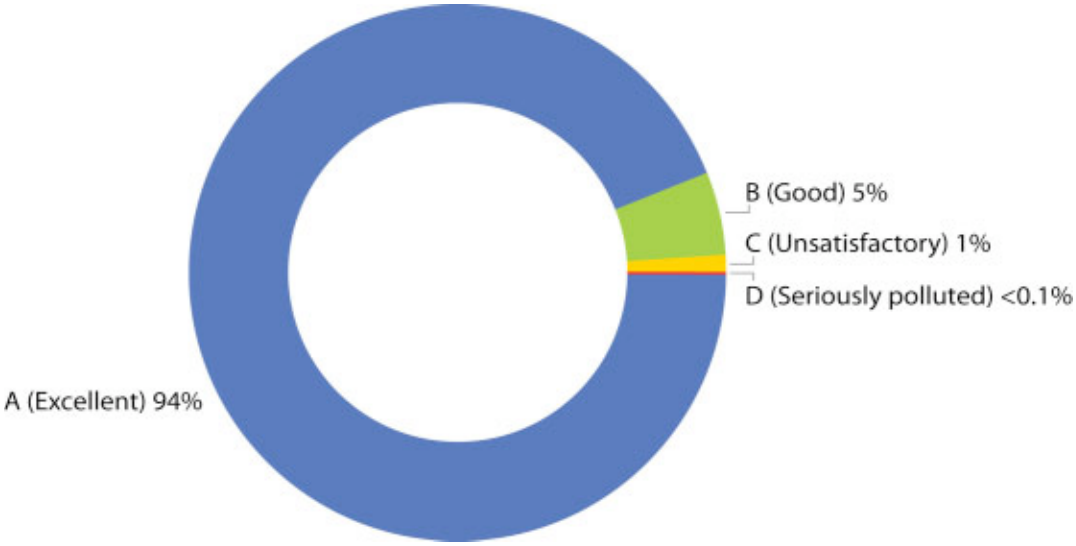
Table 5: Scottish coastal waters classification, 1999-2006

Length	Year	A Excellent	B Good	C Unsatisfactory	D Seriously Polluted	Total
km (%)	1999*	10,906.4 (92.4)	569.4 (4.8)	271.3 (2.3)	50.3 (0.4)	11,797 (100)
km (%)	2000†	10,979.8 (93.1)	556.3 (4.7)	224.7 (1.9)	37.1 (0.3)	11,798 (100)
km (%)	2001	10,995.9 (93.2)	559.7 (4.8)	217.5 (1.8)	24.8 (0.2)	11,798 (100)
km (%)	2002	11,032.4 (93.5)	549.6 (4.7)	191.6 (1.6)	22.9 (0.2)	11,796 (100)
km (%)	2003	11,080.0 (94.0)	566.5 (4.8)	127.7 (1.1)	22.3 (0.2)	11,796 (100)
km (%)	2004	11,091.1 (94.0)	568.3 (4.8)	123.6 (1.0)	11.6 (0.1)	11,794.6 (100)
km (%)	2005	11,102.9 (94.1)	579.0 (4.9)	101.6 (0.9)	11.2 (0.09)	11,794.8 (100)
km (%)	**2006**	**11,114.2 (94.2)**	**591.1 (5.0)**	**80.5 (0.7)**	**10.0 (0.09)**	**11,795.7 (100)**

Actual length of Classes C and D in 1999	**322 km**
Actual length of Classes C and D in 2006	**90.5 km**
Target length of Classes C and D by end 2006	**176 km**
Actual change in length of Classes C and D 1999 to 2006	**–231.5 km (–72%)**
Target change in length of Classes C and D 1999 to 2006	**–145 km (–45%)**

*1999 figures have been corrected relative to some earlier SEPA publications to take account of data for some islands which were unavailable at that time.
† Relative to previous annual reports, length of Class A reduced by 4.8 km and class B by 1.5 km to eliminate double counting of Tyne Estuary.

Figure 15: Coastal water class totals, 2006



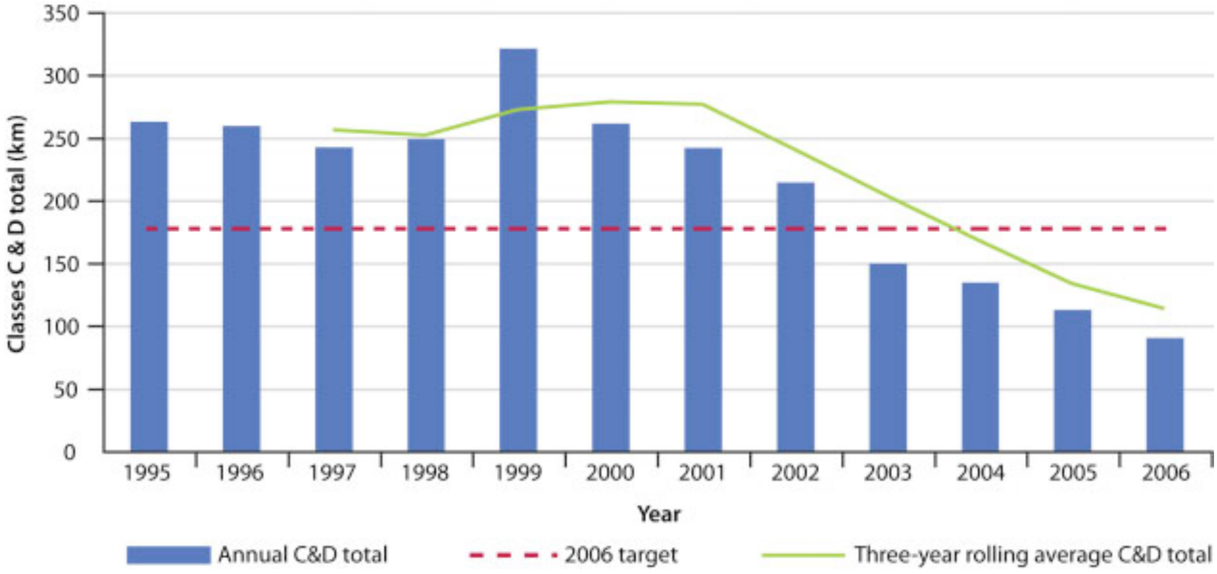
Coastal waters were predominantly of excellent quality throughout the period. In 1999 the lengths making up the total of 322 km that required improvement were mostly next to significant population centres with inadequate sewage disposal arrangements, or were affected by agricultural or urban diffuse pollution.

SEPA's target was to reduce the length of poor or seriously polluted coastal waters (Classes C and D) by 145 km before the end of 2006 compared with the 1999 baseline – equivalent to a 45% reduction. As shown in Table 5, this target has been comfortably exceeded. The length of unsatisfactory coastal water has fallen by more than two-thirds and is now only 90 km. This major achievement is primarily due to the big improvements in the treatment of sewage discharges as a result of Scottish Water's ongoing capital investment programmes and action to reduce diffuse inputs such as agricultural pollution. This continuing work is expected to further improve the quality of coastal waters.

Although having a less obvious affect than in estuaries, weather influences cause coastal water quality to vary from year-to-year. Wetter weather results in higher river flows which can, in turn, increase diffuse pollution. Diffuse run-off may contain pollutants as well as faecal indicator organisms (FIOs). Coastal quality in 2003 was undoubtedly helped by the reduced run-off resulting from the dry weather. Despite the generally wetter weather of 2004-2006, progress in improving water quality has been maintained though it is nonetheless still vulnerable to weather patterns.

Presenting coastal waters quality trends as a three-year rolling average of the total length of Class C and D waters smoothes out the influence of particularly wet or dry years. As shown in Figure 16, the rolling average continued to fall in 2006 as it has done every year since 2000.

Figure 16: Annual totals and three-year rolling average for Class C and D coastal waters



4.2 General issues relating to coastal water quality, 2000-2006

Between 2000 and 2006 there has been major investment in the sewage treatment infrastructure at a number of locations along the coastline and on islands. All the main discharges now have at least full secondary treatment. Tertiary treatment is in place at many sewage treatment works (STWs) – including small ones – where there are bathing or shellfish growing waters in the vicinity.

Another important factor has been SEPA's continuing work with the Scottish Government, Scottish Agricultural College and the National Farmers Union Scotland (NFUS) to help farmers to tackle the multiple sources of diffuse agricultural pollution. Following thousands of farm visits to give advice and resulting actions, all bathing waters in the agricultural south-west of Scotland met European microbiological standards for the first time in 2005. 2006 was even better as all Scotland's designated bathing waters met the required standards for the first time since monitoring began 20 years ago. However, much more work still needs to be done to secure good quality when heavy rainfall makes it more difficult to avoid diffuse pollution. Further information on Scotland's designated bathing waters is given in SEPA's annual reports on Scottish bathing waters (http://www.sepa.org.uk/publications/bathingwaters/index.htm).

Another driver for coastal water quality is the Shellfish Growing Waters Directive. SEPA is the competent authority charged with the task of delivering the water quality standards laid down in the Directive. Shellfish standards are set to support the growth of shellfish and contribute to the high quality of shellfish products directly edible by man. In 1996, 90% of Scotland's shellfish growing waters complied with all chemical Environmental Quality Standards (EQSs). 2003 saw a large increase in the extent of designated areas with shellfish production now concentrated in 108 designated growing waters. Despite this increase, compliance with all chemical EQS is now 100%.

The period between 2000 and 2006 also saw further expansion of fish farming in Scotland, predominantly on the west coast and around islands. The rate and scale of effluent discharges including organic matter and medicine residues from fish farms is regulated by SEPA under the Water Environment (Controlled Activities) (Scotland) Regulations 2005 [5].

SEPA uses a suite of computer models to set appropriate limiting conditions to ensure environmental protection. The licensing system is supported by monitoring.

Certain potential impacts arising from salmon farms such as releases of parasitic sea lice or escapes of stock from the farm cages are not regulated by SEPA and the coastal classification scheme does not take these into account. However, the Aquaculture and Fisheries (Scotland) Act 2007 [6] will include powers to better control these potential impacts, which will be regulated by the Fisheries Research Services Fish Health Inspectorate.

4.3 Coastal water quality around Scotland

Details of the most significant quality changes around Scotland are presented below, starting in the south-west.

Other changes within the period of study were dominated by minor inter-annual changes associated with bacteriological monitoring results, many of which were influenced by weather conditions at time of sampling.

Solway coast and Loch Ryan

The Solway coast has predominantly very good water quality. It improved between 2000 and 2006 due to the completion of new sewage treatment schemes (e.g. at Rockliffe STW which has tertiary treatment) and ongoing work to reduce diffuse pollution from agriculture. An example of the latter is the project at Brighouse Bay funded by the Scottish Government and completed in 2005. This project involved extensive fencing of watercourses and provision of alternative livestock watering points. Early results are encouraging.

SEPA has carried out intensive survey work in Loch Ryan (Galloway) since 2000 in response to a biological impact caused by the toxic anti-fouling compound tributyl tin (TBT). TBT is an endocrine-disrupting chemical (a so-called 'gender bender') and its effects are measured in terms of imposex in the dog whelk, *Nucella lapillus.*[3]

The International Maritime Organisation (IMO) has banned the ban of TBT. Its use on vessels carrying an EU flag was prohibited in 2003 and, from 2008; any ship painted with TBT will be refused entry into EU ports.

The phasing out of the use of TBT on ships is continuing to give positive environmental benefits. There were marked improvements in 2006 to stretches in Loch Ryan downgraded by TBT impacts in past years; due to the reduction in imposex levels seen in dog whelks, 6.2 km of Class B and 1.85 km of Class C were upgraded to Class A in 2006.

Ayrshire coast

Significant changes to sewerage infrastructure together with reduced bacteria levels in recreational or bathing waters along the Ayrshire coast have resulted in major upgrades to Classes A or B. These upgrades are primarily the result of the new STWs at Stevenston (taking sewage from the Garnock Valley), Meadowhead (taking sewage from Ayr and Irvine) and Girvan, together with the work being done with farmers to reduce polluting agricultural run-off. Improved disposal arrangements for an industrial discharge at Girvan also led to a small upgrading in this area.

Sequential improvements in the quality of effluents from the alginate industry and distilleries in 2001-2004 have improved the quality of a long stretch of the Grangestone–Dipple–Turnberry shoreline.

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[3] Imposex is the degree of masculinisation of females, with detrimental impacts on the ability of the animals to reproduce.

In 2002, 12 km of the Ayrshire coastline a little further north upgraded to Class B from Class C. This was due mainly to an improved bacteriological classification following extensive work to reduce pollution of coastal waters from STWs and diffuse agricultural sources. In the same year, 0.1 km of offshore coast was also upgraded to Class B due to cessation of discharge at Greenan, which removed benthic impacts and compounds designed by the European Union as dangerous substances.

In contrast, 3 km of coastline were downgraded to Class B based on results of microbiological monitoring at Troon Harbour Rocks, Turnberry Bay. A further 7.4 km of coastline were downgraded to Class C on the basis of microbiological results from Doonfoot, Fairlie and Stevenston.

Sewerage improvements resulted in the removal of the continuous sewage discharge at Maidens. Sewage from Maidens is now pumped to Girvan STW for treatment. Aesthetics at Prestwick and Saltcoats also showed improvement.

Small areas of downgraded stretches (Class C) long the Ayrshire coastline remain at Culzean, Doonfoot, Dunure, Irvine, Largs, Ardrossan, Stevenston and Turnberry. In 2005, almost 6 km of coastline returned to Class C due to a deterioration in bacteriological quality at Barassie, Seamill and Inverkip.

Isles of Arran, Cumbrae and Bute
Recent years have seen particular emphasis in south-west Scotland on reducing diffuse pollution from agriculture. One notable success was the first time achievement of EU bathing water standards at Ettrick Bay (Isle of Bute) in 2005, resulting in the upgrading of 1.3 km to Class B. Continuing investments by Scottish Water such as the long-awaited commissioning of sewage treatment at Millport on the Isle of Cumbrae also helped. Subsequent improvements in bacteriological quality resulted in an upgrading of almost 20 km of the Ayrshire coastline to Class B in 2005.

On the Isle of Arran, new sewerage systems have been installed and old septic tanks or crude outfalls removed at Blackwaterfoot, Lamlash and Brodick. This has led to some upgrading of the island's shoreline and a marked improvement in aesthetic quality was recorded at several places in 2006.

Secondary treatment has been provided at Rothesay STW (Isle of Bute) since 2001, with a new outfall to the Firth of Clyde at Ascog. The former site at Bogany Point was retained as a pumping station and combined sewer overflow (CSO). However, the frequency of operation of untreated sewage overflows has been unacceptable and engineering work is ongoing to fix this problem.

The major changes along the Ayrshire coast are summarised in Table 6.

Table 6: Length of Class C and D coastline in Ayrshire coast in 2000 and 2006

Location	Unsatisfactory and Seriously Polluted Length (km)			Comments
	2000	2006	Change	
Isle of Arran	2.5	1.8	0.7	New sewerage systems have improved some of Arran's coastline but more investment is needed.
Ardrossan to Irvine	11	9	2.0	Improvement in microbiological quality Reduction in shoreline debris
Irvine to Ayr	10.1	1	9.1	New sewerage systems Reduced agricultural run-off
Ayr to Girvan	9.1	5.2	3.9	New sewerage systems Reduced agricultural run-off
Girvan to Ballantrae	2.1	0	2.1	Improved industrial discharges
Total Improved			**17.8**	

Firth of Clyde
Moving north around the west coast, some Class D areas persist offshore at Holy Loch (2 km) and Garroch Head off the Isle of Bute (also 2 km), both due to historical impacts on sediments from spoil dumping grounds. The Holy Loch disposal site is still used for dredge spoil disposal. Most of the material originates from dredging in the Clyde Estuary with its legacy of organic enrichment and industrial contamination. The Garroch Head disposal site received millions of tonnes of sewage sludge over many decades until 1998 and was severely impacted. There is now some recovery from historical benthic impacts at the sludge dumping ground while Class D and C downgrades have lessened at Garroch Head.

The large Inverclyde STW, which was commissioned in 2002, discharges to the Firth of Clyde south of Cloch Point. The STW provides secondary treatment for all the sewage pumped from the Greenock/Gourock conurbation (formerly discharged at Battery Park/Ironotter Point). A benthic survey around the new Inverclyde discharge in 2005 found no biological impact.

Argyll and Mull, Islay and Jura
Significant changes to sewerage infrastructure together with lower bacteria levels were realised in 2003 along the Argyll and Kintyre coastline. This resulted in important coastline upgrades, especially around the settlements of Carradale (1.5 km) and Inveraray (1 km) both now Class B.

The sewage discharges from the settlement of Campbeltown on the Kintyre Peninsula go into Campbeltown Loch. Until 2002, sewage and creamery waste were discharged at Macringan's Point. Since then, a new STW with secondary treatment via membrane filtration has come online at Slaty Farlan. However, persistent overflowing of combined sewer overflows (CSOs) has resulted in aesthetic issues and many complaints from the public. Scottish Water is working to reduce the number of spills and to provide a storm sewage facility at the STW. This new CSO will discharge away from the inner loch and marina area. A recent SEPA biological survey concluded that an overall improvement is generally evident in the loch and that no biological downgrades were applicable in the vicinity of the new sewage discharge or the old creamery discharge. However, a small stretch of Campbeltown Loch remains classified as D (seriously polluted) due to aesthetics.

In Loch Gilp, leachate originating from the Lingerton landfill site has caused local problems. Conditions have improved since significant enhancements to the leachate collection and treatment system were put in place in 2003 and now only a few isolated pockets of sediment enrichment persist.

Scottish Water's proposals for a new collecting system and sewage treatment works for the Dunoon agglomeration have been delayed by difficulties in securing planning permission for the proposed new STW site. Local water quality has been unsatisfactory here for many years and SEPA has served an enforcement notice requiring the provision of appropriate treatment by 2010.

Persistent substances in Loch Goil and Loch Long resulted in 0.3 km being classed B (good). These waterbodies can be affected by the sometimes poorer waters of the Clyde Estuary.

A review of offshore benthic impacts from a fish processing unit at Loch Creran, north of Oban, demonstrated that this discharge is now adequately treated. However, there are still parts of this sea loch that remain in an unsatisfactory state due to biological impact which persists as a result of historical pollution from an alginates plant that ceased production in 1997.

In Loch Etive, a small downgrade was recorded in 2005 due to the combined pressures of Inverawe Fish Farm, Achnacloich, Taynuilt and Loch Spelve where mussels were found to contain low levels of the pesticide gHCH (hexachlorocyclohexane – also known as lindane).

A significant benthic impact was recorded at Bagh Dail nan Ceann Fish Farm (near Ardfern) in 2004 following a breach of the biomass limit in the site's discharge consent. Successful enforcement action was taken against the site operators and the site is now compliant with full recovery of the seabed expected.

On the Hebridean islands of Islay and Jura, most improvements have been achieved as a result of many years' work with the distilleries. Over 4 km of coastline upgraded to Class A on Islay at Bruaichladdich, Bunnahabhain, Bowmore, Lagavullin and Caol Ila. A further 1 km upgraded from Class D in 2000 to Class A in 2006 at Craighouse Distillery on Jura. However, the discharge from the Laphroaig Distillery still gives cause for concern due to potential toxicity issues. Copper levels are monitored in the distillery discharges but have remained below the EQS.

At Tobermory on the Isle of Mull, a small area of coastline remains downgraded at Class D. Completion of a new sewage treatment works serving the town is expected by 2007; a new STW was built at Salen in 2005.

Lochaber and Skye
Following the closure of the former British Alcan aluminium smelter at Kinlochleven in summer 2000 and associated remedial works, a marked reduction in the quantity of polyaromatic hydrocarbons (PAHs) in Loch Leven was recorded. In 2003, 24 km of the shoreline in the Kinlochleven area improved in quality from Class C to Class A. Results show a continued gradual recovery to more natural levels since then.

In 2002 at Loch Portree on Skye, a 2 km length of coastline upgraded from unsatisfactory quality following the connection of an unsatisfactory sewage discharge to the main sewer system. Also, in 2005, the upgrade of the sewage discharge from Edinbane resulted in 0.5 km of Loch Greshornish (part of Loch Snizort) improving from unsatisfactory to excellent status.

Unfortunately, a small stretch adjacent to Isle of Ornsay, Skye, deteriorated in quality in 2006 following substantiated complaints of sewage solids. Similar complaints were also made around the Dornie area, Loch Long (east of the Kyle of Lochalish). For years, many of these remote communities have never had their sewage treated prior to discharge. The provision of sewerage systems for these areas (known as first time sewerage) is necessary to solve these problems.

Western Isles and the North-West
The installation of new septic tanks and CSOs in 2006 enabled water quality improvements at Dell (0.5 km stretch of the coastline), Shader (0.5 km) and Vatisker, (0.3 km) on the Isle of Lewis. A new septic tank was installed at Eurodale, resulting in an important upgrading of 0.5 km from unsatisfactory to excellent. A septic tank was also installed at Bragar (0.5 km), Isle of Lewis, but the discharge is still to the beach above mean high water mark, so the improvement in water quality has been limited, rising from Class C to Class B in 2006. Changes to the nature of the sewage discharge at Shawbost on the Isle of Lewis meant that 0.5 km of coastline ceased to be unsatisfactory quality in 2005, improving to excellent and remaining so into 2006.

Also in the Western Isles, the coastal stretches at Bayhead (0.3 km) and Ashdail Cottages, North Uist (0.1 km), Leverburgh, Isle of Harris (0.1 km) and Coll (0.1 km), and Crossbost (0.1 km), Isle of Lewis, all saw significant water quality improvements. This follows recent SEPA action which helped improve septic tank management and reduce the amount of sewage debris being produced.

Conversely, a small stretch of water in West Loch Tarbert, Isle of Harris, was downgraded to Class B due to gross accumulations of litter.

The commissioning of a new sewage collection system, pumping station and sewage treatment works led to a welcome upgrade from Class C to Class A for 1.6 km of Ullapool's coastline.

Recent monitoring indicated a welcome reduction in environmental concentrations of TBT in Lochinver Bay (see entry for Loch Ryan for more information about TBT).

The small Kinlochbervie Harbour in the far north-west was upgraded in 2006 from Class D after SEPA inspections confirmed that efforts to reduce the frequency of oil spills had been successful. Liaison with harbour staff and less use of the harbour has also led to a reduction in the amount of litter entering the water. These reductions combined to bring the harbour up to good water quality.

North coast
The coastline around Durness Sango Sands also saw significant improvements in 2006 following the installation of a new STW to replace the old septic tank that discharged above the mean low water mark.

A length of 1.5 km of coastal waters at the east end of Dunnet Bay reduced in quality during 2001-2003. In 2001, there were elevated levels of faecal indicator organisms (FIOs) coupled with gross accumulations of litter, fishing gear and driftwood. Continued poor water quality was due to a combination of pressures including effluent from Castletown STW, septic tanks and a small caravan park. Improvements have been made in recent years to reduce the potential impact of all three sources. From 2004 onwards, water quality began to improve as the result of beach clean-ups and lower bacteria levels. The new STW serving Castletown was commissioned at the end of 2006 and provides disinfection during the bathing water season. There have also been improvements to the septic tanks serving Dunnet and the caravan park.

Water quality at Thurso Bay downgraded to Class C in 2001 and, as in Dunnet Bay, was due to lower microbiological standards. However, work with the agricultural community and landowners improved the situation sufficiently to allow SEPA to classify the waters as 'fair' from 2002 to 2005. In 2006 the new STW serving Thurso, which discharges secondary-treated effluent further around the headland to the east of the town, became operational. At the same time a problematic storm overflow in the harbour was upgraded to include screening and a reduced spill frequency. These improvements resulted in better water quality in Thurso Bay with the latest monitoring showing waters of excellent quality.

A 7 km stretch of coastline around Sandside Bay near Thurso has remained as class D throughout the period. This stretch of coastline is where the Dounreay Nuclear Power Development Establishment is situated. Although there is no effect on coastal water quality, the restriction of fishing activities and restriction of public amenity are regarded as sufficient to justify the downgrading.

Waters in Wick Harbour improved during this period from Class C to Class B following a decrease in the frequency of oil spills and less rubbish in the harbour.

Orkney Islands
In 2000, the Orkney Islands had 4.5 km of Class C and 4.9 km of Class B coastline. By 2006, this had improved to 2.0 km Class C and 6.7 km Class B.

Kirkwall Bay had 1.5 km of Class C due to sewage inputs, oil spills and discharges from vessels using the harbour. This improved to Class B in 2001, largely due to the new Kirkwall STW being completed – the main discharge now diverted to an area of water known as The String at Head of Work (several kms to the north). A further 0.5 km of Kirkwall Bay improved further to Class B in 2004, due to reduced frequency of oil spills / vessel discharges.

Weydale Bay (just to the north of Kirkwall) had 1.0 km Class C in 2000 due to an unsatisfactory discharge from Weydale sewage pumping station. This improved to Class B in 2001 as the frequency of spills was reduced. By 2003, a further improvement to Class A was achieved.

The remaining 2.0 km of Class C in 2000 was in Stromness Harbour, due to unsatisfactory CSO discharges, oil spills, and discharges from vessels. The situation has remained much the same through to 2006.

Shetland
By 2003, the coastal waters around Sandness in Shetland saw improvement following upgrades by Scottish Water to the local sewerage system.

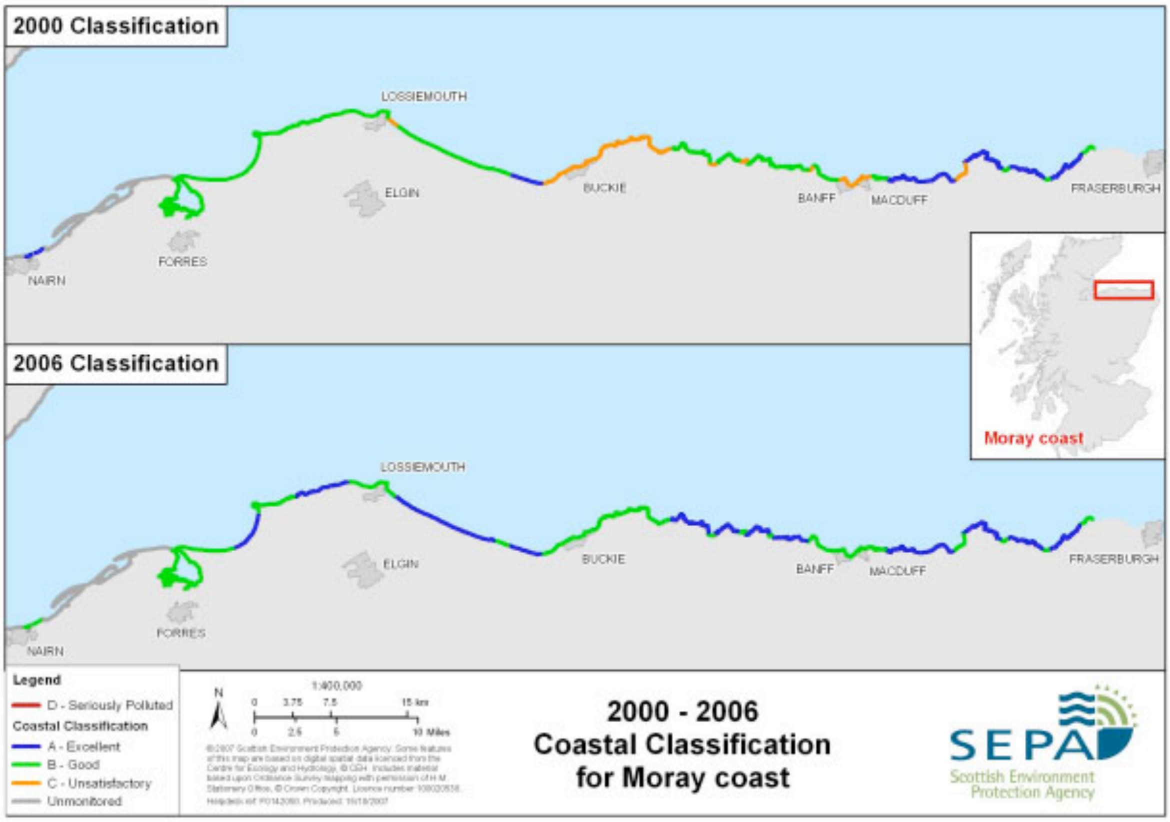
The improvement of 4 km of previously unsatisfactory quality around the Sullom Voe Oil Terminal is attributed to the phasing out of TBT as an anti-foulant on the hulls of larger vessels.

East Coast
In 2001, the quality of the waters of the Moray Firth near Golspie improved following the provision of a new STW and diversion of sewage outfalls. Similarly, another new STW led to a significant stretch of coast at Plockton (Loch Carron) improving from unsatisfactory to excellent status.

The failure of Nairn East beach to pass mandatory European standards for bathing waters caused 1 km of the Moray Firth coastline to be downgraded in 2005. There have now been considerable improvements to Nairn STW and to works located further inland that discharge to the River Nairn. Bathing water quality in this area is usually very good, so this failure was a disappointment. The bathing water passed again in 2006.

All the significant coastal towns and cities between Inverness and Aberdeen along the Moray coastline are now being served by effective STWs commissioned in the last five years. Further sewerage infrastructure improvements are planned. Map 7 shows the effects of these investments in improving the quality of a large part of the Moray coastline. Note in particular the reduction in the areas of Class C (orange).

Map 7: Moray coastline classes, 2000 and 2006



The provision of oil interceptors at RAF Lossiemouth and an upgrade of the Coulardbank surface water sewer has contributed to an improvement of the neighbouring coastline.

At Lossiemouth East Beach the waters failed mandatory microbiological bathing waters standards in 2005. The following year however, water quality improved considerably and the beach passed the more stringent guideline microbiological standards. The STW serving Lossiemouth now provides secondary treatment prior to discharge and should safeguard the future of local water quality.

The quality of the coastline at Buckie showed a significant improvement in 2004 (Class D to Class B). This followed the diversion of discharges from fish and shellfish processors to the sewage network and confirmed improvements arising from the completion of the new STW at March Road, Buckie. These improvements extended along the coastline on either side of Buckie and covered almost 3 km of coastline.

A new septic tank was installed at Sandend, resulting in improvement (Class C to Class B) to the adjacent Sandend Bay near Cullen (0.6 km).

More than 4 km of the coastline in Banff, Macduff and Whitehills improved following completion of the new STW at Berrymuir Quarry, which replaced various outfalls. The relocation and screening of the sewage at Portsoy near Banff also upgraded that stretch of the coastline to Class B, having previously been Class C.

A length of coastline at Fraserburgh deteriorated to the lowest water quality status (Class D) following five failures to comply with the Bathing Waters Directive at Tiger Hill Beach during the 2001 bathing season. Investigations suggested that the reason was contamination of the Kessock Burn, which crosses the beach close to the bathing water monitoring site. A wrong sewer connection was found and remediated, and the watercourse and surrounding bathing water recovered to Class B, good, in 2002. This improvement has subsequently been maintained.

The completion of the new STW at Phingask, just to the west of Fraserburgh, improved the quality of coastal waters at Sandhaven from an unsatisfactory to good status. At Fraserburgh itself, gross sewage contamination from several outfalls has declined considerably since 2004 as a result of improvements to the sewer network serving the new Phingask STW.

Aberdeenshire
2004 saw significant improvements to the harbour area in Peterhead. These improvements were due to a number of factors including a new STW at Burnhaven and associated improvements to the sewage network. There have been no complaints or observations of oil pollution within the general harbour area and, more specifically, a welcome dearth of reports or complaints of oil pollution from the south bay oil marine base.

At Peterhead Lido, a small length was of Class C quality following failure of the identified bathing water to meet required mandatory microbiological standards in 2002. Investigation revealed that accidental spillages during engineering works were the most probable cause of this failure. These works, completed in early 2003, were designed to reduce overflow spill frequency. Following these improvement works, the beach at Peterhead has met EU bathing water standards every year since.

The waters at Cruden Bay Harbour had previously been classified by SEPA as unsatisfactory quality. Improvements followed the removal of an untreated sewage short outfall and the diversion of sewage for treatment at Burnhaven STW in Peterhead in 2004.

On the north-east coast between Sandend and Aberdeen, a number of other stretches improved between 2000 and 2006:

- Improvements came at Gamrie Bay (1.6 km) from the new membrane filtration plant installed at Gardenstown STW.
- SEPA monitoring showed that no further pollution was being caused at Phingask (0.1 km) after the repair of an unauthorised surface water outfall.
- At Inverallochy (0.1 km), sewage is now pumped to Phingask STW.
- Sewage is now being appropriately treated at Maut Craig (by Crimond) and Scotstown Head, leading to water quality improvements.
- At Sandford Bay and Boddam (3.8 km), an underwater video in 2006 showed no evidence of gross pollution from two major discharges from Burnhaven STW and Thistle Seafoods Ltd, Boddam.
- The water quality around the Mouth of Don (1.8 km) benefited from the reduction in sewage solids and bacteriological loading from the River Don.

In Aberdeen, the Mouth of Don coastal stretch improved in 2006 from Class C to Class B as a result of a reduction in sewage solids and bacteriological loading from the River Don.

The shoreline from the Dee estuary to Girdleness (Aberdeen) has also improved as a result of sewerage-related improvements. The sewage outfalls at Abercrombie have been rerouted to the Aberdeen sewage overflow and the Girdleness CSO is now being screened.

In 2003 SEPA carried out a number of farm inspections in the catchments of the Cowie Water and the Carron Water which identified potential sources of bacterial contamination that might have been affecting Stonehaven bathing beach. There was a failure to meet bathing waters standards at Stonehaven in 2005. Improvements to the local public sewerage infrastructure had been planned to be completed by 2004, with sewage effluent from Stonehaven being pumped to the main Aberdeen treatment plant and long sea outfall at Nigg Bay. However, there had been delays in securing planning permission for the required pumping station. The matter was eventually resolved in January 2006 following a public planning enquiry, but the pumping station is unlikely to be ready until the start of the 2008 bathing season. To provide some protection of the bathing waters prior to the completion of the connection to Nigg, Scottish Water will continue to disinfect the sewage effluent discharged via the Stonehaven outfall on incoming tides during the bathing water season. The disinfection, using hypochlorite solution, is not carried out on the ebb (receding) tide as this could deter salmon from running up the adjacent rivers. Stonehaven recorded good quality in 2006.

There has been considerable improvement in the sewage treatment infrastructure in recent years especially around the Highlands, Islands and Grampian coastline following completion of Public Private Partnership schemes (PPPs). These will continue to deliver environmental quality improvements in these areas for a number of years to come.

Angus

The coast around St Cyrus has been impacted by unsatisfactory discharges. However, quality is expected to have improved in 2007 as the South Kincardine Drainage Scheme was commissioned in October 2006 and sewage from St Cyrus is now pumped to Benholm for treatment.

The stretch of coast from Scurdie Ness at the mouth of the South Esk, to Sillo Craig has also improved due to the new secondary treatment plant and screened CSOs at Montrose.

Completion of the new Hatton STW in 2001 resulted in the clean-up of a long stretch of the Angus coastline from Arbroath to Dundee. However, continued vigilance has been necessary to ensure that CSOs do not operate prematurely and that sewage is pumped to the treatment works as intended. In 2002 there were temporary problems which caused downgrading at Arbroath. Ongoing drainage investigations and local remedial works have been necessary at Carnoustie to maintain excellent bathing water quality.

Fife

A new STW serving St Andrews began operating at Kinkell Ness in 2001 and large storm tanks in the town now give better protection to the local bathing waters during heavy rainfall. The STW provides UV disinfection and effluent is discharged via a long sea outfall. The result of these improvements is an upgrade in the quality of the coastline near East Sands to excellent status.

The bathing water at Kingsbarns (East Fife) failed to meet mandatory microbiological bathing waters standards in 2001. As an interim measure pending better treatment, chemical disinfection ensured that the bathing water met required standards until a planned new treatment works was completed. This new STW was commissioned in the spring of 2006, and disinfects the treated effluent with ultraviolet (UV) radiation before discharge. This tertiary treatment will ensure continued excellent coastal water quality.

The bathing water at Crail (Roome Bay) has improved due to the combination of the Crail and Kirk Wynd sewage treatment and outfall improvements; a further section of coastal water at Hermits Well also improved.

In 2001, the introduction of a long sea outfall discharging secondary-treated sewage and trade effluent from Levenmouth STW improved the coastal waters encompassing Largo East, Lower Largo and Leven East in Fife. These areas had been in the lowest coastal class status (seriously polluted). Further improvement since 2003 also saw a particularly polluted stretch at Buckhaven upgrade. This was due to the extensive improvements associated with the Levenmouth STW and associated sewerage infrastructure, which is gradually eliminating inadequately treated discharges from this area of Fife. A new outfall was constructed to dispose of a distillery effluent. Environmental monitoring of the waters and an underwater video survey of the seabed in the vicinity of the discharge from the outfall showed no adverse impacts, confirming the improved status of this coastline.

For a number of years the coastal stretches surrounding Kirkcaldy (Linktown) failed to meet acceptable bacteriological quality standards, despite a new treatment works. The source of the long-standing problem was eventually tracked to a blocked sewer causing overflow of sewage. The tank sewer along Kirkcaldy esplanade was cleaned out at considerable cost in 2005, resulting in improved water quality at the nearby beach.

A short stretch of Class C water at Kinghorn Harbour improved to Class B in 2004. This followed the transfer of treated sewage to the long sea outfall at Pettycur.

The coastal stretch from Dalgety Bay to Braefoot Bay saw improvement in 2003. This is an industrial section of coastline, with jetties used by petrochemical companies with and associated authorised discharges. The former Dalgety Bay STW has been converted to a pumping station to transfer all sewage to Dunfermline STW. The general water quality in the area is good as indicated by the presence of shoals of small fish, seals and seabirds.

Edinburgh

The coast at Cramond failed to meet mandatory European bacteriological standards in 2002. Sewage debris was also present here on nine out of 20 visits during the bathing season. Again, exceptionally wet weather almost certainly contributed to this failure. Water quality improved in 2003 following the installation of a new pumping station. Inspection of this new station indicates it is functioning satisfactorily, and coastal water quality at this site has continued to improve with time.

A very small area of coastal water at Granton Point, near Cramond, is deemed Class D (seriously polluted) due to a former industrial works. Bioremediation of the contaminated land is expected to result in improvements to this stretch of coastline.

In 2001, following implementation of secondary treatment at Edinburgh's STW, with disinfection during the bathing season, the quality of a long length of coastline improved. The bathing beach at Portobello West (Kings Road) has subsequently been further helped by progressive improvement of sewage treatment and sewerage infrastructure. The remaining threats to water quality are from local sewage pumping stations, contaminated urban run-off and the Figgate Burn. A joint SEPA/Scottish Water work group continues to investigate possible sewage inputs to the Figgate Burn with a view to reducing them. A programme of CSO upgrading was carried out to reduce spill frequency. Several other sources of faecal contamination to the Burn have been identified and removed. A full review of all unsatisfactory intermittent discharges in the catchment is being carried out and a new tidal waters model is being developed to target where improvements are still required.

The Edinburgh treatment works and coastal sewage interceptor also resulted in the upgrading of about 10 km of previously Class C coastline around Cockenzie. Since 2000, all sewage effluents from the Tranent, Cockenzie and Port Seton area have been pumped to Edinburgh for treatment. In 2002, the interceptor sewer was further extended to convey sewage from Longniddry to Edinburgh STW. The former STW at Longniddry is now a storm treatment works with a design overflow spill frequency of only once in every five years. As a result, Longniddry beach now achieves mandatory bathing water standards with only trace amounts of sewage debris being observed.

A significant length of coastline (3.1 km) at Seaton Sands improved in 2005 from Class B to Class A. A SEPA investigation into the sources of pollution affecting Seaton Sands found elevated concentrations of faecal coliforms in the nearby Canty Burn. This is now sampled in conjunction with coastal monitoring to provide additional information should any future problems arise. Work to eliminate overflows from dual manholes in the Canty Burn catchment is also continuing.

Slightly further along the coast, there have also been continued improvements at Gullane Point to Longniddry, where shoreline water quality improved in 2002. Sewage from the whole of Gullane, north east of Edinburgh, is now taken to the local STW eliminating the unsatisfactory, untreated Gullane North discharge.

East Lothian
In East Lothian, the bathing waters at North Berwick (West Bay and Milsey Bay), can now be described as excellent in quality. North Berwick Bay failed to meet bathing water compliance in 2004 after attaining guideline microbiological standards in the previous three years. This reduction in water quality was traced to leakage from a water main, which is thought to have flushed contaminated soils into North Berwick Bay. The remedial action taken by Scottish Water should prevent this problem from recurring.

Unfortunately, the construction of the new West Barns STW at Dunbar (Belhaven) has been delayed due to land acquisition problems and is unlikely to be completed before spring 2008. Utilising new membrane technology, the new works will achieve the high quality of effluent required for compliance with bathing water standards. This will negate the need for additional disinfection and further safeguard coastal water quality.

A temporary slight fall in bacteriological quality at Whitesands Bay in East Lothian in 2004 was ascribed to unusually wet weather that year increasing surface water contamination. The beach has since returned to and maintained excellent quality.

Borders
Full biological treatment was implemented at Eyemouth STW in 2004, with this new works also serving St Abbs and Coldingham. Quality at St Abbs and Coldingham is now consistently excellent. However, the local bathing water at Eyemouth is still at risk from agricultural impacts in the River Eye catchment and local sewage pollution of the nearby North Burn.

Coastal water quality at Eyemouth fell from Class B to Class C in 2005. Some local septic tank discharges have since been removed from the North Burn, and as part of a SEPA Environmental Improvement Action Plan carried out in 2005 and 2006, awareness of the issue was raised within the agricultural community. The sewage discharge from Ayton STW was removed from the River Eye at the turn of 2005/2006 and is now pumped to the works at Eyemouth. This will reduce faecal contamination entering the River Eye and hence the bathing water at Eyemouth, but the threat from agricultural sources during wet weather remains.

Also at Eyemouth, a small stretch at Gunsgreen improved from unsatisfactory to good quality following an assessment which showed that the marine ecosystem had almost recovered from damage caused in 2002 by accidental over-chlorination of sewage effluent. Chlorination was permitted at that time to protect the bathing water pending completion of the sewage treatment and outfall schemes. It is hoped that complete biological recovery will occur soon.

5 Loch water quality 2000-2006

5.1 Overall picture

SEPA aims to protect and improve the valuable good water quality of freshwater lochs which are one of Scotland's main natural assets. They are of major conservation, amenity and tourist value and many are used for recreation, potable water supply, hydropower generation and aquaculture.

In 1995, SEPA introduced a 'standing waters' (loch) classification scheme for the first time. This classification scheme is a 'changed state' or temporal scheme, employing hindcast estimates of chemical water quality that are compared with measured current water quality. The hindcast is an estimate of what the water quality of each loch would have been in the mid-19th century before any significant impacts arising from human activity.

The classification is primarily chemical, being based on modelled changes in total phosphorus (TP) representing eutrophication and acid neutralising capacity (ANC) representing acidification, plus the presence of toxic substances.

Lochs are placed into one of four quality classes based on criteria such as total phosphorus content and acid neutralising capacity. Class 1 lochs are those whose water quality and aquatic ecology is not significantly altered by human activity. Class 4 lochs are assessed as being severely polluted and incapable of supporting fisheries due to eutrophication, acidification, and the presence of toxins or deoxygenation.

Descriptions of the four classes are given in Table 7 and full details of the classification scheme are presented in Annex E.

Table 7: Loch water quality classes

Class	Description
1	Excellent/good – lochs not significantly altered by human activity
2	Fair – lochs significantly altered by human activity
3	Poor – lochs seriously downgraded by human activity
4	Seriously polluted – lochs incapable of supporting fisheries

All standing waters ≥1 km^2 are included in the scheme together with some smaller waterbodies deemed to be of particular significance.

Lochs currently recovering from past pollution or potentially subject to adverse trends are monitored every year. However, the much longer residence time of water in lochs compared with rivers means that their water quality is usually subject to much more gradual change. It is therefore unnecessary for them to be classified annually and hence they have often been classified on a five-year cycle.

Loch water quality for 1995 and 2000 is summarised in Table 8.

Table 8: Loch classification for 1995 and 2000*

Area	Year	Class 1 Excellent/ Good	Class 2 Fair	Class 3 Poor	Class 4 Seriously Polluted	Total
km^2 (%)	1995	143 (82%)	27 (16%)	2 (1%)	1 (<1%)	173
km^2 (%)	2000†	149 (75%)	44 (22%)	4 (2%)	1 (<1%)	198
km^2 (%)	2005	*	*	*	*	199

* Results for 2005 will be available shortly.
† The statistical confidence in several of the 2000 loch quality classifications was not adequate. In these cases, the 1995 classifications were rolled forward to 2000.

As shown in Table 8, the number of lochs in the classification network has increased since its inception in 1995. In 2000, Loch Lomond and Loch Awe were each ‘split’ into two basins for classification purposes, although the total area classified was unchanged. This enabled the scale and distinctive character of these lochs to be more accurately represented in the classification scheme. Each basin was assigned its own classification.

Map 8 shows those lochs classified as fair, poor or seriously polluted in 2000.

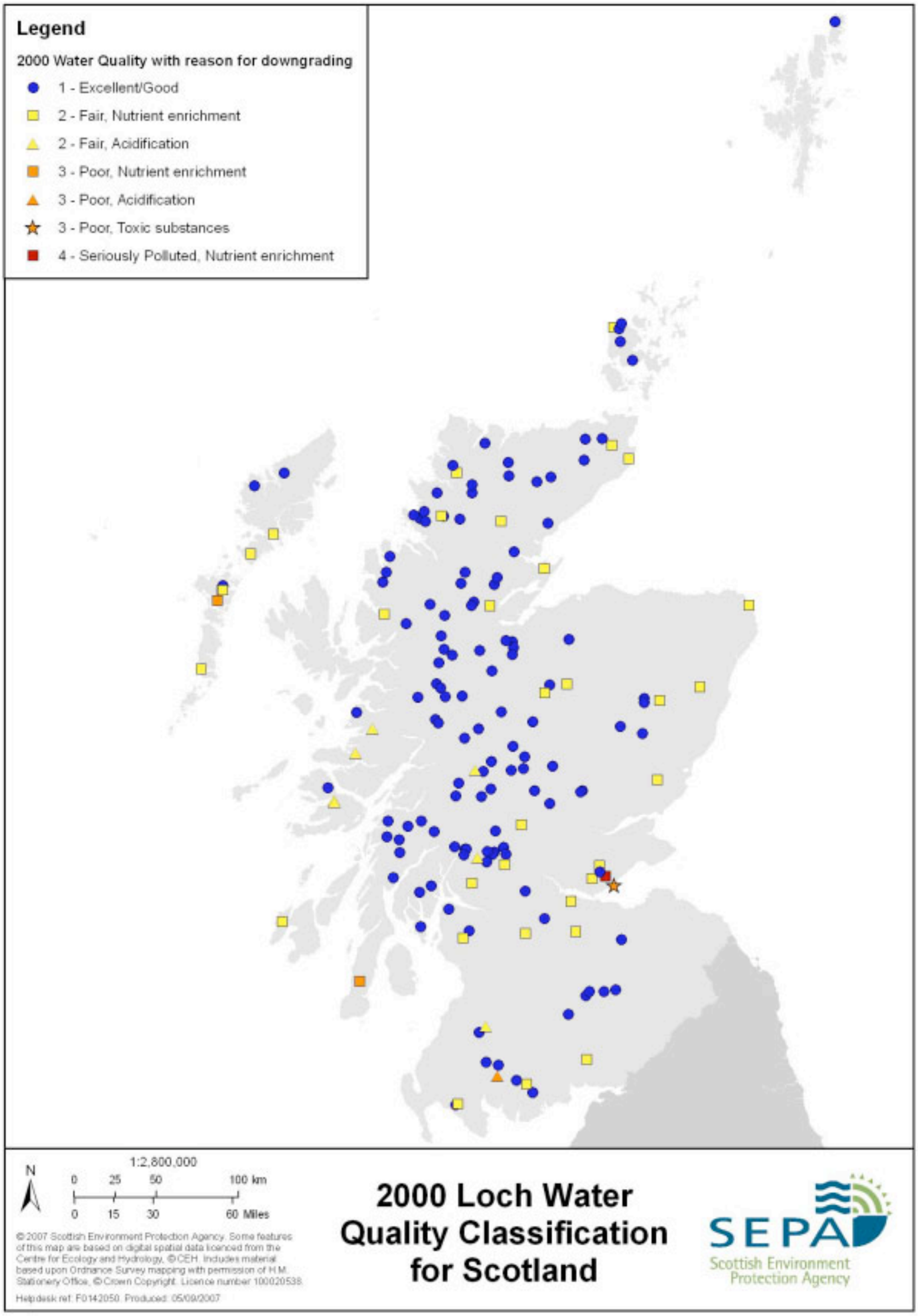
For the period 2000 to 2006, SEPA set targets to:
- prevent any deterioration in loch water quality;
- further improve Loch Gelly from Class 4 (seriously polluted) to Class 3 (poor);
- maintain the quality of any additional lochs classified for first time in 2000.

It is not possible to fully assess progress against these targets until the complete results for 2005 become available. However, the water quality of Loch Gelly is known to have improved to Class 3 in 2005.

In recent years several issues have affected the quality and consistency of data used for classifying lochs. On a more positive note, the datasets on which the 2005 classification is based are more comprehensive than those used in 1995 and 2000. Some of these datasets are available and have been used in the selected case studies (see Section 5.3).

When available in early 2008, the latest classification results from Scotland’s monitored lochs can be found in Annex F.

Map 8: Lochs classified as fair, poor or seriously polluted in 2000



5.2 General issues relating to loch water quality

SEPA considers all Class 2, 3 and 4 lochs to be downgraded. The cause of the downgrading of the majority of these lochs – especially in the south and east – is elevated phosphorus concentrations arising from diffuse agricultural sources, sewage discharges or urban diffuse pollution. In 1995, it was reported that the five of largest lochs in Scotland (Lomond, Ness, Awe, Shiel and Morar) had all undergone significant phosphorus enrichment since the mid-19th century.

In the north and west of Scotland where natural and semi-natural land cover are more prevalent, identified impacts are related to commercial forestry and point sources (e.g. fish farms). Interactions between deposition rates, land use and soils are all known to be important in terms of loss of acid neutralising capacity.

Nutrient loss to lochs from forest land is regarded as a significant pressure. Upland lochs that are considered to have high ecological status are very vulnerable to increased nutrient inputs associated with inappropriate afforestation (tree planting) or felling practices. Until recently, SEPA only had partial control over diffuse pollution from forestry (through consultations on Woodland Grant Scheme applications). Forestry best practice is now promoted by the Forestry Commission and through the national *Forest and Water Guidelines* [7]. Implementation of these measures is recognised as being effective at controlling the majority of water issues, although some problems may remain within highly sensitive catchments. Planting all new trees in accordance with the *Forest and Water Guidelines* will ensure that future forests will have minimal impact on nearby waterbodies.

All but one of lochs selected for detailed study in this report returned Class 1 (excellent) status for acidification in 2005. The waters of Loch Grannoch have been described as being ‘fair’ in quality, while Lochs Shiel and Dee have very low alkalinity values and may be considered vulnerable to episodes of acid pollution.

Freshwater cage fish farming[4] has become a significant threat to lochs, because of untreated phosphorus inputs from the floating cage units. Most of the lochs affected are small, so it may be that volumes and flushing rates are simply insufficient in many cases to deal with the inputs from the fish cages.

The significance of diffuse aquatic pollution resulting from use of fertilisers has become more apparent in recent years as the control of point source pressures improves. Until recently there was very little control over diffuse pollution sources. However, best practice guidance and policies are helping to guard against diffuse agricultural pollution and prevent any potential deterioration in water quality.

Another diffuse source, atmospheric pollution, remains an ongoing problem. The sulphur dioxide and nitrogen oxides responsible for acidic precipitation can travel long distances before being deposited and almost 90% of the fallout over Scotland comes from outside its borders. The effects of this so-called ‘acid rain’ can be exacerbated by coniferous forests, which remove acidic particles from cloud or mist more effectively than open moor land. If there is little acid neutralising capacity in the soils, most of this acidic deposition can end up in rivers and lochs. Unfortunately, many of the more susceptible geological areas are also subject to high rainfall rates.

[4] The rearing of young salmon before transfer to marine cages and the rearing of other salmonids for stocking, etc.

5.3 Selected case histories illustrating loch water quality

Data quality issues (see above) meant that it was only possible for this report to fully classify a selection of lochs. These have been selected on the combined basis of:

- likelihood to change class;
- size (area >20 km^2);
- recreational use by the public.

Table 8 lists those lochs selected for detailed case studies.

Table 8: Lochs selected for detailed study for this report

Western Scotland	Northern Scotland	Eastern Scotland
Loch Dee	Loch Shiel	Loch Ericht
Loch Grannoch	Loch Ness	Kinghorn Loch
Lussa Loch	Loch Morar	Loch Gelly
Loch Lomond	Loch Shin	Loch Leven
Kilbirnie Loch	Loch Maree	Loch Tay
Castle Semple Loch	Loch of Harray	Loch Katrine
Strathclyde Park Loch	Loch Watten	
Loch Awe	Loch Duntelchaig	
Loch Gorm	Loch Morlich	
	Loch of Strathbeg	

Three of the country's five largest lochs – Ness, Morar and Shiel – maintained Class 1 (excellent/good) quality in 2005. However, phosphorus enrichment was of such an extent as to downgrade basins of the other two largest lochs in 2005. Loch Lomond's north basin retained Class 1 status but the south basin remained in Class 2 (fair). In Loch Awe, the southern basin retained Class 1 status but the northern basin is now Class 2. However, the two lower quality basins of Lochs Awe and Lomond remain close to the classification boundary so the impacts may be reversed if sufficient measures are implemented.

Loch Dee

Loch Dee is in a remote area of the Galloway Hills and is fed by three significant streams (Dargall Burn, White and Black Laggan Burns, and the Green Burn). In 1979, concern over declining fish stocks led to this upland loch becoming the focus of a long-standing research project into the combined effects of acid deposition and forestry.

A wealth of data has since been collected and analysed. The latest publication in 1997, *A Scientific Review of the Loch Dee Water Quality and Quantity Sets* [8], assessed the results obtained so far and suggested a direction for future monitoring. Its major findings were:

- a decline in stream water sulphate (corresponding to a reduction in atmospheric deposition of sulphur);
- the importance of inputs of sea salt, which have an apparent affect on water quality lasting several years;
- a difference in water quality of the three sub-catchments reflecting differences in land management and hydrology;
- no significant trend relating to nitrate levels in stream water entering the loch.

Initially proposed to run for 25 years in order to cover the coniferous forestry cycle of planting to clear felling, the Loch Dee project will end soon. Initial SEPA findings are that pH is increasing (i.e., recovering) in the White and Black Laggan streams and the Loch Dee outfall. The rainfall collector in White Laggan catchment has also recorded a trend toward increased pH over the period. Declining acid atmospheric emissions may therefore be leading to a change in the acid status of Loch Dee, although it will take many years before this can be confirmed.

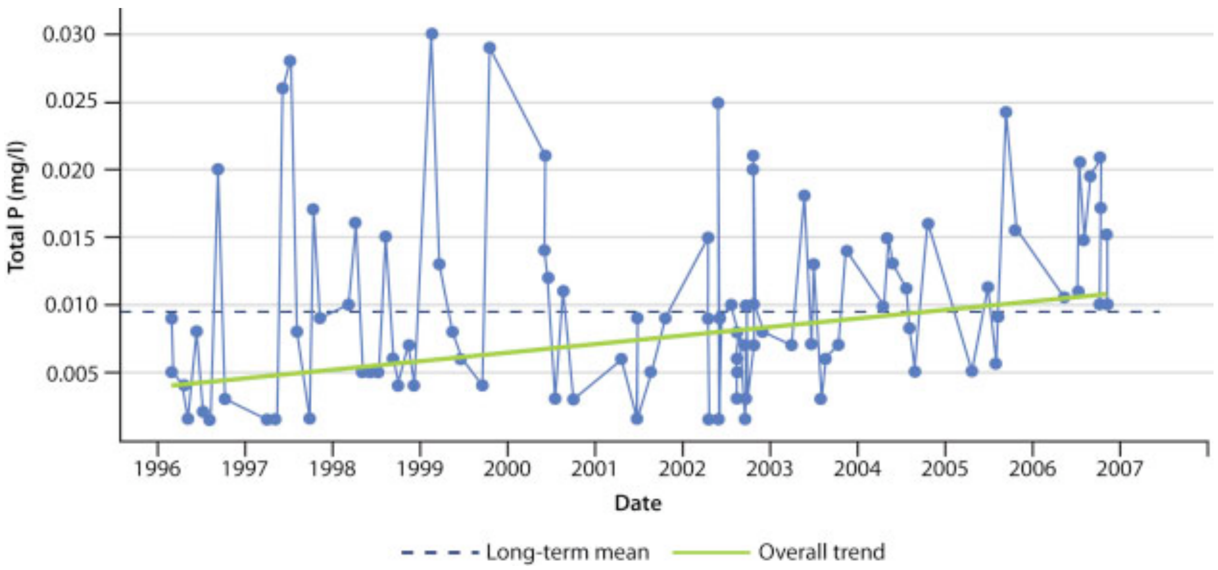
Loch Grannoch
Just south of Loch Dee and still in the Galloway Forest, Loch Grannoch was classed as poor (Class 3) in 1995 and 2000 due to acidification. The loch had lost all its population of Arctic Charr and trout stocks were declining. At present there is evidence of biological recovery from acidification. The UK Acid Waters Monitoring Network (UKAWMN) recently reported changes in the composition of diatom and invertebrate communities in Loch Grannoch [9].

Lussa Loch
This loch situated on the Kintyre peninsula near Campbeltown is moderately acidic and its catchment is almost totally afforested. Lussa Loch had deteriorated from Class 1 to Class 3 following apparent increases in total phosphorus concentrations. Further monitoring was carried out to confirm the cause of this downgrade, although it is suspected that the phosphorus levels monitored in 1995 may have been underestimated. Results in 2005 confirm that phosphorus levels in the loch continue to be elevated and the loch remains Class 3 (poor).

Loch Lomond (north and south basins)
In terms of surface area, Loch Lomond is the largest body of freshwater in Scotland and it is the second largest by volume. The loch is part of the Loch Lomond and Trossachs National Park – Scotland's first National Park created in July 2002. The loch is of considerable value to Scotland as a recreational, scientific and economic resource, and lies north-west of Glasgow in an area of great scenic beauty. A large number of people visit the loch each year; a figure as high as two million recreational visits per year has been suggested.

The south basin of Loch Lomond deteriorated from Class 1 to Class 2 between 1995 and 2000 and, in 2005, was still Class 2 (fair). SEPA studies showed that this downgrade was a consequence of increased phosphorus inputs which are threatening to cause harmful eutrophication [10]. Figure 17 shows a statistically significant upward trend in the level of phosphorus in the southern basin of Loch Lomond; modelling approaches indicate that phosphorus concentrations have risen gradually over the last 60–140 years. Additional evidence for increasing phosphorus levels comes from palaeolimnological studies on diatoms in sediment cores and phytoplankton monitoring of the loch.

Figure 17: Total phosphorus levels at Creinch in the south basin of Loch Lomond



One of the biggest sources of nutrients to Loch Lomond is from the River Endrick which flows into the south basin. SEPA is developing an Endrick Water Catchment Farm Plan, which will involve greater liaison with farmers in order to encourage good practice and adherence to regulations. Regular contact with farmers and landowners in the Luss Water catchment will also continue.

In 2001, improvements were made to many private and public discharges in the Loch Lomond area, mainly involving nutrient (phosphorus) reduction. However, there are still numerous public and private wastewater discharges within the catchment requiring investment or upgrading. These will be tackled as resources permit.

In 2002, a Catchment Management Plan (CMP) was developed for the Loch Lomond area (http://www.sepa.org.uk/pdf/consultation/closed/2002/catchments/llcmp.pdf) to address these problems and the wider issues of managing its water resources. The CMP aims to influence the management of the Loch Lomond catchment in a way that will:

- improve and maintain water quality;
- conserve water resources;
- protect and enhance the area's diverse range of aquatic habitats and species.

Achieving these objectives will require a reduction in nutrient inputs.

In 2005, SEPA produced and distributed over 2,000 leaflets, *Do a Little, Save a Loch* (http://www.sepa.org.uk/pdf/publications/leaflets/lochs/savealoch.pdf), to local authorities, businesses and communities around the loch. The leaflet gives advice to householders and visitors on action they can take to protect Loch Lomond from phosphorous enrichment. Help and support was received from the Loch Lomond and Trossachs National Park Authority, which published an article in its newsletter (distributed to around 5,000 homes in the area). The launch generated some negative press coverage but was otherwise well received within the community.

The narrower and deeper north basin Lomond is fed mainly by low nutrient upland run-off and does not show the same adverse trends as have been recorded in the south basin.

Kilbirnie Loch
Two lochs were classified as poor (Class 3) in 1995. One of these, Kilbirnie Loch in north Ayrshire, improved to Class 2 by 2000 following a reduction in measured TP concentrations. This improvement was sustained in 2005, though the loch is still under pressure from diffuse agricultural pollution and urban run-off.

Castle Semple Loch
This Renfrewshire loch is popular for recreational activities and has Site of Special Scientific Interest (SSSI) status. It is also home to a Royal Society for the Protection of Birds (RSPB) nature reserve. The loch improved in quality from 1995 to 2000, but recent data suggest it has returned to fair (Class 2) due to elevated phosphorus levels. Hindcasting from historical land cover suggests that this loch is naturally mesotrophic.

The loch is close to the boundary between Classes 1 and 2, and is expected to fluctuate in class from year to year. This loch is particularly shallow with a mean depth of only 0.7 metres. In windy conditions, resuspension of sediment may give rise to elevated TP concentrations. The loch receives treated sewage from the small town of Lochwinnoch and is at risk from eutrophication.

Strathclyde Park Loch
Located in a country park near Glasgow, this loch was artificially created for use by the water sports events of the 1986 Commonwealth Games. The South Calder Water flows into the

loch, which then outfalls to the River Clyde. The large consented sewage discharges in the catchment have had phosphorus removed from their effluents to reduce nutrient levels reaching the loch. Water quality has remained consistent, with SEPA classing the loch as fair (Class 2) in 2005.

Loch Awe (north and south basins)
Loch Awe is notable for being Scotland's longest freshwater loch. It is situated in Argyll among some of the most beautiful scenery in Britain. The loch is of major cultural and natural importance and is economically significant as a result of tourism, fish farming, angling and power generation. The loch comprises two distinct basins, with the south basin making up most of its length and volume. In terms of water quality, eutrophication is the main threat to Loch Awe.

Changes in the diatom flora suggest that this loch has become enriched since the 1970s and that current total phosphorus levels are approximately double historical values. The onset of enrichment coincides with the introduction of fish farming on the loch. Current analysis of some key determinands in Loch Awe has shown that phosphorus levels in the south basin have remained steady though there is evidence of increasing phosphorus levels in the north basin. The latter was downgraded to fair status (Class 2) in 2005.

Loch Gorm (Isle of Islay)
This SSSI loch is situated near the Atlantic coastline of Islay and is home to a diverse array of wildlife including thousands of migrating geese.

Hindcasting from land cover data suggests that this loch is naturally oligotrophic with low levels of historical total phosphorus. The SEPA classification scheme suggests the loch is now significantly enriched, resulting in Class 2 rating. However, the Water Framework Directive classification scheme indicates that Loch Gorm will be classed as being of 'good status'.

Loch Shiel
This waterbody near Glenfinnan was a Class 2 loch in 2000 due to acidification. However, recent results show some improvement in quality with regard to acidity levels. Nevertheless, Loch Shiel has very low alkalinity values, making it vulnerable to acid episodes.

Lochs Ness and Morar
Loch Ness has the largest volume and Loch Morar is the deepest of the Scottish lochs. Both continued to be Class 1 (excellent/good) in 2005.

Loch Shin
The apparent increase in phosphorus levels in Loch Shin, near Ullapool, detected in 2000 resulted in its downgrading to Class 2. However, recent data suggest the loch has returned to Class 1. There is still concern about the impact of surrounding forestry and fish farming on the loch.

Loch Maree
Loch Maree near Kinlochewe in Scotland's north-west remained a Class 1 loch in 2005.

Loch of Harray, Orkney
This loch was downgraded to Class 2 in 2000 due to elevated phosphorus levels. The latest data suggest phosphorus levels in the loch can still fluctuate.

Loch Watten
This loch, near Wick, was downgraded to Class 2 in 2000 due to elevated phosphorus levels. The latest data suggest phosphorus levels in the loch can still fluctuate.

Loch Duntelchaig
Loch Duntelchaig constitutes part of the public water supply for the city of Inverness. The loch and its surrounding catchment area are designated as a Drinking Water Protected Area under the WFD (http://www.sepa.org.uk/wfd/register/). In 2005, the loch was classified as being of excellent/good status.

Loch Morlich
This loch is situated in a forested area near Aviemore in the Cairngorms National Park. It has high recreational value but has previously recorded increased levels of phosphorus. However, the latest data suggest that phosphorus levels in the loch have declined and this waterbody is now classified as Class 1.

Loch Ericht
This long and narrow Highland loch is situated just south of the Highland boundary fault at Dalwhinnie. This large loch has remained in excellent quality for many years.

Loch of Strathbeg
Loch of Strathbeg is situated on Scotland's eastern coastline, south of Fraserburgh. Phosphorus nutrient inputs are unnaturally elevated and despite fluctuations WFD classification is likely to place this loch in a downgraded class.

Kinghorn Loch
Kinghorn Loch in Fife was Class 3 (poor) in 2000 due to historic vanadium contamination from a former aluminium smelter. However, the concentration of vanadium found in this loch has declined significantly since 2000 and recent data reclassified this waterbody as Class 1 (excellent).

Loch Gelly
In 2000, Loch Gelly in Fife was the only seriously polluted loch (Class 4 for phosphorus) monitored in Scotland. However, the overall classification masked some real improvements noted since the discharge of treated sewage from Cowdenbeath to the loch ceased in 1991. The loch is gradually recovering and phosphorus concentrations are reducing year-on-year via self-purification processes. Evidence of this is shown by the loch's improvement to Class 3 in 2005. In 1995 there were virtually no fish in the loch but it now supports populations of roach and pike.

Loch Leven
This waterbody near Kinross is designated as a Natura site and an SSSI. It has been subject to extensive research and remedial work for many years. There have been significant and progressive reductions in phosphorus load in recent years, although internal phosphorus loading from sediments is still a problem as the loch undergoes recovery. There have also been encouraging signs of loch ecosystem recovery, but it remains very variable from year-to-year and is subject to the vagaries of the climate. The loch remained at Class 2 in 2005.

Loch Tay
This high amenity value loch was Class 1 (excellent/good) in both 1995 and in 2000, but was downgraded to Class 2 (fair) for 2005. Loch Tay is close to the good/fair boundary but is likely to be downgraded to less than good status in the WFD classification scheme. Fish cage units may be a significant source of phosphorus in the loch.

Loch Katrine
This loch is an important source of drinking water for the City of Glasgow and the water remains in excellent quality.

5.3 Blue-green algal monitoring

Blue-green algae (cyanobacteria) are a group of bacteria with some of the characteristics of algae. They occur in a wide range of freshwater bodies and are potentially toxic. In nutrient-enriched lochs, there is a greater risk of the formation of blooms or scums. Mats of blue-green algae can also form on the bottom of lochs. In Scotland most blooms occur between April and October though, in some waters, blooms can occur outwith this period. They are a problem because many species contain powerful toxins.

Episodes of blue-green algal contamination of drinking water supplies occur periodically. In September 1997, for example, a large blue-green algal bloom affected the main water supply loch on Westray, Orkney Isles, resulting in a ban on the use of water for drinking, cooking and washing. In July 2005, consumers of water from the Loch of Boardhouse supply (again in Orkney) complained of an earthy taste and musty odour. A visual check of the loch identified green growth around the loch consistent with an algal or cyanobacterial bloom. A temporary plant was installed to dose the water with powdered activated carbon which improved the taste and odour of the final treated water. The blue-green algae had virtually disappeared by mid-August. A similar problem with blue-green algae resulted in tainting affecting the taste and odour of water from the Glenfarg reservoir in 2006. This also necessitated the use of carbon dosing.

There have been occasional reports of animal deaths attributed by their owners to contact with blue-green algal scums. However, objective evidence is not always available to confirm an association with toxin exposure. In summer of 2003, there was good evidence to suggest that the deaths of two dogs in Fife were associated with ingestion of blue-green algal sludge at Town Loch in Dunfermline. Restrictions were imposed and were supported by ongoing monitoring and the safe removal and disposal of shoreline deposits. Further incidents have been reported involving dogs and calves where the associations were circumstantial. As often occurs with such incidents, there were gaps in the recognition of a possible link in the investigation such that it was difficult to establish a definitive cause.

SEPA undertakes monitoring to assess the risk to public health posed by blue-green algae in Scotland’s waters. The work involves counting the numbers of cyanobacterial cells in water samples from inland recreational waters and comparing the counts with threshold values corresponding to moderate or low probability of adverse health effects. This monitoring may be carried out within the framework of a Local Action Plan co-ordinated by a NHS Board. The Scottish Government published revised guidance on the risks of blue-green algae to public health in 2007 [11].

6 Groundwater quality

Because groundwater is not easily seen its importance can be overlooked. However, around 30,000 private supplies are taken from groundwater in Scotland. These are vital to many households and small businesses, particularly in rural areas. Groundwater is also used as a source for public water supply and by industries such as breweries and mineral water producers. Groundwater is essential for irrigation in some highly productive agricultural areas.

Groundwater is inextricably linked to surface water in the water cycle as it maintains wetlands and river flow during dry spells, and is essential to the maintenance of their rich ecology and biodiversity. If groundwater quality or quantity is not protected, our rivers and lochs will also be impacted as natural groundwater discharges into them.

SEPA's integrated groundwater monitoring programme is designed to meet all needs including those arising from the EU:

- Water Framework Directive;
- Nitrates Directive;
- Groundwater Directive.

Details of SEPA monitoring to comply with the Nitrates and Groundwater Directives are given in Section 6.2.

6.1 Proposed UK groundwater classification scheme

A groundwater classification scheme is currently being developed by the UK Technical Advisory Group (UKTAG) supporting the implementation of the Water Framework Directive (http://www.wfduk.org). The methods for deriving threshold values for pollutants, pollutant groups and pollution indicators will match the current draft Groundwater Daughter Directive. Threshold values will be tailored to individual groundwater bodies.

6.2 Monitoring to comply with EU directives

Nitrates Directive monitoring

In 2000, SEPA established a groundwater monitoring network to better comply with the requirements of the Nitrates Directive. The Macaulay Land Use Research Institute (MLURI) and the Robert Gordon University (RGU) were commissioned to produce a general groundwater sampling strategy for Scotland [12].
Click to view the report *'A Groundwater Monitoring Network for Scotland'*.

This sampling strategy was used to design the monitoring network and was based on the risk of contamination to groundwater through consideration of:

- land use;
- aquifer permeability;
- soil leaching potential.

The potential sampling locations identified by the strategy were assessed by SEPA and a subset of 134 chosen to form its initial groundwater nitrates network. However, it was found that not all sites were satisfactory, and several were replaced or removed with others added. In 2005 the Scottish Government commissioned the British Geological Society (BGS) and MLURI to carry out a review of the effectiveness of the nitrate monitoring network [13].
Click to view the report *'Scotland's groundwater monitoring network: its effectiveness for monitoring nitrate'.*

Private drinking water supplies in rural areas are often drawn from shallow wells and springs, which have a greater susceptibility to pollution. In 2001, the British Geological Survey found that some private supplies had a median nitrate concentration exceeding 50 mg/litre – the maximum permitted in drinking water.

Diffuse groundwater impacts also vary geographically as a consequence of variable nitrate loading, leaching and dilution rates, and groundwater vulnerability. Data from the BGS study found that 67% of all supplies sampled in highest risk catchments failed the 50 mg/litre limit in the Borders. Equivalent statistics were 12% for Edinburgh and East Lothian, 34% for Fife, 27% for Strathmore, 21% for Aberdeenshire Banff and Buchan, and only 4% for Moray [14].

Map 9 shows the average levels of nitrate in groundwater sites monitored by SEPA from 2000 to 2006. It also shows the four current Nitrate Vulnerable Zones (NVZs) which cover almost 15% of the country. Nitrate concentrations at the majority of these sites were below the guideline value of 25 mg/litre. The map illustrates the high quality of Scottish groundwater with only 10% (19 sites) exceeding the upper threshold of 50 mg/litre.

Groundwater Directive monitoring

The Groundwater Regulations 1998 [15] state that SEPA may only grant an authorisation to discharge prescribed chemicals to land or groundwater if the associated groundwater is subject to the requisite surveillance. To fulfil this requirement, SEPA undertook an initial round of groundwater monitoring between October 2000 and January 2001.

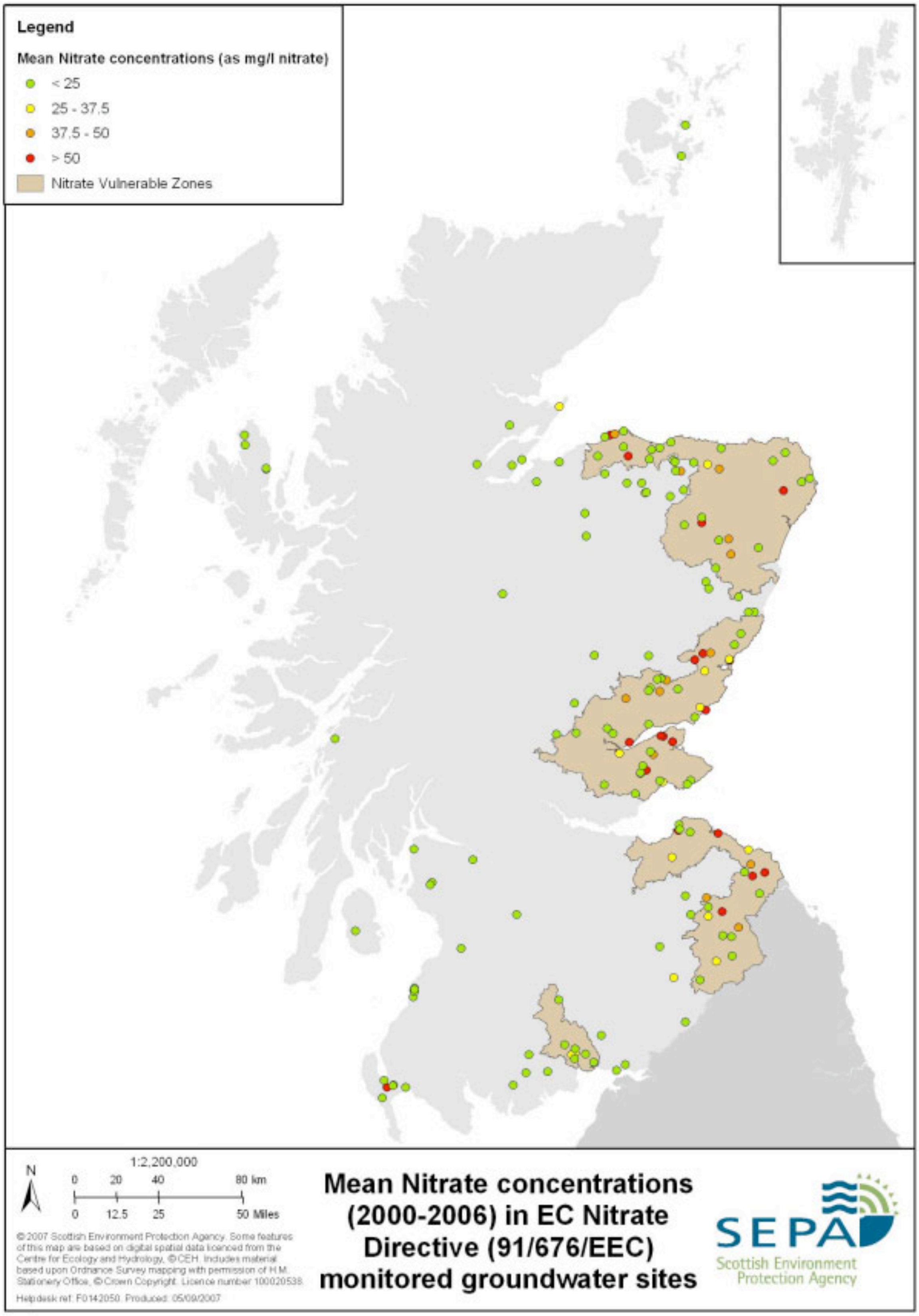
Since then SEPA has monitored for sheep dip (e.g. cypermethrin) and agrochemical compounds (e.g. atrazine) at a small number of selected sires. Recently, this effort has expanded to include industry-related compounds such as methyl tertiary-butyl ether (MTBE).

As with nitrates, the network has evolved over time with sites added where necessary and removed where conditions indicate they are not under any threat or not representative. Key influences on network design have been the monitoring returns themselves and predictive risk assessments carried out for the Water Framework Directive. In general the number of sites where sheep dip has been detected is declining, but the detection of other agrochemicals has increased. Not all of these detections are significant.

A groundwater monitoring site is said to have an 'exceedence' when the current Environmental Quality Standard (EQS) limit or the relevant Drinking Water Directive limit is not met. Details of drinking water limits can be found in The Water Supply (Water Quality) (Scotland) Regulations 2001 [16] while current EQS limits are taken from SEPA guidance [17].

In 2002 mandatory limits for sheep dip compounds were exceeded at 10% of the sites sampled and for and agrochemical compounds at 20% of the sites sampled. In 2006 levels of sheep dip compounds were too high at only 8% of sites sampled and too high for agrochemical compounds at 10% of sites sampled. Appropriate action was taken in these cases. (see Section 6.4).

Map 9: Nitrate concentrations in Scottish groundwater, 2000-2006



6.3 General issues relating to groundwater quality, 2000-2006

Monitoring results show that the majority of Scottish groundwaters continue to be of good quality.

Agricultural activity is believed to be the source of virtually all elevated concentrations of nitrates and agrochemicals in groundwater. However, significant contamination of groundwater with agrochemicals is not widespread. SEPA continues to expand its groundwater monitoring network, undertaking additional agrochemical programmes in Moray/Easter Ross and Strathmore/Angus in 2006.

Sampling of industrial compounds will continue at a number of selected sites in urban areas. Recent results are of sufficient concern to justify continued sampling of industrial compounds at a number of selected sites in urban areas. SEPA also intends to expand monitoring of related parameters to new sites in urban areas, particularly in the Glasgow area.

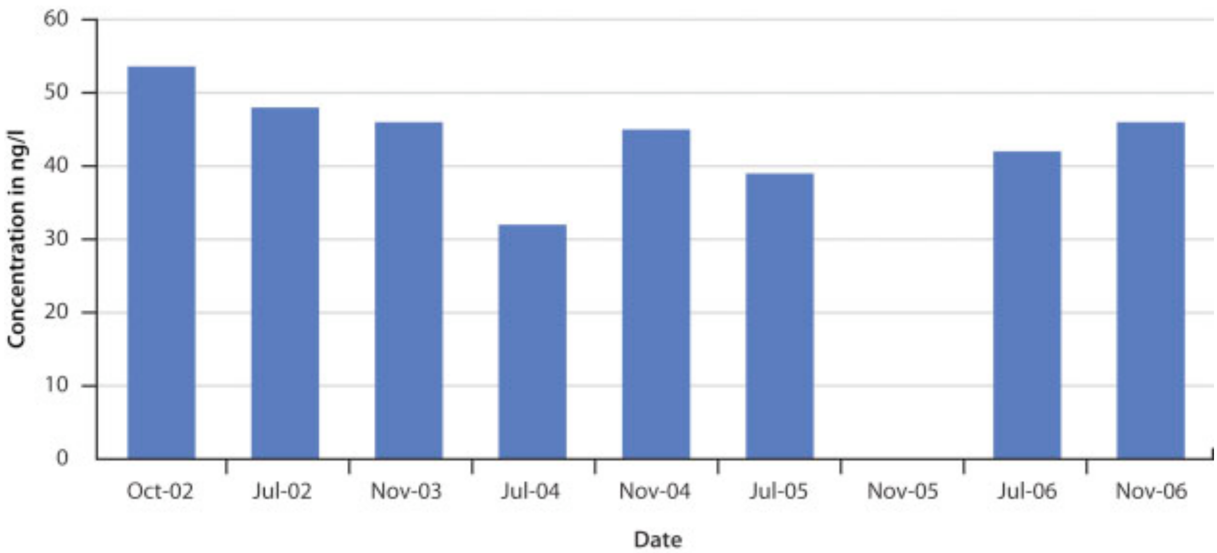
6.4 Case studies relating to groundwater quality, 2000-2006

Example case studies are given below.

Dumfries and Galloway

The persistent positive results for the herbicide atrazine in the Dumfries aquifer since October 2002 are shown in Figure 18.

Figure 18: Atrazine concentrations in the Dumfries aquifer, 2002-2006*



* No sample was taken in November 2005.

The levels reported are well below the Drinking Water directive limit of 100 ng/litre. However, the results show there is still a persistent input of atrazine at this site. Further investigation is underway to ascertain if these results are representative of wider bulk conditions in the aquifer.

Angus

A number of high levels of agrochemical and fungicides have been detected in the Strathmore/Angus area. Investigations indicate that most of these are the result of current or historic diffuse pollution. The problem could therefore be widespread enough to impact on groundwater status in the region.

SEPA has selected the River Lunan south of Montrose as a representative catchment in the area and has installed a number of additional monitoring wells to investigate the problem more thoroughly. All monitoring sites will be sampled for relevant organics parameters. Work will be co-ordinated with sampling for significant inorganics, soil and surface water parameters which is also being undertaken in the catchment.

Lothian

A recent study in the West Peffer catchment provides a good example of how groundwater and surface water investigation can be integrated to achieve a higher degree of confidence in appropriate remedial strategies. In this case groundwater and surface water were monitored for agrochemical pesticides. No evidence was found for diffuse groundwater contamination but pesticides were detected in surface water. It was concluded that the main source is likely to be a point source and more targeted investigation of possible point sources is underway. The most obvious point source had already been remediated and, without the groundwater investigation, diffuse sources of pesticide might have been targeted unnecessarily.

7 Conclusions

This report describes the results and outcomes of SEPA's monitoring and classification of Scotland's water quality and overall trends in the quality of the aqueous environment.

In 2000 SEPA set itself water quality improvement targets to be met during 2006. This report focuses mainly on this period but also provides data on more long-term trends where available. The improvement targets were essentially met, though the cost and effort involved in achieving these targets serves to emphasise the size of the task required to meet future EU Water Framework Directive objectives.

Some year-on-year fluctuations have been brought about by uncontrollable factors such as rainfall. However, these do not mask the overall long-term improvements. These can be attributed to a range of factors including:

- investments in new sewage treatment schemes and improved sewerage infrastructure;
- improved levels of effluent treatment by industrial operators;
- continuing work by SEPA and others to minimise diffuse pollution from agricultural and urban sources;
- the implementation of new legislation;
- increasing public awareness and reporting of pollution incidents.

Combined with routine monitoring, SEPA maintains a programme of Environmental Improvement Action Plans, many of which are directed at problems arising from more diffuse, currently unregulated sources. These Plans will also produce environmental quality improvements in the future.

This publication is the last time water quality will be reported using SEPA's classification methodology. Future annual classifications from 2007 will be undertaken using the new WFD classification tools (Section 8).

Much remains to be done to bring the quality of all waters up to desired standards. This ongoing work is being given fresh impetus by the new requirements of the WFD. To meet these, SEPA is implementing a new water quality classification scheme along with new regulatory regimes for abstractions and engineering works. These will bring under control many activities that impact on ecological quality, but which have not previously been subject to direct regulation [14].

The high ecological and economic value of Scotland's waters must be maintained as a valuable resource for fish and wildlife, recreation, the transport of well-treated wastes, abstraction and power generation. Through its policies and actions SEPA aims to ensure that:

- the future for the quality of all waters and aquatic environments remains positive;
- current improvement trends are maintained for the enhancement of all uses and benefit of users.

8 Future Quality Assessments

Future water quality work will be increasingly dominated by continuing implementation of the WFD. The current rivers and coastal results reported here are now all available via SEPA's web-site GIS which includes location search facilities (see: http://www.sepa.org.uk/rqc/map.asp).

Reports outlining the first WFD "characterisation" of all relevant Scottish waters are also available on the web-site, backed up by database search facilities (see: http://www.sepa.org.uk/wfd/index.htm). It is inevitable, for various reasons, that the WFD characterisation reports present a less positive view of the quality of our water environment.

The most significant reason for this less positive view is the wider range of pressures which have to be considered for the purposes of the WFD. The assessments reported in this and previous SEPA water quality reports concentrate on the effects of discharges and diffuse inputs of potential pollutants. For WFD characterisation, account is also taken of water abstractions, impoundments and engineering works such as river straightening, which may impact ecological quality in ways not measured by the current classification schemes.

Also significant is that characterisation is a risk assessment, rather than a classification (though the two are linked), and that the WFD "good status" quality target is defined by the Directive as being well up the quality spectrum. It may be that a slightly precautionary estimate of this quality target has been taken at the characterisation stage, particularly in respect of the previously unregulated hydrological and engineering pressures.

Finally, characterisation assessment by water bodies, rather than by the stretches currently classified has some effect. The current stretches are sometimes quite short (perhaps between a discharge point and confluence with a cleaner or larger stream), whereas the WFD water bodies are mostly larger, and take the overall quality of the poorest stretch within them. This implies that a 3 km poor stretch could result in the whole of a 10 km water body being regarded as failing to meet WFD quality standards.

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10 Abbreviations and acronyms

ASPT	Average Score Per Taxon
BGS	British Geological Society
BOD	biochemical oxygen demand
CSO	combined sewer outflow
Cusum	cumulative sum
d/s	downstream
DO	dissolved oxygen
DRN	Digitised Rivers Network
EIAP	Environmental Improvement Action Plan
EQI	Ecological Quality Index
EQS	Environmental Quality Standard
FIO	faecal indicator organisms
GBRs	General Binding Rules
GIS	geographical information system
MLURI	Macaulay Land Use Research Institute
NVZ	Nitrate Vulnerable Zone
OSPAR	Oslo and Paris Convention
PPC	Pollution Prevention and Control
Q&S	Quality & Standards
RIVPACS	River Invertebrate Prediction and Classification Scheme
SEPA	Scottish Environment Protection Agency
SSSI	Site of Special Scientific Interest
STW	sewage treatment works
SUDS	sustainable urban drainage system
TBT	tributyl tin
TON	total oxidised nitrogen
TP	total phosphorus
uCSO	unsatisfactory combined sewer outflow
UV	ultraviolet
UWWTD	Urban Waste Water Treatment Directive
WFD	Water Framework Directive

11 Glossary of terms

Term	Definition
A	
Acidification	Refers to reducing the pH of something to make it more acidic. In terms of surface waters and soils, acidification generally refers to the enhanced changes due to the deposition of sulphur and nitrogen species as a result of human activity.
Aesthetics	In this sense refers to the general condition of the aqueous environment as perceived by the naked eye. Poor aesthetic conditions can be caused by sewage solids, sanitary goods and items which are offensive to human senses.
Algae	A general term for a group of photosynthetic organisms (microscopic or very large such as seaweeds), which may have bacteria-like cell structures or ones like all other organisms, containing chlorophyll *a* and a variety of other pigments that give the organisms a range of characteristic colours.
Algal bloom	An algal bloom is a rapid increase in the population of algae in an aquatic system. Algal blooms may occur in freshwater as well as marine environments. Some blooms may be recognised by discoloration of the water resulting from the high density of pigmented cells. Some algal blooms are the result of an excess of nutrients (particularly phosphorus and nitrogen). As the algae die off this dead organic matter becomes food for bacteria that degrade it using oxygen. When the dissolved oxygen content decreases, many fish and aquatic insects cannot survive. Algal blooms may also produce neurotoxins.
Ammonia	At normal environmental conditions, pure ammonia is a colourless, pungent-smelling, corrosive gas. For further information see http://www.apis.ac.uk/overview/pollutants/overview_NH3.htm and http://www.sepa.org.uk/spri/substance/sublist.aspx
Anoxic	Anoxic refers to 'depleted of oxygen'. It is generally found in areas with restricted water exchange. In most cases, oxygen is prevented from reaching the deeper parts of the sea area by a physical barrier (sill) as well as pronounced density stratification. Anoxic conditions will occur if the rate of oxidation of organic matter by bacteria is greater than the supply of oxygen.
ASPT (Average Score per Taxon)	The average sensitivity of the families of the organisms present is known as the ASPT and can be determined by dividing the BMWP score by the number of taxa present. A BMWP score >100 with an ASPT value >4 generally indicates good water quality.
B	
Benthic	The benthic zone is the lowest level of a body of water such as an ocean or a lake. It is inhabited by organisms that live in close relationship with (if not physically attached to) the ground, called benthos or benthic organisms.
Bioaccumulative	The uptake of chemicals from the environment and their concentration and retention by organisms (e.g. in fatty tissue).
Biodiversity	The richness and complexity of plant and animal communities.
Biomass	Biomass is a collective term for all plant and animal material. A number of different forms of biomass can be burned or digested to produce energy
Biomonitors	A biological monitor, or biomonitor, is defined as an organism that

Term	Definition
	provides quantitative information on the quality of the environment around it. Therefore, a good biomonitor will indicate the presence of the pollutant and also attempt to provide additional information about the amount and intensity of the exposure.
BMWP (Biological Monitoring Working Party)	A scoring system developed in the UK in which organisms are identified to the family level and then each family is allocated a score between 1 and-10. The most sensitive organisms, such as mayfly nymphs score 10, and least sensitive worms score 1. The BMWP score is calculated by summing the scores for each family represented in the sample. The number of taxa gives an indication of the diversity of the community (high diversity usually indicates a healthy environment).
BOD (biochemical oxygen demand)	The amount of dissolved oxygen (in mg/litre) consumed by chemical and biological action when a sample is incubated for five days at 20^0C in the dark. Allylthiourea (ATU) is used for suppression of oxygen consumption by nitrification.
Buffer strip	A 1–5 metre strip of agricultural land left uncultivated alongside watercourses to minimise erosion.
C	
Catchment	An area from which surface run-off is drained away into a river
Chlorophyll	The main green photosynthetic pigment of algae. Chlorophyll *a* is used widely as a measure of algal biomass.
Combined sewer overflow (CSO)	A combined sewer is a type of sewer system which provides partially separated channels for sanitary sewage and storm water run-off. This allows the sanitary sewer system to provide back-up capacity for the run-off sewer when run-off/rainfall volumes are unusually high, but it is an antiquated system that is vulnerable to sanitary sewer overflow during peak rainfall events.
Culvert	A culvert is a conduit used to enclose a flowing body of water. It may be used to allow water to pass underneath a road, railway or embankment for example.
Cyanobacteria	A community of largely microscopic photosynthesising organisms with bacteria-like structures, but which also contain chlorophyll *a* and pigments similar to that found in other algae. They are commonly referred to as blue-green algae although their characteristic pigments may be red, brown and purple.
D	
Deoxygenation	Deoxygenation is a chemical reaction involving the removal of molecular oxygen (O_2) from a reaction mixture or solvent.
Diatoms	A group of algae, brown and yellow in colour, commonly found in waters. Their cell walls are made of polymerised silicate acting like a glass shell, which makes them readily preserved in sediments when the organic part decays.
Diffuse pollution	Pollution arising from land use activities (urban and rural) dispersed across a catchment or sub-catchment, and which does not arise as a result of the discharge of an industrial, domestic sewage, deep mine or farm effluent (this is point source pollution).
Dissolved oxygen (DO)	Oxygen dissolved in a liquid, the solubility depending upon temperature, partial pressure and salinity. Expressed in mg/litre.
E	
Ecological	From ecology which is the scientific study of systems of living organisms and the interactions among organisms their environment.

Term	Definition
Ecosystem	Living organisms (species, populations and communities of plants and animals), their physical environment (habitat) and their inter-relationship within a particular system.
Effluent	A discharge of pollutants into the environment, partially or completely treated, or in its natural state. Generally used in regard to discharges into waters.
Environmental Improvement Action Plans (EIAPs)	Also called Action Plans. Action Plans describe and legitimise proactive projects that are undertaken to achieve a specific positive environmental outcome. Many are derived from staff initiatives and involve working with other departments or organisations.
Environmental Quality Standard (EQS)	A regulatory value defining the maximum concentration of a potentially toxic substance which can be allowed in an environmental compartment, usually air or water, over a defined period. It can also be used to establish the allowable minimum concentration for necessary substances such as dissolved oxygen in water.
Episode (pollution)	An air pollution incident in a given area caused by a concentration of atmospheric pollutants under meteorological conditions that may result in a significant increase in effects on people and ecosystems.
Erosion	Erosion consists in the removal of soil or rocks by water or wind. It is a natural phenomenon but it can be accelerated by human activities.
Eutrophic Eutrophication	The enrichment by nutrients, especially compounds of nitrogen and/or phosphorus, causing an increase in the growth of algae and plants that produces an undesirable disturbance to the natural balance of the ecosystem.
F	
Faecal coliforms	A specific type of coliform bacteria found only in the gut, where they can aid the digestion of food, and consequently can be found in waters suffering recent contamination with human sewage or animal faeces. The number of faecal coliform bacteria found in 100 millilitres (ml) of water is used as an indicator of pollution by faecal material.
Foul sewer	Also known as a sanitary sewer, is a type of underground carriage system for transporting sewage from houses or industry to treatment or disposal. In some areas, foul sewers are separate sewer systems specifically for the carrying of domestic and industrial wastewater, and are operated separately and independently of storm drains, which carry the runoff of rain and other water which wash into city streets.
G	
Groundwater	The term groundwater refers to all water that is below the surface of the ground in the saturated zone and which is in direct contact with the ground or subsoil.
H	
Habitat	Place where an organism (e.g. human, animal, plant, microorganism) or population of organisms live, characterised by its surroundings, both living and non-living.
I	
Indicator	Observed value representative of a phenomenon to study. In general, indicators quantify information by aggregating different and multiple data. The resulting information is therefore synthesised.
Inorganic	Composed of material other than plant or animal matter.
J	
K	
L	

Term	Definition
Land use	The human employment of the land; a change in land use at any location may involve a shift to a different type of use (e.g. from farming to residential) or a change in the intensity of use.
Land cover	The physical state of the land such as the quantity and type of surface vegetation, water and earth materials.
Landfill	Area of land in or on which waste is deposited.
Leachate	Leachate is a toxic liquid most commonly found in association with landfills where rain percolates through the waste and reacts with the products of decomposition, chemicals and other materials in the waste to produce the leachate. Leachate can enter and pollute surrounding watercourses or groundwater. Leachate has a very distinctive smell which is not easily forgotten.
Leaching	Process by which water removes chemicals (e.g. from soil) through chemical reactions and the downward movement of water.
M	
Macro-invertebrate	Also referred to as invertebrates or simply inverts. Any non-vertebrate organism that is large enough to been seen without the aid of a microscope and lives in or on the bottom of a body of water.
Mesotrophic	Waterbody which contains moderate quantities of nutrients and is moderately productive in terms of aquatic animal and plant life.
Minewater	Water escaping from a former mine. After mines are closed and flooded, iron next to the coal seams is washed out into nearby streams, where it reacts with oxygen, rusts and turns bright orange.
Morphology	Physical attributes that describe the shape, form and texture of river or loch environments, e.g. bars, sediment, riffles.
N	
Natura	Natura 2000 is an ecological network in the territory of the European Union. In May 1992, governments of the European Union adopted legislation designed to protect the most seriously threatened habitats and species across Europe. This legislation is the Habitats Directive and complements the Birds Directive adopted in 1979. These two Directives are the basis of the creation of the Natura 2000 network.
Nitrate Vulnerable Zone (NVZ)	An area designated in accordance with the requirements of the Nitrate Directive 91/676/EEC, which aims to reduce water pollution caused by nitrates from agricultural sources. For more information see http://www.scotland.gov.uk/Topics/Agriculture/Environment/NVZintro
Nitrogen oxides (NO_X)	Oxides of nitrogen (NO_X) is the term usually used to refer to nitrogen monoxide (nitric oxide or NO; a colourless and odourless gas) and nitrogen dioxide (NO_2; a red-brown gas with a pungent smell which is soluble in water). For further information see http://www.apis.ac.uk/overview/pollutants/overview_NOx.htm and http://www.sepa.org.uk/spri/substance/sublist.aspx
Nitrogen	Soluble nitrate is an important limiting factor in the growth of certain bacteria in ocean waters. In many places in the world, artificial fertilisers applied to crop lands to increase yields result in run-off delivery of soluble nitrogen to oceans at river mouths. This process can result in eutrophication of the water, as nitrogen-driven bacterial growth depletes water oxygen.
Nutrient	A nutrient is either a chemical element or compound used in an organism's metabolism or physiology. Oversupply of plant nutrients in the environment can cause excessive plant and algae growth.
O	

Term	Definition
Oligochaetes	The oligochaetes are a group consisting of terrestrial earthworms and species that live in both marine and freshwater environments.
Oligotrophic	Water body containing few nutrients, e.g. nitrogen or phosphorus; often referred to as nutrient poor.
Organic	Containing carbon compounds.
OSPAR	The Convention for the Protection of the Marine Environment of the North East Atlantic (known as the OSPAR Convention), to which the UK is a party, agreed a strategy to 'prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous chemicals with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring chemicals and close to zero for man-made synthetic chemicals.'
P	
Persistent	The ability of a chemical to remain unchanged in the environment. Persistent chemicals can become distributed worldwide, particularly in the marine environment or the atmosphere.
Pesticide	Any substance, preparation or organism prepared or used (among other uses) to: protect plants or wood or other plant products from harmful organisms; regulate the growth of plants; give protection against harmful creatures; or render such creatures harmless.
pH	A scale that denotes how acidic (<7) or basic (>7) a substance is based on the measurement of hydrogen ions in solution. The smaller the number on the pH scale, the more acidic the substance is.
Phosphate	Phosphates are the naturally occurring form of the element phosphorus and are found in many phosphate minerals. In ecological terms, phosphate is often a limiting reagent in environments, and its availability may govern the rate of growth of organisms. Addition of high levels of phosphate to the environment can have significant ecological consequences (e.g. blooms). In the context of pollution, phosphates are a principal component of total dissolved solids – a major indicator of water quality.
Phytoplankton	A community of largely microscopic algae, adapted to suspension in waters, and maintained in suspension by wind-generated water currents.
Plankton	A term used to describe a community of plants (phytoplankton) and animals (zooplankton) adapted to suspension in open water, and maintained in suspension by wind-generated water currents. Plankton abundance and distribution are strongly dependent on factors such as ambient nutrients concentrations, the physical state of the water column, and the abundance of other plankton.
Point source pollution	Pollution caused by a discharge from a fixed installation such as the end of a pipe, stack or drain.
Pollutants	Substances which, when present in the environment under certain conditions, may become injurious to human, animal, plant or microbial life, or to property, or which may interfere with the use and enjoyment of life or property.
Polychorinated biphenyls (PCBs)	PCBs are mixtures of 209 different chemicals (congeners) that come in various forms including oily liquids, solids and hard resins. They are very persistent in the environment, taking years to degrade. They are fat-soluble and bioaccumulate in the tissues of animals. PCBs have become worldwide pollutants due to long-distance transport on air

Term	Definition
	currents.
Polycyclic aromatic hydrocarbons (PAHs)	Polycyclic aromatic hydrocarbons (PAHs) are a group of compounds formed during the incomplete combustion of coal, oil, gas, wood, garbage or other organic substances.
R	
Reed bed	Constructed wetlands are artificial reed beds which are increasingly being adopted for efficient small-scale sewage treatment systems. Sewage water trickling through the reed bed is rapidly cleaned up by the extensive root system and its associated microorganisms utilising the sewage for growth nutrients, giving an extremely clean effluent.
Residence time	Residence time is used to express how fast something moves through a system in equilibrium. It is the average time a substance spends within a specified region of space, such as a reservoir. For example, the residence time of water stored in deep groundwater, as part of the water cycle, is about 10,000 years.
RIVPACS (River Invertebrate Prediction and Classification Scheme)	A microcomputer-based system developed by the Institute of Freshwater Ecology (IFE) for the biological assessment of river quality. This computer package uses environmental measurements such as width, depth and location to predict the fauna to be expected at a river site in the absence of environmental stress (e.g. pollution, habitat degradation). By comparing the observed with the expected fauna, the biological quality of a site can be determined.
Run-off	Portion of rainfall, melted snow or irrigation water that flows across the ground's surface and is eventually returned to streams. Run-off can pick up pollutants from air or land and carry them to receiving waters.
S	
Salmonids	Freshwater fish of the salmonid family (e.g. salmon, trout)
Secondary treatment	Following primary treatment (removal of solids), secondary treatment is designed to substantially degrade the biological content of the sewage such as are derived from human waste, food waste, soaps and detergent. The majority of municipal and industrial plants treat the settled sewage liquor using aerobic (with oxygen) biological processes.
Septic tank	A septic tank is a small-scale sewage treatment system common in areas with no connection to main sewerage pipes. The term 'septic' refers to the anaerobic bacterial environment that develops in the tank and which decomposes or mineralises the waste discharged into the tank. Periodic preventive maintenance is required to remove the irreducible solids which settle and gradually fill the tank, reducing its efficiency. A properly cared for system can last for decades and possibly a lifetime.
Sewage	The waterborne wastes of a community. Domestic sewage is derived from a residential area. An industrial sewage is from a mixed residential and industrial area. Storm sewage is that flowing to a treatment works in wet weather or discharged from storm overflows, when the sewage is diluted to a greater or lesser extent with rain water.
Sewage fungus	Filamentous bacteria including *Sphaerotilus natans* which can produces a sludge blanket smothering riverbeds. Its presence often indicates organic pollution.
Sewage treatment works (STW)	Site where the process of removing contaminants from wastewater, both run-off and domestic is carried out. Includes physical, chemical

Term	Definition
	and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge also suitable for discharge or reuse back to the environment.
Sewerage	A system of pipes and appurtenances for the collection and transportation of domestic and industrial waste waters.
Sheep dip	The term sheep dip refers to a liquid formulation of insecticide and fungicide which shepherds and farmers may use to protect their sheep from infestation against external parasites. The sheep are completely immersed in the preparation. Sheep dips have been found to contaminate surrounding soil, creating environmental problems.
Silage	Silage is fermented, high-moisture forage that can be fed to ruminants (cud-chewing animals such as cattle and sheep). Silage must be firmly packed to minimise the oxygen content or it will spoil.
Slurry	Slurry is, in general, a thick suspension of solids in a liquid and, in this case, refers to a mixture of water and animal waste used as fertiliser.
Sludge	Sludge is the residual semi-solid material left from industrial, water treatment, or wastewater treatment processes. When fresh sewage or wastewater is added to a settling tank, approximately half the suspended solid matter will settle out. This collection of solids is known as raw sludge or primary solids.
Soakaway	A pit, filled with broken stones, etc. below ground to take drainage from rainwater pipes or land drains and allow it to disperse.
Sulphur dioxide	A gas that contributes to acidification. Burning fossil fuels, such as coal, releases sulphur dioxide into the atmosphere. See http://www.apis.ac.uk/overview/pollutants/overview_SO2.htm and http://www.sepa.org.uk/spri/substance/sublist.aspx
Sustainable urban drainage system (SUDS)	SUDS are designed to reduce the potential of flooding on new and existing urban developments. Unlike traditional urban stormwater drainage systems, they also help to protect and enhance ground water quality.
Sustainable development	The ability to meet our needs and enjoy a better quality of life without jeopardising the quality of life of future generations.
T	
Tertiary treatment	Tertiary treatment provides a final stage to raise the effluent quality before it is discharged to the receiving environment. More than one tertiary treatment process (i.e. nitrification or UV disinfection) may be used at any treatment works. If disinfection is practiced, it is always the final process.
Total oxidised nitrogen (TON)	Total oxidised nitrogen measures the type of nitrogen (nitrite and nitrate) that is immediately available to plants in brine or freshwater and as such provides a useful indicator of a waterbody’s ability to support a bloom.
Toxic	Harmfulness to living organisms. Toxicity is the capacity of a chemical to cause toxic effects to organisms or their progeny such as: reduction in survival, growth and reproduction; carcinogenicity; mutagenicity; tetragenicity; and endocrine disruption.
U	
V	
W	
Water treatment works/plant	Where the process of treating and supplying (potable) water for human consumption and domestic use takes place.

Term	Definition
Waterbody	Any mass of water having definite hydrological, physical, chemical and biological characteristics and which can be employed for one or several purposes.
Watercourse	A stream, river or canal; the channel, bed or route along which this flows.
Water table	The water table is the surface where the water pressure is equal to atmospheric pressure. In undeveloped regions or areas with high amounts of precipitation, the water table roughly follows the contour of the overlying land surface, and rises and falls with increases or decreases in infiltration.
Wetlands	Areas that are inundated by surface water or groundwater at a frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth or reproduction.
X	
Y	
Z	

For a more widespread glossary see http://glossary.eea.eu.int/EEAGlossary