

# Contents and Acknowledgements

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1	Executive Summary	2
2	Air Quality Management in Scotland	5
2.1	Scottish Environment Protection Agency	5
2.2	NAQS Air Quality Pollutants	8
2.3	The Local Authority Role in Air Quality Management	9
2.4	SEPA'S Role in Local Air Quality Management	11
2.5	Air Quality Standards and Guidelines	11
2.6	Measuring Air Quality	12
3	Atmospheric Emission Inventories	14
3.1	UK National Atmospheric Emissions Inventory	14
3.2	Emission Inventory Data for Scotland	15
3.3	Transboundary Emissions	16
3.4	Industrial Emission Reductions	17
3.5	Evaluation of Model Estimates and Research Studies	19
4	Air Quality Review	21
4.1	Historic Improvements in Air Quality	21
4.2	An Overview of NAQS Air Pollutant Concentrations in Scotland	23
4.3	Overview of Local Authority Stage 1 Reviews	30
4.4	Effects of Air Quality	31
5	Air Quality Issues	34
5.1	Strategic Air Pollution Issues	34
5.2	Localised Pollution Issues	37
5.3	Forth Valley	41
5.4	Scotland's Cities	41
5.5	Diffuse Pollution Inputs to Land and Sea	42
6	SEPA'S Goals and Targets for Improving Air Quality	44
7	References	47
	Annexes	49
A	NAQS Pollutants	49
B	Air Quality Standards and Guidelines for Human Health and Flora	52
C	Legislation, Protocols and Initiatives	54
D	Measuring Air Quality	56
E	Health Effects of NAQS Air Pollutants	56
F	Glossary	58
G	Conversion Tables	59
H	Units	59
I	Percentiles	59
J	Internet Sites of Interest	59
K	Useful Addresses and Contacts	60
L	Acknowledgments	61
	SEPA Contacts	62

Information and data relating to air quality are held by many of SEPA's partner organisations. In order to present a picture of the state of the air environment in Scotland, it has been necessary to draw together these data, many of which are held by Local Authorities. The Local Authorities have a long historical involvement in the management of air quality and in the collection of data. Their contribution to this report in the form of the data, which they have given us, is gratefully acknowledged.

The Councils and their contact details are listed at the end of this report, along with the other organisations whose data provision is also acknowledged with thanks.

# Executive Summary

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Alasdair C. Paton  
CHIEF EXECUTIVE

Good air quality is absolutely fundamental not only for people's health but also for the environment. In Scotland as a whole we are justly proud of our excellent air quality, but as this report shows, we should not be complacent.

The overall picture in Scotland is one of good air quality which has been getting better over the last 30 years or so, particularly in urban areas.

But the picture is not perfect. There are some localised problems in Scottish towns, mainly caused by traffic emissions. Other pollution comes from more widespread sources. Acid rain, whilst declining over recent years, is still damaging Scotland's soils, waters and buildings. Low level ozone is regularly measured in parts of rural Scotland at concentrations known to affect vegetation. Nitrogen deposits from air pollution are causing undesirable effects on rivers, lochs, coastal waters and some sensitive natural habitats. Scotland's carbon dioxide emissions are contributing to global climate changes which are likely to have significant long term environmental impacts.

SEPA plays a significant role in reducing air pollution. We use our powers to make sure that industrial emissions are minimised. We work with others, in the public, private and voluntary sectors, and of course with Local Authorities who are key players, towards the common aim of a continuing overall improvement in air quality. The goals and targets against which our progress should be judged are set out in Chapter 6.

This report presents a fascinating picture of the state of Scotland's air environment at the beginning of the 21st century. It brings together information which was previously dispersed or unobtainable. It allows us to take an overview of air quality issues and provides the basis for informed debate about the way forward.

The report could not have been produced without the help of Scotland's 32 Local Authorities, who undertake most air quality monitoring. Their relationship with SEPA is crucial to achieving the improvements we are all seeking, and we look forward to developing this fruitful partnership in the years to come.

A handwritten signature in black ink, appearing to read 'Alasdair Paton', written over a horizontal line.

# 1. Executive Summary

Good air quality is a fundamental aspect of the quality of life and is an essential component of sustainable development. Indeed, the UK Government has identified ambient air quality as a headline indicator for sustainability in its first report on indicators to follow up the UK Sustainable Development Strategy, *A Better Quality of Life* (1999). Poor air quality can contribute to ill health and environmental impacts such as acidification, eutrophication and damage to vegetation and buildings.

Emissions to the atmosphere have an impact on local and national air quality, and it is now clear that emissions of some substances have international and global environmental impacts. For example, emissions of oxides of nitrogen and particulates from road transport and industrial activity affect local and national air quality, while emissions of greenhouse gases such as carbon dioxide and methane are having an effect on the earth's climate. Other emissions such as ozone depleting chemicals have been shown to affect the earth's ozone layer which protects plant and animal life from harmful UV-radiation. Emissions of sulphur dioxide and oxides of nitrogen have contributed to the acidification of sensitive ecosystems in northern Europe and elsewhere. It is, therefore, essential that the effects

of human activities are properly understood and, where necessary, controlled to protect human health and environmental quality.

Deposition of air pollutants onto the land and subsequently into water can also have significant environmental impacts. Acidification and eutrophication of rivers and lochs resulting from air pollution are serious issues for Scotland. However, since the impact is on water quality, those issues are covered in SEPA's report *Improving Scotland's Water Environment*.

The Scottish Environment Protection Agency (SEPA) is responsible for the regulation of air emissions from many industrial processes and from landfill sites. Such emissions contribute significantly to air pollution alongside other sources such as transport, agriculture, domestic and other economic development activities. SEPA must therefore play its part alongside others in ensuring that air quality is protected and improved where necessary and that emissions of other air pollutants, which have the capacity to affect the earth's environment, are carefully controlled.

SEPA was established under the Environment Act 1995 as a Non-Departmental Public Body with responsibility for environmental protection in Scotland. It became fully operational on 1 April 1996 and its main aim is:

*"to provide an efficient and integrated environmental protection system for Scotland which will both improve the environment and contribute to the Government's goal of sustainable development."*

To fulfil this aim, SEPA must operate as an integrated business in its approach to regulatory matters and in undertaking its wider duty to deliver environmental quality improvements.

With respect to air pollution SEPA's duties are to:

- *regulate some 2,000 industrial processes under the system of Local Air Pollution Control. This applies to smaller, generally less complex process where the major concern is air pollution.*
- *regulate around 200 larger industrial processes under the system of Integrated Pollution Control. This applies to the more complex and potentially more polluting industrial processes, where regulation relates to impacts to air, land and water.*
- *promote improvements to local air quality through the UK National Air Quality Strategy. This requires working in partnership with Local Authorities, who have the main responsibility for implementing the Strategy, and 'having regard' to the aims and objectives of the Strategy when carrying out its pollution control functions.*
- *report on the general state of the air environment in Scotland.*
- *have regard to EC legislation pertaining to air pollution, and carry out the necessary measures to meet air quality targets contained therein.*

This report assesses the state of Scotland's air environment and the emissions made to it. The main responsibilities in Scotland for the control of air emissions and for air quality management are identified. SEPA's goals and targets for maintaining and improving air quality and reducing emissions to the air environment are detailed overleaf.

## Report Structure

There are four main chapters with a series of annexes to complement information referred to in the text. These chapters are as follows:

- *Air Quality Management in Scotland*

SEPA has specific statutory duties for preventing and reducing emissions to the atmosphere under the Environmental Protection Act 1990, Part I. These are set out along with information on forthcoming responsibilities under the Integrated Pollution Prevention and Control (IPPC) Directive (EC 96/61). An overview is given of SEPA's review and inspection duties and a summary of the Agency's main aims for air pollution is provided.

The next part of this chapter looks at the UK National Air Quality Strategy (NAQS) and the eight pollutants covered in it. Under the Environment Act 1995, Scottish Local Authorities have a primary role in local air quality management and ensuring that the objectives in the NAQS are achieved by 2005. They are required to review and assess air quality in their area to identify pollution hot spots and pollutants for which the NAQS objectives are not likely to be met. SEPA also has a role in the NAQS and is consulted by Local Authorities during the review and assessment process.



Mineral Extraction, Part B Process



Grangemouth at Night

Finally, this chapter details the main sources of air quality monitoring data in Scotland and the standards and guidelines used to assess air quality.

- *Atmospheric Emission Inventories*

An atmospheric emission inventory is an important tool for identifying and quantifying significant sources of pollution in a locality. SEPA is currently piloting an emission inventory with a view to establishing this approach across the organisation. This chapter introduces the role of an emission inventory and considers national emission trends for sulphur dioxide, nitrogen oxides, carbon monoxide and VOCs, which have decreased since 1995.

The chapter then looks at reductions in mass emissions from industrial plant regulated by SEPA and identifies specific sites where changes to the process operation and the application of new technology have reduced pollution to the atmosphere.

- *Air Quality Review*

This chapter gives an overview of historical trends in air quality to show that considerable improvements have been made throughout the latter part of the twentieth century and at present Scotland's air quality can be regarded as good. However, it is important not to become complacent, and a closer study of local trends in the NAQS pollutants shows the impact of the motor vehicle on urban air quality.

The remainder of this chapter details trends in NAQS pollutants and provides a summary of air quality in Scotland. This is followed by a discussion on the main impacts of the pollutants and their effects on ecosystems, vegetation, buildings, human health and visibility.

- **Air Quality Issues**

The previous chapters identify various trends in air quality and the mechanisms available for reducing emissions in Scotland. In general, Scotland's air quality is good. There are, however, strategic air pollution issues which have a European or international dimension, and which need to be addressed. These include acidification, climate change and ozone depletion and this chapter provides an overview of these problems.



Clydeside Smog, Early 20th Century<sup>12</sup>



Traffic in Edinburgh

This is followed by a study of local air pollution issues, looking at the Forth Valley, air quality in Scottish cities and, finally, diffuse pollution inputs to land and sea.

### Summary of goals and targets:

SEPA will:

- *continue to reduce atmospheric emissions through the use of Best Available Techniques (Not Entailing Excessive Cost) BAT(NEEC)*
- *work to secure at least 90% satisfactory operator performance for regulated processes by 2003*
- *establish an atmospheric emissions inventory which characterises and quantifies all significant emissions from SEPA regulated processes by 2003*
- *work with the Scottish Executive to establish a CO<sub>2</sub> emissions reduction target and take forward relevant and cost effective steps to achieve it*
- *establish as appropriate, regulated emissions reductions targets for other key pollutants*
- *monitor the changes in future energy production which could significantly impact on emissions of CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> over the next 10 to 15 years*
- *continue to develop beneficial relationships with regulated industries, trade bodies and associations*
- *support the revised UK NAQS, including the achievement of its objectives for the eight priority pollutants set for 2003 and 2005*
- *further develop beneficial relationships with other organisations that have responsibility for improving air quality, notably local authorities*
- *establish an air quality database*
- *remain informed on transport issues and continue to encourage the development of a Scottish Transport Strategy which will achieve reductions in vehicle emissions*
- *monitor progress in achieving predictions for the reduction of areas exceeding critical loads for acidification*
- *continue to develop SEPA's understanding of the impact of air emissions and poor air quality on the environment and human health*
- *continue to collect and make available, long-term monitoring data relevant to the assessment of climate change impacts*

## 2. Air Quality Management in Scotland

### 2.1 Scottish Environment Protection Agency

SEPA is a Non Departmental Public Body responsible for the protection of the environment in Scotland. It employs a multidisciplinary staff operating in three regions, with a head office in Stirling (Figure 2.1).

The main elements of legislation, which SEPA must apply, relate to the control of:

- *Emissions to the atmosphere and the aquatic environment*
- *The management and disposal of controlled wastes*
- *Radioactive substances*

SEPA is continually given additional powers and duties, stemming from the Environment Act 1995 and through regulations implementing a range of new EC Directives.

#### SEPA's Air Pollution Responsibilities

SEPA is responsible for the regulation of industrial processes under the Environmental Protection Act 1990, Part I (EPA). The Act introduced a system for authorisation for polluting industries through two systems of pollution control. Major processes (Part A) are controlled under Integrated Pollution Control (IPC) and the smaller and potentially less polluting, although more common processes (Part B), are controlled under Local Air Pollution Control (LAPC) (Table 2.1).

Table 2.1

Number of SEPA Regulated Authorised Processes <sup>a</sup>			
	North Region	East Region	West Region
IPC	43	90	92
LAPC	399	733	675

a) At October 1999

Under BATNEEC, industry is required to take all steps (subject to a test of excessive costs) to prevent, minimise or render harmless releases of a series of prescribed substances listed in the regulations, and to render harmless other releases.

Figure 2.1  
Map of SEPA Regions



Under IPC industrial processes are regulated according to individual site specific judgements of what is BATNEEC and, in the case of the processes likely to give rise to emissions to more than one medium, what is the Best Practicable Environmental Option (BPEO). The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in both the long- and short-term.

The site specificity of BATNEEC judgements means that appropriate account can be taken of local factors, such as air dispersion conditions at the site, peculiarities of site configuration and particularly sensitive local environmental receptors. The requirement for a judgement of the BPEO in the case of most IPC processes means that air quality may not be the sole criterion, unlike for LAPC, according to which decisions about authorisation conditions are taken. Indeed the primary purpose of IPC is to facilitate consideration of the effect of industrial installations on the environment as a whole, of which air quality is frequently a major consideration.

Under LAPC a range of small and potentially less polluting industrial processes are regulated for emissions to air only, including mobile plant (i.e. those designed to move or be moved on roads). Processes releasing substances in 'trivial' amounts (except where the release results in an offensive smell outside the premises) are exempt from EPA 1990, as are engines for propelling most forms of transport, such as aircraft or road vehicles. There are approximately 1800 LAPC authorised processes in Scotland, currently. This number has markedly increased through an amendment to the Environmental Protection (Prescribed Processes and Substances) Regulations in 1996 which requires the authorisation of petrol stations and terminals over a certain size to control emissions of Volatile Organic Compounds (VOCs) resulting from storage and distribution of petrol.

air and water. In addition to these media, IPPC will require consideration of the condition of the site when the installation closes, energy efficiency, waste reduction, noise, vibration and heat, consumption of raw materials and accident prevention. IPPC will provide SEPA with greater powers to control and regulate industry. In Scotland, approximately 500 new installations will come under IPPC in addition to about 220 existing IPC and 1800 LAPC processes. Some food processing and intensive agriculture installations will fall into the new IPPC regime. These are currently not regulated under either IPC or LAPC.

The implementation of the IPPC Directive will also result in certain Part B processes, such as animal rendering plants, requiring full authorisation (or permitting) under IPPC.

### How will IPPC help SEPA to control pollution?

- *Many more installations will come under IPPC than currently come under IPC*
- *IPPC takes into account more environmental impacts than IPC including noise, accident prevention and energy efficiency*
- *IPPC applies to installations, whereas IPC applies only to processes*
- *IPPC does not exempt installations that only give rise to trivial emissions*
- *IPPC allows Member States to make general binding rules instead of site specific conditions in authorisations*
- *IPPC allows for information exchange between EU Member States and within industry*

From October 1999 all EU Member States will have to incorporate the requirements of EC Directive 96/61 on IPPC into their national legislation. New industrial installations, listed in the Directive, must comply with IPPC immediately and existing installations are allowed a transitional period until 2007. IPPC will be enforced in Scotland by SEPA through regulations made under the Pollution Prevention and Control Act 1999, which will ultimately replace EPA 1990, Part I.

There are a number of important differences between IPPC and IPC. Under the Directive there is a requirement that certain industrial installations prevent or reduce pollution from their operations using Best Available Techniques (BAT). IPPC applies to installations whereas IPC applies to processes. An installation is a stationary unit where one or more activities are carried out and includes any other directly associated activities with a technical connection which could have an effect on emissions and pollution. This means that associated activities, such as fuel storage, will now also have to apply BAT. IPC only takes into account immediate effects on land,

### Reviews and Inspections

One of SEPA's key activities is the enforcement of authorisation conditions through inspections and reviews. There is a statutory requirement under EPA 1990 that all authorisations are reviewed not less than once every four years. Reviews are particularly important, as they are a means of ensuring that emission controls are in line with developments in pollution control techniques.

The number of reviews carried out by SEPA increased in 1998/99 more than three fold compared to the previous year and represented about half of all IPC authorisations and approximately 40% of all principal LAPC authorisations (Table 2.2). In 1998/99 enforcement action resulted in final warning letters being issued against three IPC and 21 LAPC processes respectively. Two convictions were secured and 10 enforcement notices were also issued against LAPC processes. There were 1,986 complaints concerning IPC and LAPC processes in 1998/99, of which 82% were responded to within 24 hours.

Table 2.2

Number of Inspections and Reviews				
	Inspections		Reviews	
	LAPC	IPC	LAPC	IPC
1997/98	2203	471	151	21
1998/99	1793	682	502	94

### Operator Performance Assessment (OPA)

OPA was introduced for the first time during 1998/99. The procedure provides a systematic methodology for judging whether an operator has complied with the terms and conditions of their authorisation.

The information provides useful guidance to gauge SEPA's performance as a regulator and also provides feedback to the operator. In addition OPA acts as a form of risk assessment on how often process inspections may be carried out. A plant returning an unsatisfactory performance may require more frequent inspections.

Table 2.3

Results of OPA for 1998/99			
	No. of assessments	Satisfactory (%)	Target (%)
IPC	110	90	80
LAPC	931	74	80

During 1998/99 approximately half of all the IPC processes were assessed, 90% of which were found to be satisfactory (Table 2.3). More than half of all LAPC processes were assessed, 74% of which were found to be satisfactory.

### Monitoring Programmes

Most authorisations granted under IPC and LAPC regimes contain conditions requiring operators of prescribed processes to monitor certain emissions. In addition to the monitoring undertaken by operators, SEPA also select sites for audit monitoring. Monitoring, whether in the form of measurement of discharges or ambient air quality, may be undertaken where there is either:

- *concern over the sample or analytical methods used by the operator*
- *concern over the results from operator monitoring*
- *any lack of confidence in operator compliance monitoring*

Roadside Air Quality Monitoring Station in Aberdeen



- *a release to air is significant*
- *concerns about the impact or potential of a release into the air*
- *low scores in OPA*
- *a process is under complaint*
- *to provide independent data on a discharge*

SEPA is increasing its audit monitoring programme on emissions to air to ensure public confidence in the IPC and LAPC control regimes which both rely on self monitoring by operators. In 1998/99 372 samples were taken.

### SEPA's Aims

SEPA continually seeks to improve the performance of its activities (see SEPA Air Pollution Aims overleaf). SEPA's Environmental Strategy identifies key strategic statements that will direct future policy and operations within the Agency. With regard to air quality the Agency aims to reduce atmospheric emissions; encourage research and development in air pollution; pursue the objectives of the NAQS; educate, advise and develop links with interested parties on air quality issues; formulate views and opinions on various instruments and policies; and collect data and information on air quality.



## SEPA Air Pollution Aims

- *Continue to reduce atmospheric emissions through use of BATNEEC and BPEO*
- *Bring forward itself, or encourage others to carry out, research and development in the transportation, trends and impacts of atmospheric emissions*
- *Pursue the objectives of the NAQS including attaining air quality standards and regulation of ground level O<sub>3</sub> formation precursors*
- *Encourage planners to ensure that the planning system takes account of emissions from transport*
- *Provide clear focused advice to encourage the inclusion of a wider range of pollutants in the NAQS*
- *Establish an atmospheric emissions inventory*
- *Develop links with Scottish Local Authorities and give advice in respect of compliance with the NAQS*
- *Collect data for an air quality database*
- *Formulate its views on the use of economic instruments to make progress towards the Government's targets for reducing CO<sub>2</sub> emissions from all sources*
- *Encourage planners to ensure that the planning system takes account of the Government's CO<sub>2</sub> targets and other energy supply issues*
- *Formulate a view on using economic instruments to reduce fossil fuel use*
- *Increase its understanding of the potential contribution of sea salt in rainfall to acidification*
- *Encourage others to develop a Scottish energy and transport policy, which will contribute to meeting Government SO<sub>2</sub>/NO<sub>x</sub> targets*

## 2.2 NAQS Air Quality Pollutants

The NAQS focuses upon the concerns of eight pollutants (see Annex A) and sets air quality criteria to be met by 2005 (see Table 2.4 and Annex B).

The Strategy is based on two broad trends which have been brought together to provide a strategic and integrated approach to air quality management.

The first strand was the enhancement of the principles of sustainable development and the second element was the broader understanding at national and international levels of air pollution and the legal instruments to tackle it (see Annex C).

Where statutory air quality standards are likely to be exceeded, SEPA is required by legislation to consider what contribution an authorised process might make to achieve them. SEPA must therefore have regard to the NAQS in the performance of its pollution control functions. However, SEPA has no regulatory responsibilities for the control of emissions from transportation.

All of the pollutants identified in the NAQS are prescribed substances for release to air, with the exception of O<sub>3</sub>, which is a secondary pollutant. The precursors of O<sub>3</sub>, VOCs and NO<sub>x</sub>, are both prescribed substances. Industrial processes, regulated by SEPA, emit a large number of prescribed

substances other than those listed in the NAQS.

This report focuses on the pollutants detailed in the NAQS as they have been identified as priority pollutants with potentially significant effects on the environment and human health. However, some NAQS pollutants contribute to the formation of secondary pollution problems such as acid deposition, ozone formation and depletion, and therefore these issues are also detailed in this report.

The NAQS has recently been revised, as *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland Working Together for Clean Air (2000)*, in accordance with the requirements of the Environment Act 1995. It recommends bringing forward target compliance dates for CO, 1,3-butadiene and benzene from 2005 to 2003 and tightening or introducing revised air quality standards for PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>2</sub> and Pb (see Table 2.4). There are also two new objectives to protect vegetation and ecosystems.

The list of pollutants in the NAQS is not fixed. The Government and the devolved administrations will consider setting objectives for additional pollutants as new evidence that would justify doing so becomes available, or as the EC brings forward proposals for legislation covering further pollutants. For example, there is emerging evidence to suggest that the health effects of particulates are due principally to fine particles (PM<sub>2.5</sub>).

Table 2.4

NAQS Objectives	
<b>Objectives for the protection of human health</b>	
SO <sub>2</sub>	(a) 15-min mean of 266 µg/m <sup>3</sup> (100 ppb) not to be exceeded more than 35 tpy by 31 December 2000 (b) 1-hr mean of 350 µg/m <sup>3</sup> (132 ppb) not to be exceeded more than 24 tpy by 31 December 2004 (c) 24-hr mean of 125 µg/m <sup>3</sup> (47 ppb) not to be exceeded more than 3 tpy by 31 December 2004
Benzene	Annual mean of 16.25 µg/m <sup>3</sup> (5 ppb) by 31 December 2003
1,3-Butadiene	Annual mean of 2.25 µg/m <sup>3</sup> (1 ppb) by 31 December 2003
CO	Running 8-hr mean of 11.6 mg/m <sup>3</sup> (10 ppm) by 31 December 2003
Lead (Pb)	Annual mean of 0.5 µg/m <sup>3</sup> by 31 December 2004 and 0.25 µg/m <sup>3</sup> by 31 December 2008
NO <sub>2</sub> *	(a) 1-hr mean of 200 µg/m <sup>3</sup> (105 ppb) by 31 December 2005 not to be exceeded more than 18 tpy (b) Annual mean of 40 µg/m <sup>3</sup> (21 ppb) by 31 December 2005
O <sub>3</sub> *	8-hr mean of 100 µg/m <sup>3</sup> (50 ppb) not to be exceeded more than 10 tpy by 31 December 2005
PM <sub>10</sub>	(a) Annual mean of 40 µg/m <sup>3</sup> by 31 December 2004 (b) 24-hr mean of 50 µg/m <sup>3</sup> by 31 December 2004
<b>Objectives for the protection of vegetation and ecosystem</b>	
NO <sub>2</sub>	Annual mean for the protection of vegetation of 30 µg/m <sup>3</sup> (16 ppb) by 31 December 2000
SO <sub>2</sub>	Annual mean for the protection of vegetation 20 µg/m <sup>3</sup> (8 ppb) by 31 December 2000 and 20 µg/m <sup>3</sup> (8 ppb) winter average (October to March) by 31 December 2000

tpy times per year

\* The objectives for O<sub>3</sub> and NO<sub>2</sub> are provisional

The Expert Panel on Air Quality Standards (EPAQS) has recognised that PM<sub>2.5</sub> might better represent the toxic fraction of particulate air pollution, and that a PM<sub>2.5</sub> standard may be a desirable objective. Polycyclic aromatic hydrocarbons (PAHs), which occur as both gases and associated with particles, are another pollutant of concern. Several of the individual PAHs have been shown to be carcinogenic. EPAQS have recommended an air quality standard (AQS) for PAHs using benzo[a]pyrene as a marker. This recommendation is currently being reviewed.

## 2.3 The Local Authority Role in Air Quality Management

There are occasions when Local Authorities have to resort to enforcement to secure local improvements in air quality. Local Authorities remain responsible for a number of statutes designed for this purpose. Unlike in England and Wales where Local Authorities share with the Environment Agency for England and Wales the responsibilities for controlling emissions from IPC and LAPC processes, SEPA has sole responsibility. Nevertheless, Scottish Local Authorities still have important responsibilities to enforce statutory nuisance legislation under the Part III of EPA 1990 and enforcement of the Clean Air Act 1993, which includes regulation of smoke, grit, dust and fumes from furnaces and for the implementation and enforcement of smoke control.

Under the Environment Act 1995, Local Authorities are also required to review and assess air quality within their areas to see if any of the NAQS objectives are unlikely to be met. In this event a further more detailed assessment will be required for areas of concern. Any areas in which air quality will not or is unlikely to meet the NAQS objectives must be designated an Air Quality Management Area. The Local Authority must draw up an action plan, within 12 months of designation, for each area detailing measures and target dates in order to meet the objectives<sup>1</sup>. The air quality assessments are to be carried out in three progressive stages, of which all Local Authorities have now completed their First Stage Reviews.



Road Traffic is the main source of air pollution in urban areas.

### First Stage Review

The First Stage requires collation of information on any existing or proposed pollution sources within the Local Authority's area or the wider vicinity outwith the Local Authority boundaries which may affect their air quality. The potential population exposure to these pollutants should be assessed against the NAQS objectives. Following the First Stage Review, the Local Authority will be in a position to demonstrate that all potentially significant pollutant sources have been considered; that sufficient information has been collected on these sources; and that the need to proceed to the Second Stage within the assessment process has been fully considered<sup>1</sup>.

#### First Stage Review Reports



### Second Stage Review

The Second Stage Review focuses on the areas where the highest pollutant concentrations are likely to occur. In these areas, the Local Authority is required to identify general locations, which may not meet the NAQS objectives. Within these areas ground level concentrations should be estimated where there is greatest risk of exceedance, such as combinations of road side and industrial sources, using available air quality monitoring data, and carrying out screening modelling studies. These estimations should allow the Local Authority to predict or evaluate air quality both now and in 2005<sup>1</sup>.

### Third Stage Review

The Third Stage comprises a more detailed assessment of current and future air quality. This will require more advanced air dispersion modelling and monitoring techniques. On completion of the review a Local Authority should be able to evaluate whether the NAQS objectives will be met or where exceedances might occur. Third Stage Review techniques may include detailed emission inventories and validated air

dispersion modelling, backed up by a continuous automatic air quality monitoring exercise<sup>1</sup>.

Many Local Authorities are presently appraising their position following their First Stage Reviews and are consulting with SEPA and the Scottish Executive on whether they need to progress to a further review. Some Local Authorities, predominantly rural, are unlikely to progress to either a Second or Third Stage Review. However, for Councils that have a high percentage of urban or industrial emissions, it is likely that a more detailed assessment may be required. Some Local Authorities have already embarked upon their Second or Third Stage Reviews. Local Authorities are expected to submit their Stage 3 Reviews and Assessments by June 2000. The Department of the Environment, Transport and the Regions (DETR) and the Scottish Executive are currently evaluating the appropriate methodologies for measuring and assessing PM<sub>10</sub> and the standard is under review.

The decision on whether a Local Authority should proceed to a Second Stage Review has, in part, been hindered by a lack of information. Some First Stage Reviews were undertaken before guidance on the specific information requirements for the Review was available. Other Local Authorities did not have all the data or resources required in the guidance to fully assess whether they should progress a Second Stage Review. Also some rural Local Authorities had limited information on air quality for their area which further hindered their assessments. Consequently, certain Local Authorities are extending the information given in their First Stage Reports and are consulting with SEPA on these.



Cement Batching Plant, Part B Process

## 2.4 SEPA's Role in Local Air Quality Management

Under the Environment Act 1995 SEPA has reserve powers, acting with the approval of the Secretary of State, to carry out a review of air quality within the area of a Local Authority:

- *To assess whether NAQS objectives are being met*
- *To identify those parts of a Local Authority area where it seems objectives and standards are not being met*
- *To make an assessment of the possible reasons why they are not being met either within the area of the Local Authority or within a designated area*

Both the Local Authorities and SEPA have a common objective to ensure that health risks from air pollution are minimal under the NAQS. Effective control of authorised industrial processes by SEPA will contribute to the overall management of air quality in Local Authority areas. SEPA must have regard to the NAQS in the performance of their pollution control functions. However, for many Local Authorities the principal air emissions are not industrial based. Instead, motor vehicles, commercial or domestic sources predominate.



Vapour Recovery at a Filling Station, Part B Process

Under these circumstances the role of SEPA is likely to be more advisory. For highly industrialised areas SEPA's involvement on local air quality management issues is likely to be more substantial. The regimes of BATNEEC and BPEO will have a significant part to play in the improvement of air quality. SEPA is currently advising Local Authorities on the preparation of their local air quality management assessment reports.

A Memorandum of Understanding between SEPA and the Convention of Scottish Local Authorities (COSLA) in 1996 agreed outline working arrangements and communications on all the various aspects, in which both parties have responsibilities, including air quality management. SEPA's aim is to continue to develop liaisons with COSLA and Local Authorities and give advice in respect to air pollution issues.



Longannet Power Station, Part A Process

## 2.5 Air Quality Standards and Guidelines

The aim of AQS is to provide a basis for protecting public health from adverse effects of air pollutants and eliminate, or reduce to a minimum, exposure to those pollutants that are known, or are likely, to be hazardous to human health or well being (see below)<sup>2</sup>.

The DETR have identified<sup>48</sup> that AQS and guidelines are pollutant levels that are considered to be acceptable in the light of what is known about the effects of each pollutant on human health and on the environment. The standards can be used to review air pollution and also to see if air pollution is getting better or worse (see Annex B). Although health effects are a major consideration in establishing AQS, ecological guidelines for preventing adverse effects on terrestrial vegetation are also considered.

### WHAT IS AIR POLLUTION?

Air Pollution can be defined as the presence in the external atmosphere of one or more contaminants (pollutants), or combinations thereof, in such quantities and of such duration as may be or may tend to be injurious to human health, plant or animal life, or property (materials), or which unreasonably interfere with the comfortable enjoyment of life, or property, or the conduct of business<sup>56</sup>

Table 2.5

Current Local Authority Monitoring in Scotland <sup>a,b,c</sup>								
Local Authority	Pollutants							
	CO	NO <sub>2</sub>	SO <sub>2</sub>	PM <sub>10</sub>	O <sub>3</sub>	Pb	Benzene	1,3-Butadiene
Aberdeenshire		✓	✓					
Aberdeen City	✓	✓	✓	✓				
Angus	✓	✓	✓	✓				
Argyll and Bute		✓	✓					
Clackmannanshire		✓	✓					
Comhairle nan Eilean Siar		✓						
Dumfries and Galloway		✓	✓					
Dundee City	✓	✓	✓	✓		✓	✓	
East Ayrshire		✓	✓	✓			✓	✓
East Dunbartonshire		✓	✓					
East Lothian		✓		✓			✓	
East Renfrewshire		✓	✓	✓		✓		
City of Edinburgh	✓	✓	✓	✓	✓		✓	✓
Falkirk	✓	✓	✓	✓		✓	✓	✓
Fife		✓	✓					
Glasgow City	✓	✓	✓	✓	✓	✓	✓	
Highland		✓						
Inverclyde		✓						
Midlothian		✓	✓					
Moray		✓	✓					
North Ayrshire	✓	✓	✓	✓				
North Lanarkshire		✓	✓	✓	✓	✓		
Orkney Islands		✓	✓				✓	
Perth and Kinross	✓	✓	✓	✓				
Renfrewshire		✓						
Scottish Borders		✓	✓	✓				
Shetland Islands								
South Ayrshire		✓			✓		✓	✓
South Lanarkshire	✓	✓	✓	✓	✓			
Stirling		✓	✓					
West Dunbartonshire		✓		✓				
West Lothian	✓	✓	✓	✓			✓	

a) An Assessment of Air Quality Monitoring in Scotland, Central Research Unit, The Scottish Office, 1998

b) DETR Air Pollution in the UK, July 1998

c) Modified following consultation with Local Authorities

✓ Indicates current monitoring of particular pollutant at the beginning of 2000

## 2.6 Measuring Air Quality

### Air Quality Networks

The DETR funds a network of air quality monitoring sites throughout the UK known as the UK Air Monitoring Network (UKAMN) which also is partially funded by the Scottish Executive. The network is organised into three automatic and six sampler based programmes, operated by the National Environmental Technology Centre (NETCEN). Much of the UKAMN data is collected by Local Authorities on behalf of the DETR and NETCEN (see Annex D).

### Local Authority Monitoring

In addition to the DETR/NETCEN monitoring sites, individual Local Authorities carry out their own air quality monitoring programmes as part of their local air quality management responsibilities under the Environment Act 1995 (Table 2.5). The extent of their monitoring is variable across Scotland, but is generally operated and co-ordinated by the Environmental Health Departments in each Local Authority<sup>1</sup>. Many Local Authorities have previously carried out discrete projects aimed at specific problems. These have targeted specific pollutants and monitored sites which are potential 'problem' areas such as traffic related pollution problems.

### Additional Sources of Monitoring Data

In addition to the UKAMN and Local Authority monitoring networks, air quality monitoring may also be carried out at a localised scale by various other interested bodies. For example<sup>1</sup>:

- IPC and LAPC processes may be required to carry out ambient air quality monitoring as part of their authorisations regulated by SEPA (see Section 2.1)
- Universities and educational institutions may carry out ambient air quality monitoring as part of research projects
- Research organisations and institutes (e.g. Institute of Terrestrial Ecology)
- Local action/pressure groups may commission their own air quality monitoring if sources of emissions give rise to local concerns

Table 2.6

UKAMN in Scotland <sup>a</sup>			
Network	Type of sampling (see Annex D)	No. Sites	Pollutants monitored
Automatic urban	Automatic	5 <sup>b</sup>	NO <sub>2</sub> , CO, SO <sub>2</sub> , PM <sub>10</sub> , O <sub>3</sub>
Automatic hydrocarbon	Automatic	1	Benzene, 1,3-Butadiene and other hydrocarbon species
Automatic rural	Automatic	3 <sup>b</sup>	O <sub>3</sub> , NO <sub>2</sub> , SO <sub>2</sub>
NO <sub>2</sub> diffusion tubes	Passive	108 (1998)	NO <sub>2</sub>
Smoke and SO <sub>2</sub>	Active	45 (1997)	Smoke and SO <sub>2</sub>
Acid deposition	Active/passive	8	anions and cations
Rural SO <sub>2</sub>	Passive	7	SO <sub>2</sub>
Lead	Active	3	Lead
TOMPS	Active	2	PAH, PCB, dioxins

a) DETR Internet Site <http://www.aeat.co.uk/netcen/airqual> October 1999

b) Not all the pollutants may be monitored at each site.



Passive Monitoring Using Diffusion Tubes

## Monitoring Sites in Scotland

Similar to the rest of the UK, monitoring of different pollutants is carried out extensively as part of the UKAMN in Scotland (Table 2.6). In addition many Local Authorities undertake their own studies.

The extent of monitoring has significantly increased since the mid-1970s when most measurements were limited, in many Local Authorities, to SO<sub>2</sub>, smoke and particulates. Today most Local Authorities are carrying out more ambitious forms of monitoring although rural areas still have lower levels of monitoring compared to urban localities.

The principal pollutants monitored by Local Authorities are NO<sub>2</sub> and SO<sub>2</sub>. NO<sub>2</sub> is monitored using an extensive network of diffusion tubes, to give monthly average concentrations, as part of the UK National Nitrogen Dioxide Diffusion Tube Survey with over 108 sites in Scotland. While the results from this network do not allow direct comparison with short-term UK AQS, they can be compared to the annual mean UK AQS.

Diffusion tubes allow easy and cost effective measurement of NO<sub>2</sub> concentrations and are therefore of great use to Local Authorities in carrying out their assessments of air quality. Typically the diffusion tubes are distributed throughout city and town centres. A limited number are located in rural areas, however, the majority are between Edinburgh and Glasgow, within a reasonable distance of main roads and potential industrial sources.

In addition to the UK National Nitrogen Dioxide Diffusion Tube Survey, Local Authorities are carrying out their own NO<sub>2</sub> monitoring at more than 250 other sites across Scotland. Although the vast majority of the monitoring is carried out using diffusion tubes, a limited number of Local Authorities operate automatic sites (e.g. Glasgow, Aberdeen, Edinburgh, Falkirk). SO<sub>2</sub> is also widely monitored using diffusion tubes and, with smoke, at nearly 50 sites together using the daily volumetric apparatus and at seven rural sites as part of the UKAMN rural network. Pb and O<sub>3</sub> are monitored at three sites and benzene and 1,3-butadiene are monitored at one automatic site. Total organic micro-pollutants (TOMPS) are also measured at several sites in Scotland.

## 3. Atmospheric Emission Inventories

Table 3.1

Emission Sources of NAQS Pollutants <sup>1</sup>		
Industrial sector	Sub-section	Pollutants emitted
Fuel production and combustion processes	Gasification, carbonisation and combustion processes	NO <sub>2</sub> , SO <sub>2</sub> , CO, PM <sub>10</sub> , VOCs, lead
	Petroleum processes	PM <sub>10</sub> , benzene, 1,3-butadiene, VOCs
Metal production and processing	Iron and steel	PM <sub>10</sub> , lead
	Non-ferrous	Lead, PM <sub>10</sub> , SO <sub>2</sub> , VOCs
Mineral industries	All sections	NO <sub>2</sub> , SO <sub>2</sub> , CO, PM <sub>10</sub> , VOCs, lead
Chemical industries	All sections	NO <sub>2</sub> , SO <sub>2</sub> , CO, PM <sub>10</sub> , VOCs
Waste disposal and recycling	Incineration and the production of fuel from waste	NO <sub>2</sub> , SO <sub>2</sub> , CO, PM <sub>10</sub> , VOCs, lead
	Recovery	VOCs
Other industries	Pulp and paper	NO <sub>2</sub> , SO <sub>2</sub> , PM <sub>10</sub> , VOCs,
	Di-isocyanate processes	PM <sub>10</sub>
	Tar and bitumen	VOCs, PM <sub>10</sub>
	Coating processes and printing	VOCs, CO, NO <sub>2</sub> , PM <sub>10</sub>
	Manufacture of dyestuffs and coatings	VOCs, CO, NO <sub>2</sub> , PM <sub>10</sub>
	Timber	VOCs, PM <sub>10</sub>
	Rubber	VOCs, CO, NO <sub>2</sub> , PM <sub>10</sub>
	Animal and vegetable matter processing	SO <sub>2</sub> , NO <sub>2</sub> , PM <sub>10</sub>

The purpose of an emission inventory is to identify and quantify sources of emissions to the atmosphere.

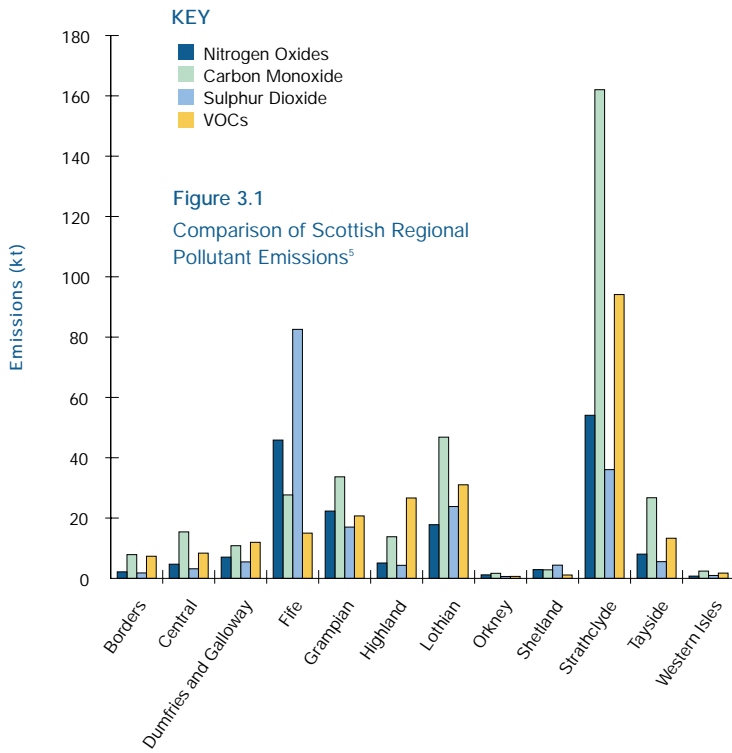
An inventory requires the compilation of data on the nature and characteristics of the individual sources, and processing it to calculate emissions for the pollutant of interest. An inventory allows an assessment of the relative significance of the different air pollution sources, and an examination of their spatial distribution across a defined area. In addition inventories help to refine air quality monitoring strategies; facilitate an assessment of trends in air quality; and help identify pollutant sources that may need emission control<sup>3</sup>. Knowledge of the nature of sources and their associated pollutant emissions are necessary for effective pollution control. SEPA is quantifying the emissions from principal authorised processes and SEPA East Region are piloting an emission inventory study for the Forth Valley that will be eventually adopted across SEPA. SEPA North Region has also started an emission inventory of their IPC processes along the same lines as the East Region study.

Pollutants may be emitted from point, area or line sources, each having their own distinct emission characteristics. Point sources include stacks and flues. Area sources are groupings of small sources spread over a delineated area such as industrial complexes, and mobile sources include motor vehicles or aircraft<sup>2</sup>.

### 3.1 UK National Atmospheric Emissions Inventory (NAEI)

The NAEI has been developed to cover the entire UK. In the inventory the total emissions for each pollutant are derived from national data and then attributed to each one kilometre grid square on the basis of population density (major large emission sources such as major roads and IPC processes are entered separately). While this type of emission inventory is useful on a general basis, it lacks detailed local information<sup>4</sup>.

The NAEI for Scotland shows that the largest emissions of NO<sub>x</sub>, SO<sub>2</sub>, CO and VOC occur in the central belt and along the eastern coastline, Dundee and Aberdeen, to Inverness. Emissions diminish north and south of the central belt. The pollutant emissions of particular concern to SEPA are those emitted from industrial processes (see Table 3.1).

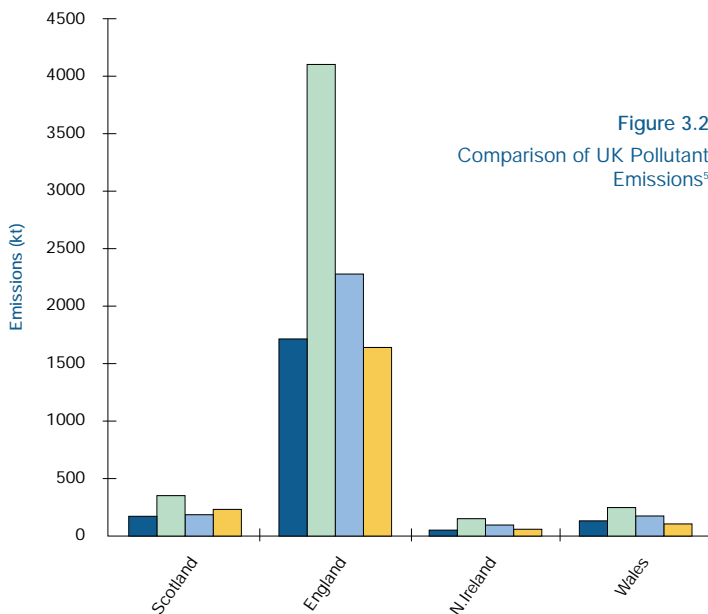


### 3.2 Emission Inventory Data for Scotland

#### National emissions

Pollutant emissions vary considerably across Scotland (Figure 3.1). The Strathclyde area accounts for 32%, 19%, 46% and 41% of NO<sub>x</sub>, SO<sub>2</sub>, CO and VOC of total national emissions respectively. The regional spread of emissions is generally reflected by the distribution of population, industry and road network. Rural areas have the lowest pollutant emission rates.

A comparison of national emissions show that Scotland's emissions account for approximately 8%, 7%, 7% and 11% of NO<sub>x</sub>, CO, SO<sub>2</sub> and VOC of total UK emissions respectively (Figure 3.2). Compared to total EU Member State emissions Scotland's contribution is minor, accounting for significantly less than 1% of NO<sub>x</sub>, CO, and SO<sub>2</sub> respectively. For VOC Scotland's contribution is about 1% of total emissions (Figure 3.3). Estimates for UK CO, VOC, NO<sub>x</sub> and SO<sub>2</sub> total emissions in 2005 show a 61%, 34%, 17% and 46% reduction respectively on 1995 levels<sup>6</sup>.



#### Local emissions

To gain an appreciation of localised emission sources the DETR has funded the compilation of more detailed inventories in a number of urban and industrial areas of the UK. These inventories are compiled on a bottom-up principle, using local detailed inventory data, and address the limitations of the NAEI. In Scotland, the City of Glasgow was included in this programme<sup>3</sup>.

The inventory showed that within the City of Glasgow motor vehicles were the most dominant pollutant source contributing more than 76%, 95%, 92%, 98% and 73% of NO<sub>x</sub>, CO, benzene, 1,3-butadiene and PM<sub>10</sub> emissions respectively (Table 3.2).

The contribution of industry to total emission levels is less of a concern in Glasgow than for other urban areas. Commercial, residential and industrial combustion sources accounted for 64% and 66% of SO<sub>2</sub> and CO<sub>2</sub> emissions respectively. Industrial processes and solvent use accounted for 36% of VOC emissions.

Similar comparisons were also found for an emission inventory study undertaken by the City of Edinburgh Council<sup>7</sup> although a higher proportion of SO<sub>2</sub> emissions were estimated to be from the transport sector. Emissions for Glasgow and Edinburgh account for approximately 32%, 1% and 25% of NO<sub>x</sub>, SO<sub>2</sub> and CO of total Scottish emissions respectively (Table 3.3).

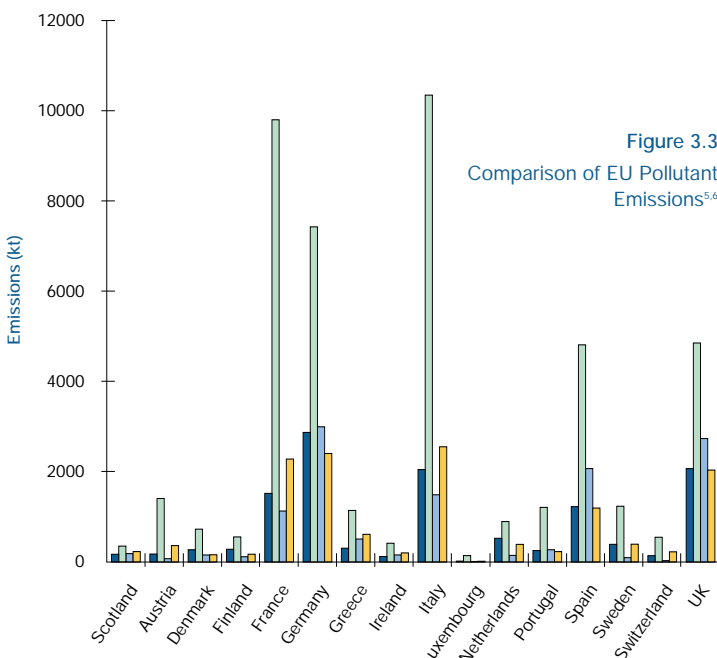




Table 3.2

Contribution of Transport to Emissions (%) <sup>3,7</sup>		
	Edinburgh	Glasgow
NO <sub>x</sub>	96	76
SO <sub>2</sub>	94	28
CO	99.8	95
CO <sub>2</sub>	-	29
VOC	-	56
Benzene	98	92
1, 3-butadiene	100	98
PM <sub>10</sub>	62.4	73

### 3.3 Transboundary Emissions

All countries are estimated to export a very large fraction of their emissions. Over 75% of SO<sub>x</sub> emissions are exported from most European countries and most countries export more than 80% of their NO<sub>x</sub>. Reduced nitrogen is not transported as far, however, with all countries exporting more than 40% of their emissions<sup>6</sup>. Typically across Europe reduced nitrogen shows the most rapid depletion and, therefore, deposition away from the emitting source or country shows the steepest

Table 3.3

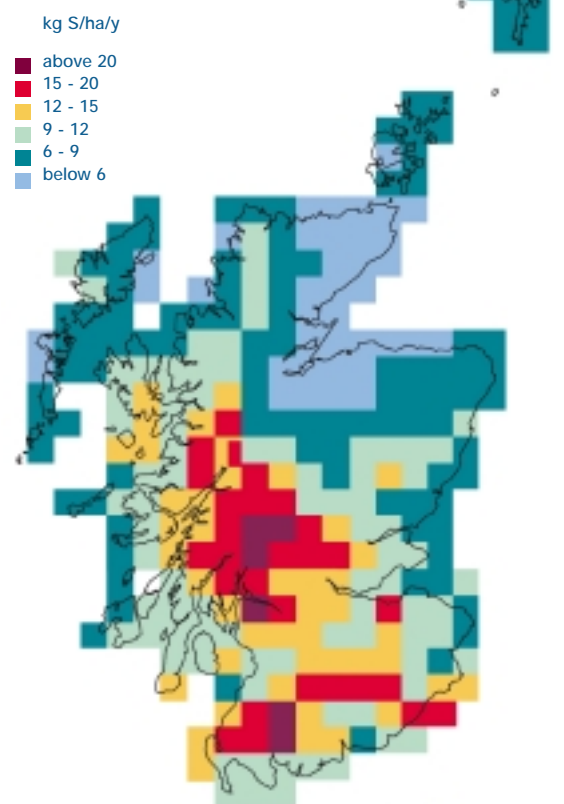
Total Emissions of Pollutants for Glasgow and Edinburgh (t/a) <sup>3,7</sup>		
	Edinburgh	Glasgow
NO <sub>x</sub>	10790 <sup>a</sup>	11894
SO <sub>2</sub>	601	1798
CO	49816	36726
CO <sub>2</sub>	-	2721000
VOC	-	13514
Benzene	295	308
1, 3-butadiene	88	70
PM <sub>10</sub>	912.4	1023

a) NO<sub>2</sub>

gradient and restricted field of influence. This pattern is then followed by SO<sub>x</sub> with NO<sub>x</sub> demonstrating a lesser initial depletion that is it has a lower dispersion gradient and a wider field of influence. These dispersion patterns are reflected in the overall export and import budgets of these pollutants for European countries.

Studies have estimated the transboundary budgets, both import and export, of emissions for the UK<sup>6, 11</sup>. The UK imports 20% of total SO<sub>x</sub> depositions and exports 81% of emissions. With regard to NO<sub>x</sub> annual import and export levels are 39% and 90% respectively. For reduced nitrogen they are 20% and 50% respectively. The percentage of emissions retained in the UK for sulphur and nitrogen oxides are 75% and 68% respectively. For reduced nitrogen the value is 90%<sup>6</sup>.

Figure 3.4  
Sulphur Deposition in Scotland<sup>43</sup>



Studies relating to Scotland<sup>43</sup> show that European sources account for 44% of the total sulphur deposition annually on the Scottish landscape. English and Welsh sources account for 33% of emissions, Northern Ireland 4% and Scottish sources a maximum of 19%. It is possible that some of the sulphur attributed to Scottish low level sources may be from sources in Northern Ireland or the North of England.

Results indicate that at least 80% of sulphur deposited in Scotland comes from sources outside the country, but also that 80% of sulphur emitted in Scotland is exported. The spatial distribution of sulphur across Scotland shows greatest levels in the west central highlands (Figure 3.4).

## 3.4 Industrial Emission Reductions

### Large Combustion Plants

Emissions of SO<sub>2</sub> and NO<sub>x</sub> are particularly important at the regional and transboundary level, as they are the precursors to the formation of acid deposition (see Section 5.1). Significant emissions of these pollutants arise from the combustion of fossil fuels in large industrial boilers or heaters which are used in the refining of crude oil, the generation of electricity and manufacturing industries. SEPA is under a statutory requirement to ensure that emissions from these activities, which are regulated under IPC, make an appropriate contribution to the reductions in emissions of these pollutants required under various international treaties and EC legislation (see Annex C).

The most important of these are the UNECE Second Sulphur Protocol and the Large Combustion Plant (LCP) Directive (88/609/EEC). The relevant emission reductions are delivered by ensuring all such plant is operated and upgraded in accordance with the requirements of BATNEEC.

Table 3.4

Emissions of SO <sub>2</sub> and NO <sub>x</sub> from Large Combustion Plant in Scotland (kt/a) <sup>8</sup>			
	1996	1997	1998
SO <sub>2</sub>			
Electricity supply industry	99.1	90.5	77.0
Refinery	11.3	14.2	10.0
Other industries	2.5	3.0	2.2
NO <sub>x</sub>			
Electricity supply industry	44.7	38.9	38.3
Refinery	2.9	3.4	3.4
Other industries	1.5	2.1	1.8

It is estimated that large combustion plants account for around 90% of SO<sub>2</sub> emissions and less than 50% of NO<sub>x</sub> emissions in Scotland<sup>8</sup>. The principal source of NO<sub>x</sub> emissions are motor vehicles (see Annex A). Overall, SO<sub>2</sub> and NO<sub>x</sub> emissions from large combustion plant were considerably less in 1998 than in 1996 with 20% and 10% reductions in SO<sub>2</sub> and NO<sub>x</sub> emissions respectively (Table 3.4).

Two of Scotland's major power stations are Longannet and Peterhead, both of which have, or are undergoing, significant upgrading programmes to meet IPC legislative requirements.

### Longannet Power Station

Longannet Power Station lies on the northern bank of the Forth estuary close to Kincardine Bridge. The coal fired power station comprises four 600 MWe units. Total emissions for the plant for 1998/99 were 48.8 and 19.2 kt/a for SO<sub>2</sub> and NO<sub>x</sub> respectively, and are the most significant power station emissions in Scotland (Table 3.5).

Table 3.5

SO <sub>2</sub> and NO <sub>x</sub> Emissions from Principal Power Stations in Scotland (kt/a) <sup>9,10</sup>		
	NO <sub>x</sub>	SO <sub>2</sub>
Longannet <sup>a</sup>	19.2	48.8
Cockenzie <sup>a</sup>	10.2	19.2
Peterhead <sup>b</sup>	8.5	3.1

a) April 1998 - March 1999

b) 1998

The low sulphur levels in coal, approximately 0.3% - 0.6%, presently limit further SO<sub>2</sub> emission reductions. The sulphur coal content levels are however, much less than those found for power stations in England and Wales (~1.8%). Nevertheless, effective reductions in NO<sub>x</sub> and particulate emissions have occurred. The introduction of low NO<sub>x</sub> burners has reduced emission concentrations from about 1000 - 1100 mg/Nm<sup>3</sup> to approximately 500 - 600 mg/Nm<sup>3</sup>. Gas re-burn facilities in one unit have further reduced concentrations to 250 - 300 mg/Nm<sup>3</sup>. The most noticeable improvement in emissions, however, has been for particulates. The refurbishment of the electrostatic precipitators at the plant in the early 1990s reduced emissions to <50 mg/Nm<sup>3</sup> from more than 800 mg/Nm<sup>3</sup>.

### Peterhead Power Station

Peterhead Power Station, on the Aberdeenshire coast, has a total installed capacity of 1550 MWe. The plant has two principal 660 MWe steam turbines and two 115 MWe gas turbines. The power station is 99% fired by gas and 1% by heavy fuel oil (HFO) and in 1998 emitted approximately 3.1 kt/a and 8.5 kt/a of SO<sub>2</sub> and NO<sub>x</sub> respectively.

To improve performance the plant is currently undergoing a Repowering development involving the construction of three gas turbines and generators (265 MWe each) and heat recovery steam generators (HRSG) adjacent to the existing conventional steam power station. The HRSG water and steam cycles are to be integrated with the water and steam cycle of an existing unit (Unit 1) to drive a 660 MWe steam turbine.

The existing Unit 2 will remain capable of independent operation with a maximum output of 660 MWe. The existing open gas turbines will remain on site for possible future use.

The redevelopment will ensure that the rate of emissions of NO<sub>x</sub>, SO<sub>2</sub>, particulates and CO<sub>x</sub> per unit of useful energy supplied will be significantly lower than can be achieved by using a conventional boiler plant, and single cycle gas turbines (Figures 3.5 and 3.6).

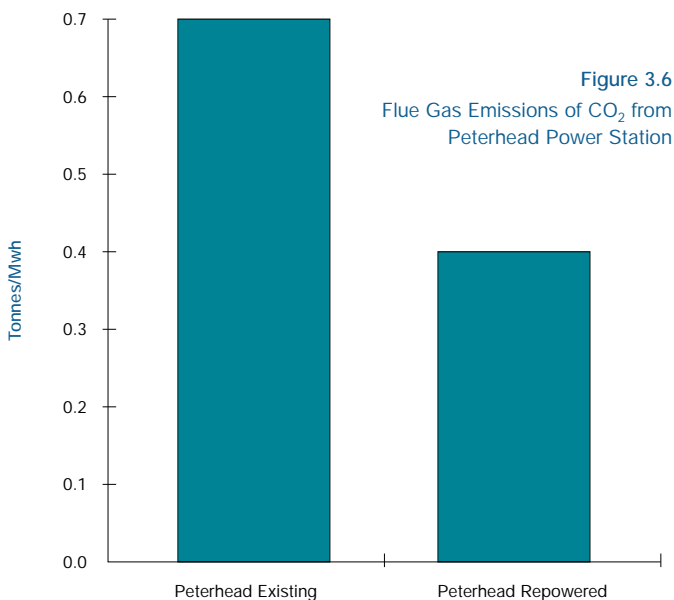
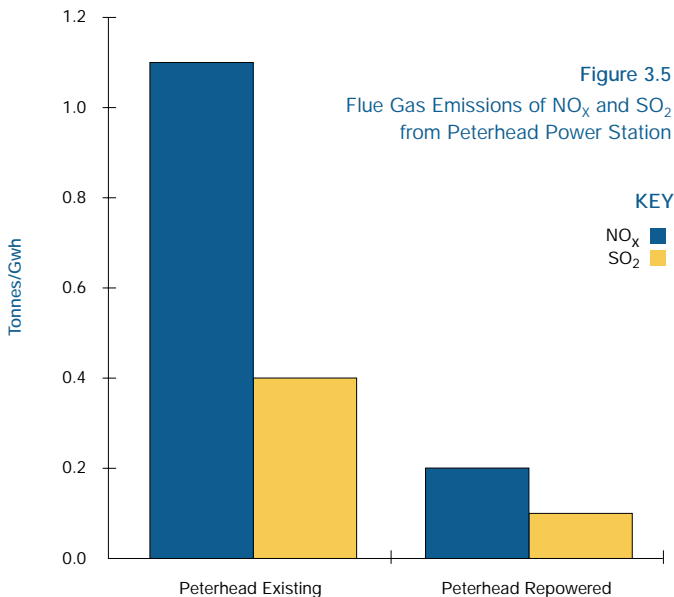
The new process will have a design thermal efficiency of approximately 55%, which will be a significant increase over the 37% obtained from the existing arrangement. The combustion of natural gas will result in low levels of NO<sub>x</sub> and CO<sub>x</sub>, compared to coal or oil combustion, and insignificant rates of particulate matter, VOC and SO<sub>x</sub><sup>10</sup>.

BPEO is also addressed by the new development. During normal operations only one steam turbine will be running. Therefore discharges at the cooling water outfall will be reduced giving an additional benefit to the marine environment<sup>10</sup>.

### Major Industrial Plants

Scotland's major industrial plants have the potential to cause severe impacts on air quality. However, correct and effective pollution control of industrial processes, regulated by SEPA, will reduce risks to the environment significantly. The processes which pose particular risks are regulated through IPC in respect of emissions and the Control of Major Accident Hazard (COMAH) Regulations 1999 in respect of accidents. The COMAH Regulations cover the prevention of major accidents that affect both the environment and safety. The COMAH regulations were introduced in April 1999 and will be enforced by both SEPA and the Health & Safety Executive (HSE) through a Joint Competent Authority. In authorising processes under IPC, SEPA not only requires correct management of the technical aspects, such as plant design and maintenance, but also the operational aspects, such as adequate procedures, staff competence and training. These are reviewed and improved with a view to the best environmental options to control, reduce and minimise the risk of emissions at source. This will apply equally to COMAH.

IPC authorisations apply the BPEO and BATNEEC hierarchies, enforcing the concept that prevention is better than cure. Process operators must consider all aspects of the process including raw material consumption, waste reduction and continuous improvements. This is also reflected in the COMAH Regulations, which cover prevention and minimisation of harm caused by major accident hazards.



### Examples of Industrial Emission Reductions for IPC and LAPC Processes

- *Additional sulphur plant at Grangemouth refinery has reduced emissions of SO<sub>2</sub> by around 3000 t/a.*
- *SGL Technic at Muir of Ord has reduced emissions of hydrogen cyanide (HCN) considerably by additional abatement equipment.*
- *Improvements in the handling of materials and odour control techniques at Westcot Hides have virtually eliminated odour complaints.*
- *An estimated 386 t/a of VOCs were reduced by fitting a thermal oxidiser at an East Lothian printing works.*
- *The BP Hound Point oil terminal IPC authorisation has been revised to reflect a new vapour recovery system. Calculations indicate that the new system should capture 5000 t/a of hydrocarbon vapours, but it is expected to capture up to 30,000 t/a.*
- *A major upgrade being implemented at Blue Circle, Dunbar will result in a significant decrease in particulate emissions.*
- *A £20 million upgrade programme of the Caberboard Plant at Cowie has already significantly reduced the amount of particulate matter discharged to atmosphere.*
- *A new solvent transfer system installed at Glaxo Wellcome has reduced emissions of the volatile solvent, dichloromethane, by 30 t/a.*
- *Improvements in the rotary vacuum filters at Glaxo Wellcome have reduced solvent emissions by 7 t/a, whilst improvements to product drying ovens have reduced solvent emissions by 13 t/a.*

Very significant reductions in air emissions can be achieved through process improvements and new technology and SEPA is actively encouraging operators to minimise their air emissions by these means. Through these activities, the process of authorisation reviews and new legislative requirements, significant reductions in emissions have been achieved at authorised processes around Scotland (see above).

### 3.5 Evaluation of Model Estimates and Research Studies

An important component of air quality management is impact prediction. This is generally carried out using air dispersion modelling techniques. The types of model available to predict the impact of source emissions on ambient air quality or a sensitive air receptor depends on the user's needs and the emitting source morphology and characteristics. Models can be point, area, volume or linear; statistical, mathematical or physical; and simple or complex. They have been developed for a variety of pollutant types, time scales and operational scenarios. Short-term models are used to calculate concentrations of pollutants over a few minutes, hours or days and can be employed to predict worst-case conditions or high pollution episodes. Long-term models are designed to predict seasonal or annual average concentrations, which may

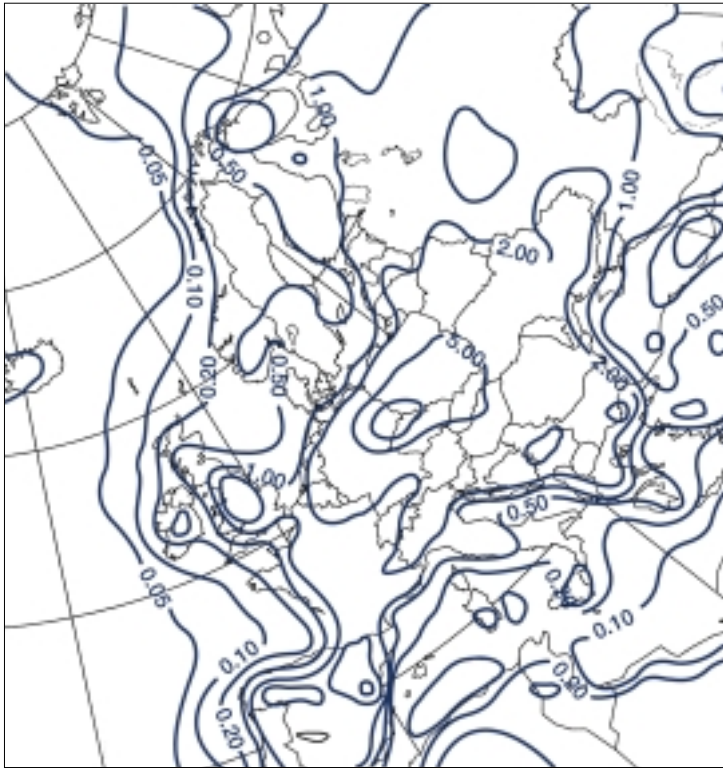
prove more useful in studying health effects and impacts on vegetation, materials and structures<sup>2</sup>.

The versatility of air dispersion modelling techniques can be useful in assessing the impact of a development or process or deciding where it should be sited. The air dispersion model widely used in the UK is the ADMS model version 3, which has the capabilities to model long-term predictions in complex topography and building down-wash effects on plume dispersion.



Chipboard Manufacturer, Part B Process

Figure 3.7  
 Predicted Pollutant Levels in  $\mu\text{g}/\text{m}^3$  for  $\text{SO}_2$  for the EU<sup>11</sup>

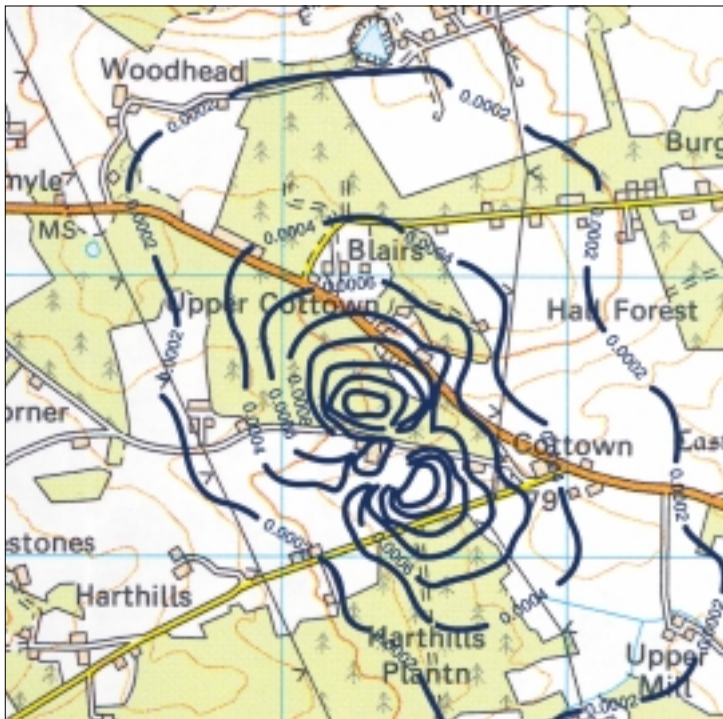


Emission inventories can be used for air dispersion modelling purposes to quantify the transportation, deposition and effects of emissions at either a local, national or international level. The NAEI provides the UK emission data to various interested parties such as UNECE, for assessment and air dispersion modelling purposes.

At a national and international level the European Monitoring and Evaluation Programme (EMEP) set up under the 1979 UNECE Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP), has used data to help develop a European Acidification Strategy. Emission data has been used to model  $\text{SO}_2$ ,  $\text{NO}_x$  and  $\text{NH}_3$  deposition and concentration levels and calculates fields of transboundary acidifying and eutrophying air pollution across northern Europe. Results show deposition levels in Scotland of  $500 - 1000 \text{ mg}/\text{m}^2$  for  $\text{SO}_x$  and  $200 - 400 \text{ mg}/\text{m}^2$  for  $\text{NO}_x$  respectively. The associated air concentrations were 0.2 to 0.5 and 0.5 to  $1.0 \mu\text{g}/\text{m}^3$  for  $\text{SO}_2$  (Figure 3.7) and  $\text{NO}_2$  respectively<sup>11</sup>. Actual levels for  $\text{SO}_2$  and  $\text{NO}_2$  in remote areas are approximately 1.2 and  $2 \mu\text{g}/\text{m}^3$  respectively.

At a local level, emission inventories are now becoming widely used by SEPA to evaluate the impact of emissions against the objectives of the NAQS (Figure 3.8). SEPA's main objective is to prevent or minimise, remedy or mitigate the effects of pollution on the environment. To evaluate the environmental consequences of process operations requires knowledge of emissions and their dispersion into the environment. For many principal authorised processes SEPA is now requesting that companies model their emissions to ensure that the environmental consequences of their operations are minimised.

Figure 3.8  
 Predicted Pollutant Levels Requested by SEPA for a LAPC Process ( $\mu\text{g}/\text{m}^3$ )



## 4. Air Quality Review

A range of air pollutants are now measured across Scotland. Historically, the focus of attention was on monitoring particulates (smoke) and SO<sub>2</sub> due to the requirements of the Clean Air Acts. The NAQS strategy focuses attention on these and other pollutants that may be harmful to human health and the environment (see Annex A). The interest in these pollutants reflects the concerns of air pollution emissions from both motor vehicles and industrial processes.

### 4.1 Historic Improvements in Air Quality

UK air pollution control legislation has for the most part resulted from the Industrial Revolution of the late 18th and 19th centuries although it was first acknowledged to be a problem many centuries earlier. However, it was this period of time which brought about a worsening level of air pollution (see photograph above). In 1863 the first Alkali etc Works Act was passed. However, this made no attempt to control smoke, but required the arrestment of 95% of offensive emissions. The remainder, after dilution, was emitted to the atmosphere. The second Alkali Act (1874) required the application of the Best Practicable Means (BPM) to prevent the escape of



Historic industrial pollution in Coatbridge, Lanarkshire<sup>12</sup>

noxious or offensive gases, and was subsequently extended to all the major air polluting industries. These and other Acts were eventually consolidated by the Alkali etc Works Regulation Act 1906<sup>15</sup>. The Act linked together a schedule of defined and chosen processes and works with a list of 'noxious and offensive gases', and was a forerunner to EPA 1990. The improvement in pollution levels was dramatic (Figure 4.1).

Despite the powers of the Alkali Act to extend its influence to control industrial emissions, there was still no measure to control the more widespread concern of smoke from domestic fires.

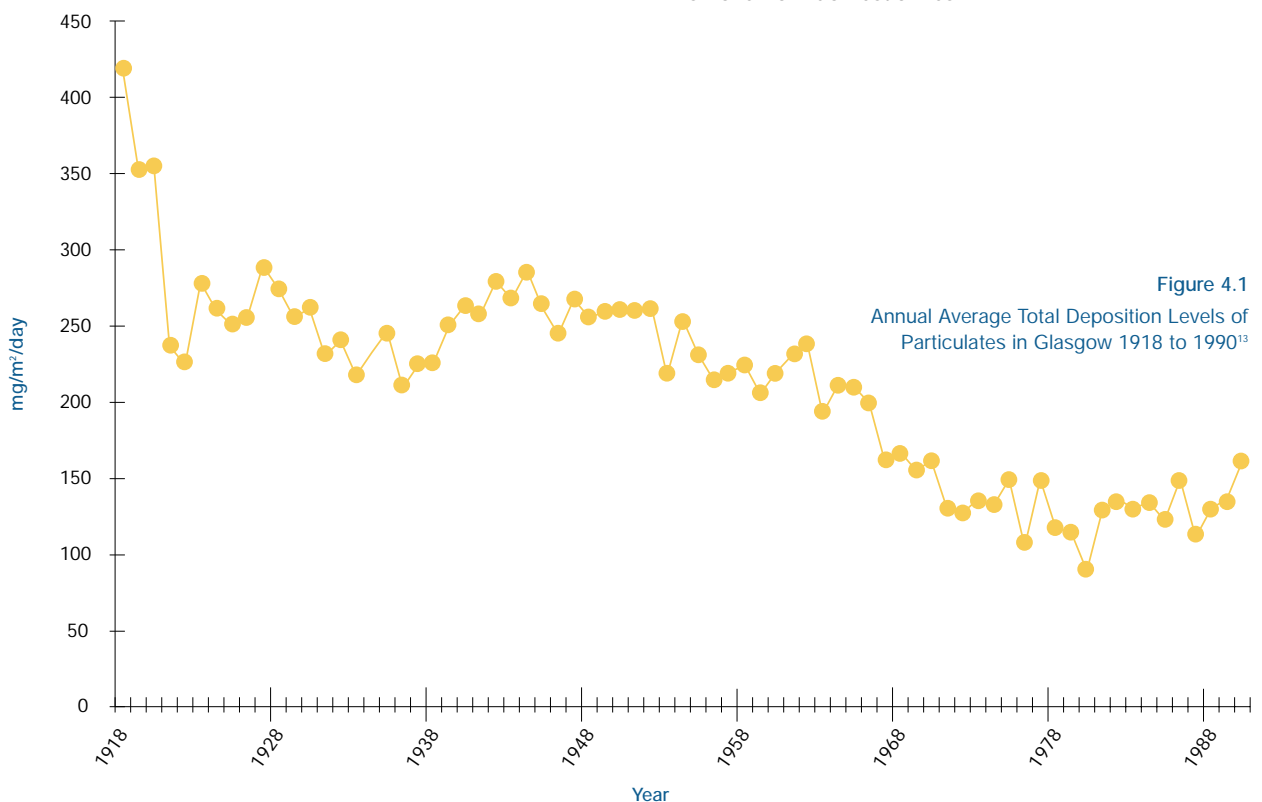


Figure 4.1  
Annual Average Total Deposition Levels of  
Particulates in Glasgow 1918 to 1990<sup>13</sup>

Therefore the air quality in urban areas was frequently characterised by elevated levels of smoke and sulphur fumes from household chimneys. The prevalence of smogs soiled buildings and respiratory complaints, such as bronchitis due to the smoke and sulphur fumes, had almost become an accepted price of progress<sup>15</sup>. In the early 1950s the Government appointed a committee with a remit to 'examine the nature, causes and effects of air pollution and the efficiency of present preventive measures; to consider what further measures are practicable; and to make recommendations'. The outcome of the study was the Clean Air Act in 1956, which was subsequently followed by the 1968 Clean Air Act. These Acts enabled the control of pollution by smoke, grit and dust from domestic fires and other commercial and industrial processes not covered by the earlier Alkali Acts<sup>15</sup>. The 1956 and 1968 Acts have now been superseded by the 1993 Clean Air Act.

### THE GLASGOW SMOG

Smog occurrences and their effect on human health have been chronicled in Scotland by such bodies as the Glasgow Corporation Medical Officers of Health. The Glasgow smog of 1909 received particular attention. A series of exceptionally bad smogs in that year contributed to a rise in the death rate from respiratory ailments - from 35 in October to 233 in November. This accounted for 49% of the total death rate. Well documented episodes also occurred in 1912 and 1929. Smog episodes were also reported for other Scottish cities. Despite these smog occurrences cities like Glasgow began to show an improvement in air quality during the 20th Century particularly with respect to particulates<sup>13</sup>.

### WHAT IS SMOG?

In 1905 Dr H A Des Voeux used the term smog to describe the conditions of fuliginous, sooty or smokey fogs. The word smog is derived from the words **smoke** and **fog**. Since the introduction of the first Clean Air Act in 1956, the occurrence of smog has diminished considerably. Now, the term is also applied to the photochemical haze produced by the action of sunlight on motor vehicle and industrial emissions, principally hydrocarbons and NO<sub>2</sub><sup>14</sup>.

Following introduction of the 1956 Clean Air Act air quality measurements show annual average SO<sub>2</sub> and smoke levels have diminished considerably<sup>16</sup>. The most dramatic reductions have been in urban areas (Figure 4.2).

Motor traffic emissions are now posing the principal threat to air quality in urban areas. Petrol and diesel engine motor vehicles emit a wide range of pollutants, principally CO, NO<sub>x</sub>, VOCs and particulates, which have an increasing impact on urban air quality (see Section 5.4). Whilst improvements in motor exhaust emission controls and fuel technology have resulted in an improvement in air quality (e.g. lead-in-air) concerns still persist about the elevated levels of air pollution occurring in urban areas; including photochemical smogs or hazes.

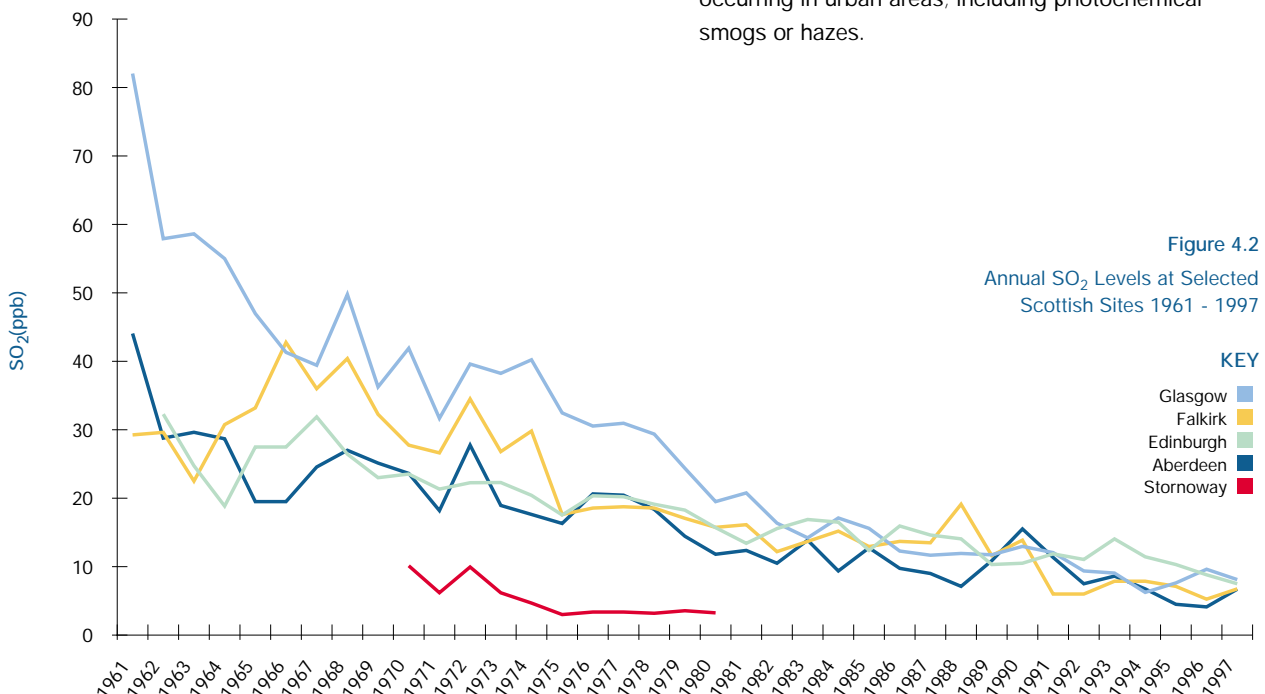


Figure 4.2  
Annual SO<sub>2</sub> Levels at Selected Scottish Sites 1961 - 1997

KEY  
 Glasgow (blue)  
 Falkirk (yellow)  
 Edinburgh (green)  
 Aberdeen (dark blue)  
 Stornoway (red)

Photochemical reactions resulting from the action of sunlight on NO<sub>2</sub> and VOCs from motor vehicles leads to the formation of O<sub>3</sub>, a secondary long-range pollutant, which often impacts in rural areas far from the original emission site. These pollutants, O<sub>3</sub>, VOC and NO<sub>2</sub>, together with NH<sub>3</sub> emissions contribute to the formation of acid deposition (see Section 5.1). Emissions of oxides of carbon, such as CO<sub>2</sub> from motor vehicles and industrial processes, contribute to global warming concerns.

In all except worst-case situations, industrial and domestic pollutant sources, together with their impact on air quality, tend to be constant or have improved over time. However, traffic pollution problems are worsening. The problem is particularly acute in urban areas with numbers of motor vehicles, infrastructure limitations, poor engine emission control technologies and limited provision for maintenance or vehicle regulation. Despite improvements in the control of industrial emissions, there still remains a need for SEPA to reduce and regulate emissions to ensure compliance with existing and proposed legislation.

By assessing the NAQS pollutants, consideration is given to those pollutants of principal concern with regard to human health and the environment (see Annex B).

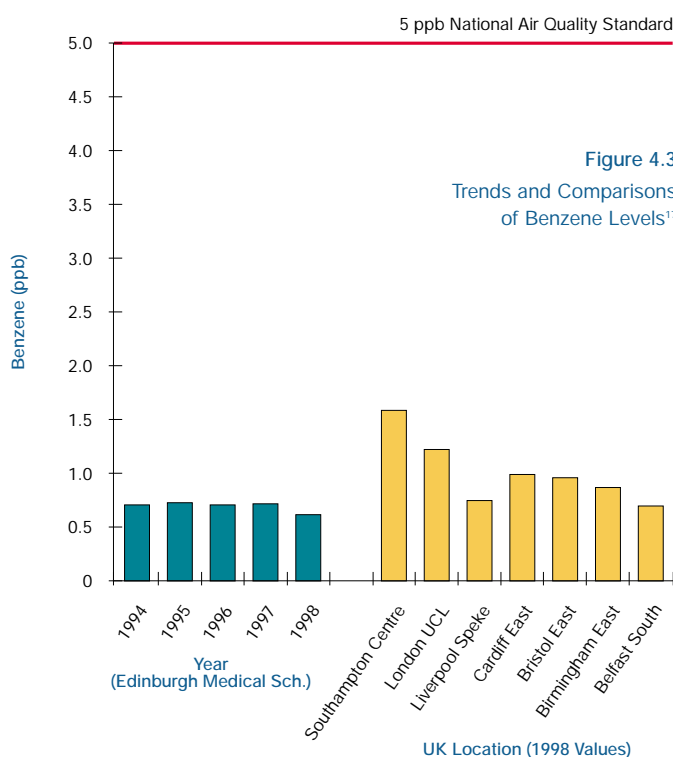


Figure 4.3

Trends and Comparisons of Benzene Levels<sup>17</sup>

## 4.2 An Overview of NAQS Air Pollutant Concentrations in Scotland

### Benzene

Within the UKAMN ambient benzene concentrations have been monitored automatically since 1993 at one site in Scotland at the Edinburgh Medical School. The annual average benzene concentration recorded at the site in 1998 was 0.6 ppb, which was well below the UK AQS of 5 ppb. Results show that benzene levels for Edinburgh for 1998 were lower than for other UK monitoring sites (Figure 4.3). Annual concentrations have remained generally constant since 1994.

### 1,3-Butadiene

1,3-butadiene is monitored automatically at the same location as benzene. The annual average concentration recorded at the Edinburgh Medical School in 1998 was 0.1 ppb, which was well below the UK AQS of 1 ppb. Results for 1998 show that levels for Edinburgh were lower than for other UK monitoring sites (Figure 4.4).

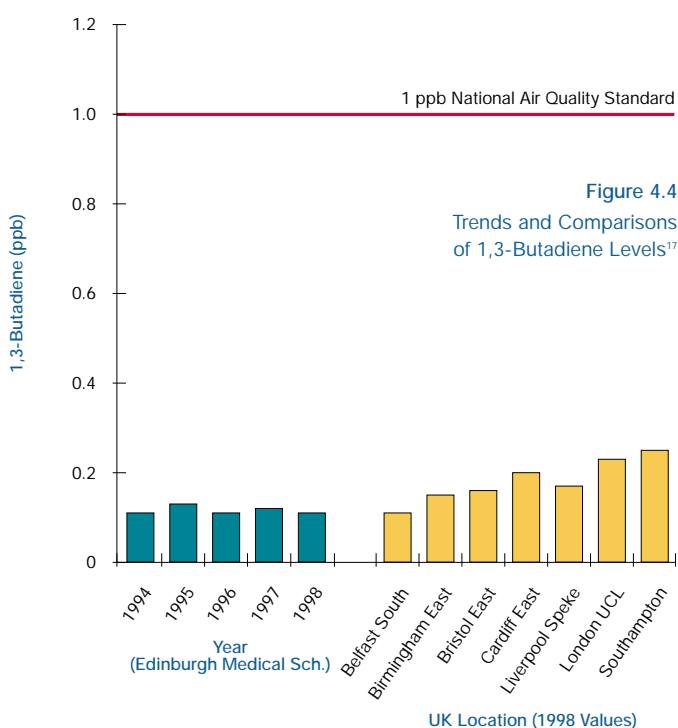


Figure 4.4

Trends and Comparisons of 1,3-Butadiene Levels<sup>17</sup>

### Carbon Monoxide

CO is currently monitored at four locations in Scotland as part of the UKAMN. CO is also monitored automatically at Falkirk. Aberdeen has recently become part of the UKAMN. The results show that the 8-hour running mean concentrations were below the UK AQS of 10 ppm (Table 4.1). A maximum 8-hour 1998 level of 5.2 ppm was recorded at the roadside site in Aberdeen, reflecting the contribution of road traffic to overall CO concentrations.



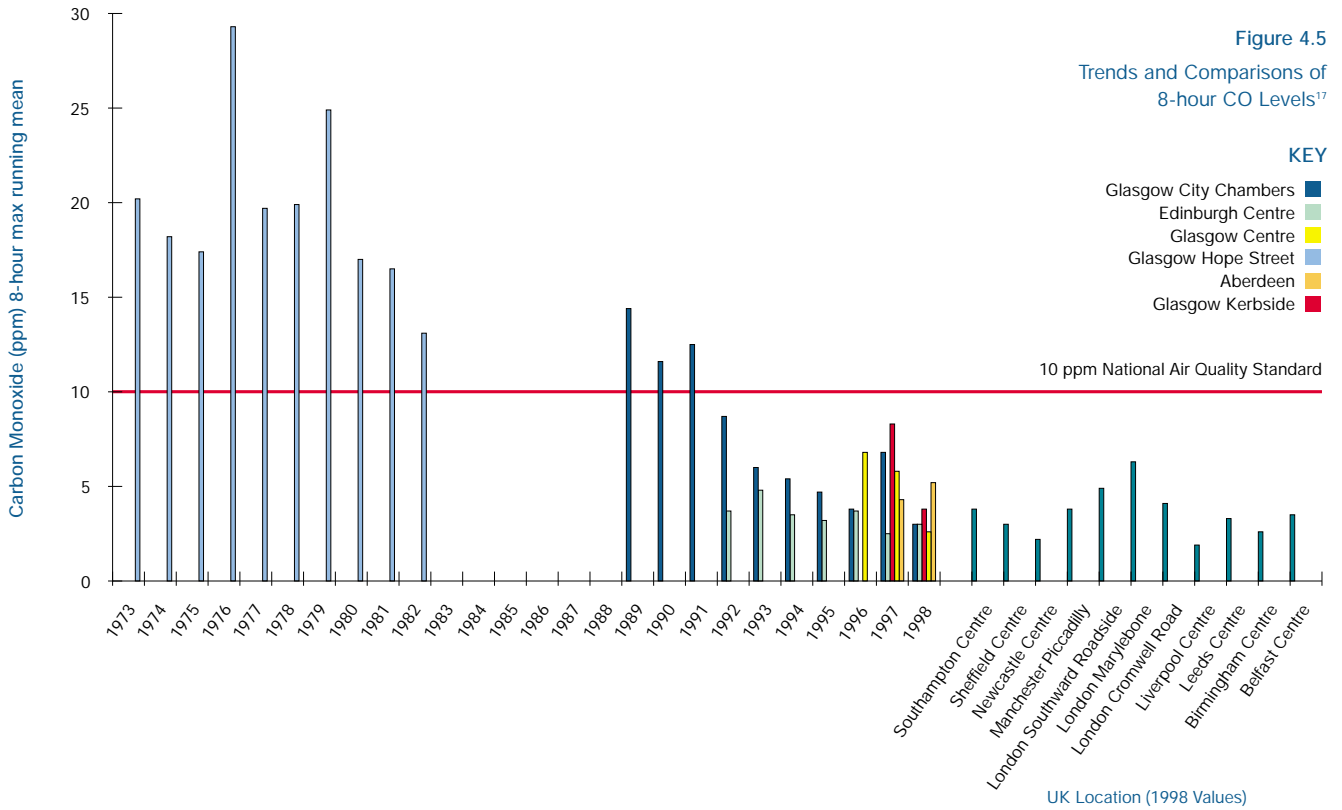


Table 4.1

CO Levels (ppm) for UKAMN Sites (1998) <sup>17</sup>	
Site	Maximum 8-hr mean
Edinburgh Centre	3.0
Glasgow Centre	2.6
Glasgow City Chambers	3.0
Glasgow Kerbside	3.8
UK AQS	10

Maximum 8-hour and annual average CO levels for Glasgow for 1973 to 1998 have declined as a consequence of improved motor vehicle exhaust emission controls (Figure 4.5). Prior to 1990, the UK AQS would have been frequently exceeded. Average concentrations have declined from more than 5.5 ppm to less than 1 ppm at UKAMN sites today. CO concentrations for Scottish sites in 1998 were similar to other UK urban monitoring sites. Roadside monitoring sites show the greatest recorded CO levels.

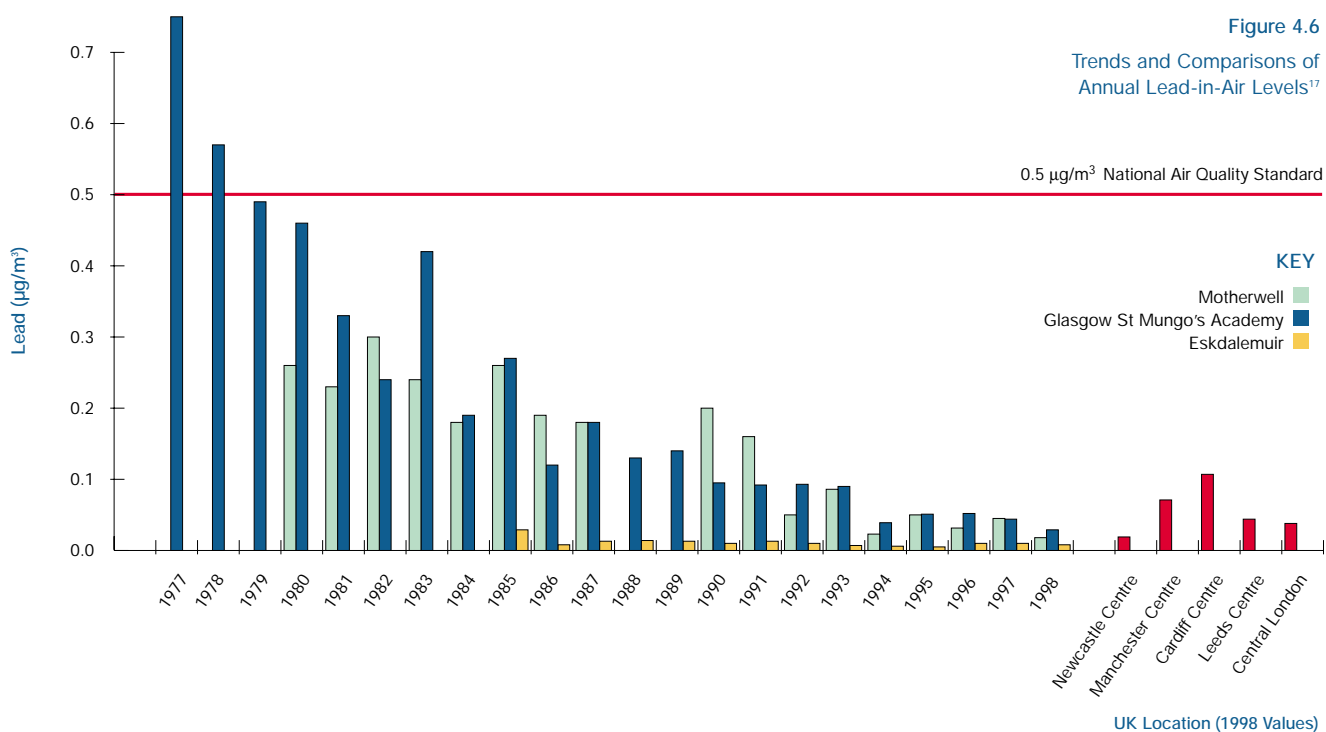
Table 4.2

Lead Levels (ng/m <sup>3</sup> ) for UKAMN Sites (1998) <sup>17</sup>		
Site	Type	Annual Average
Motherwell	Town Centre	18
Glasgow	City Centre	29
Eskdalemuir	Open moorland	8
UK AQS		500

**Lead**

Ambient lead-in-air concentrations are monitored at three locations in Scotland as part of the UKAMN. The Glasgow and Motherwell sites are part of the UK multi-element survey. At Eskdalemuir, lead is monitored as part of the Lead in Petrol UK network. Average annual results for 1998 are well within the 500 ng/m<sup>3</sup> (0.5 µg/m<sup>3</sup>) UK AQS (Table 4.2).

Results show that annual lead-in-air levels for Motherwell and Glasgow have declined from concentrations of 260 and 460 ng/m<sup>3</sup> to 18 and 29 ng/m<sup>3</sup> in 1998 respectively, since 1980. Concentrations in Glasgow for 1977 were almost 750 ng/m<sup>3</sup>. The reduction in levels is a consequence of improved motor vehicle emission controls and the reduction of lead in petrol. Lead-in-air concentrations for 1998 are less than those found for other UK urban monitoring sites (Figure 4.6).



### Nitrogen Dioxide

NO<sub>2</sub> concentrations are monitored as part of the UKAMN at five locations in Scotland and, until recently, at one location as part of the Automatic Rural UK network. Aberdeen has recently joined the network. Monitoring at the rural location has recently ceased. In addition automatic monitoring is also carried out at other sites in Scotland, such as Falkirk.

Results for 1998 show that ambient NO<sub>2</sub> concentrations at all the monitoring sites were within the EC 98th percentile AQS of 104.6 ppb. Exceedance of the UK annual mean AQS (21 ppb) occurred at all of the urban

sites and is only complied with at the remote site of Strath Vaich. The maximum 1-hour NO<sub>2</sub> concentrations have exceeded the revised NAQS level of 105 ppb (Table 4.3 and Figure 4.7).

Average NO<sub>2</sub> levels since 1987 have remained relatively constant at the UKAMN sites (Figure 4.8). However, the introduction of the Glasgow kerbside site in 1997 shows higher monitored levels compared to other Scottish UKAMN sites.

Average concentrations of NO<sub>2</sub> for 1998 were similar to other UK urban monitoring sites and less than levels found for the roadside sites in the centre of London (Figure 4.7).

Table 4.3

NO <sub>2</sub> Levels (ppb) for Selected UKAMN Sites (1998) <sup>17</sup>			
Site	Annual mean	1-hr max	98 <sup>th</sup> %ile
Edinburgh Centre	24.8	87	51
Glasgow Centre	22.9	184	49
Glasgow City Chambers	27.2	109	57
Glasgow Kerbside	36.7	194	90
Strath Vaich	1.8 <sup>a</sup>	-	-
UK and EC AQS	21	105 <sup>b</sup>	104.6

- no data

a) 1997

b) Not to be exceeded more than 18 times per year

In addition to automatic monitoring, NO<sub>2</sub> concentrations are monitored at more than 100 sites in Scotland as part of the UK Nitrogen Dioxide Diffusion Tube Survey. Of these sites, approximately 26% are classified as kerbside (1 to 5 m from a busy road), 29% as intermediate (20 to 30 m from the same or equivalent road) and 47% as background (more than 50 m from any busy road). Average NO<sub>2</sub> levels for kerbside, intermediate and background sites since 1993 show a discernible decline in background concentrations of 39%. Intermediate site concentrations have declined by 21%. Average levels at kerbside, intermediate and background sites for 1998 were 19.2, 10.0 and 7.7 ppb respectively. Concentrations were below the annual UK AQS of 21 ppb.

Figure 4.7

Trends and Comparisons of Maximum 1-hr NO<sub>2</sub> Levels<sup>17</sup>

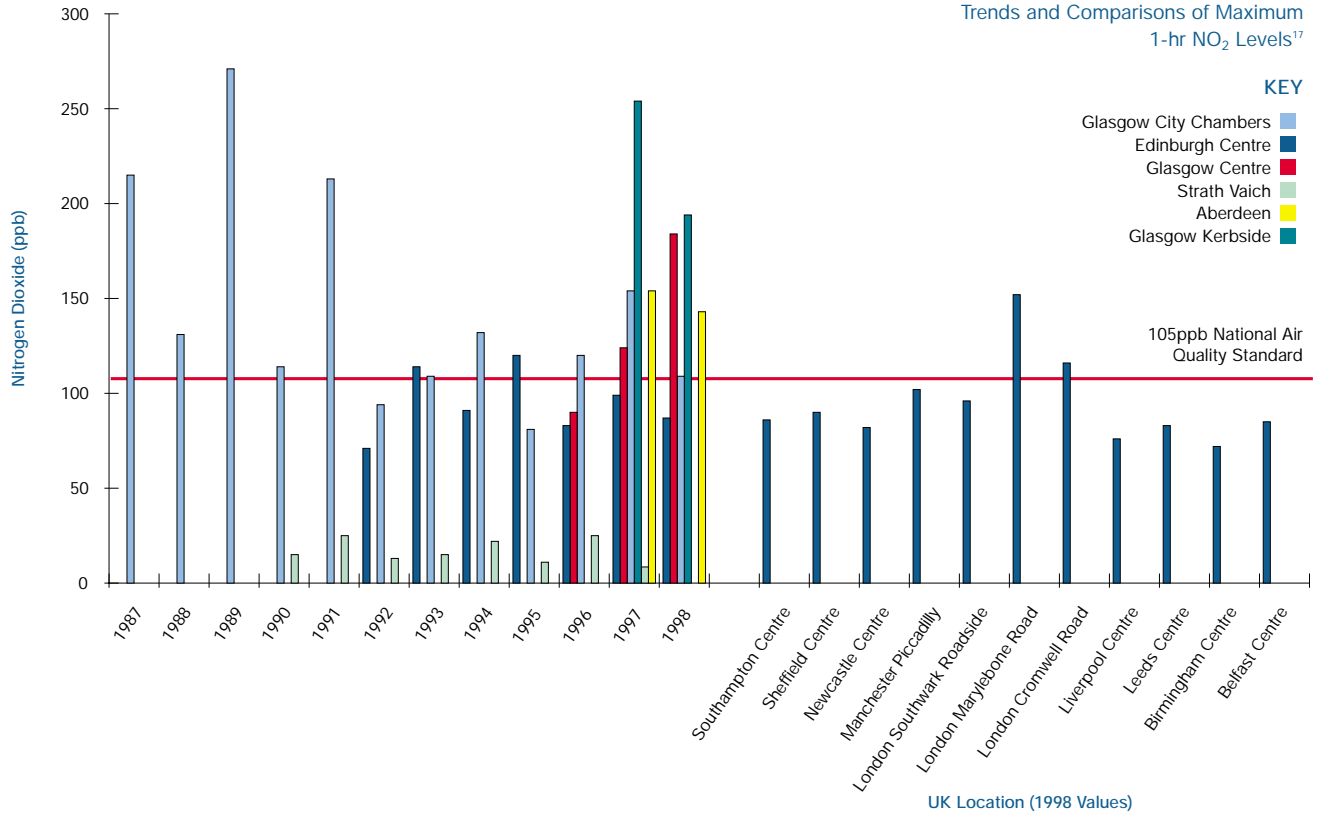
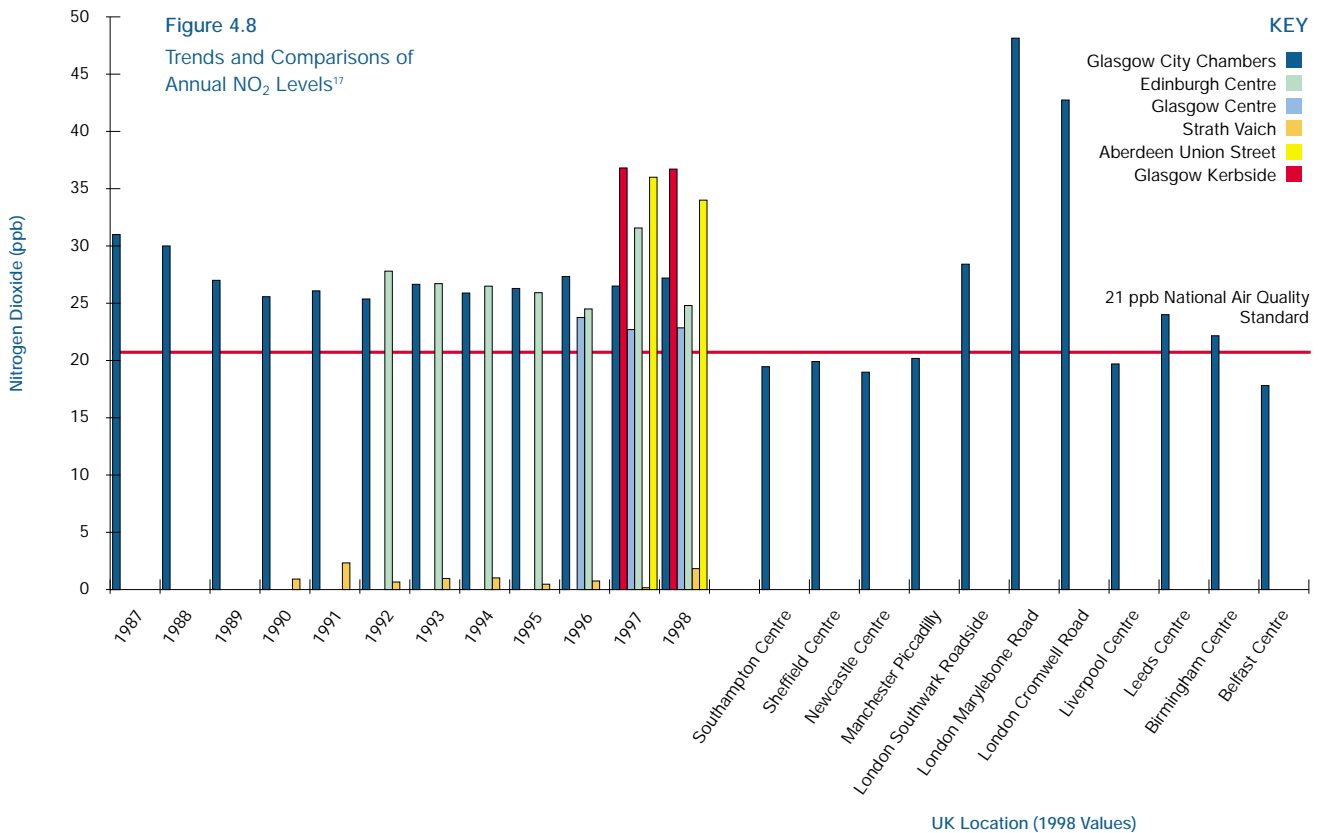


Figure 4.8  
Trends and Comparisons of Annual NO<sub>2</sub> Levels<sup>17</sup>



**Ozone**

Ambient concentrations of O<sub>3</sub> are monitored at five UKAMN locations in Scotland; at two locations as part of the Automatic Urban UK monitoring network; and at three locations as part of the Automatic Rural UK monitoring network.

Maximum concentrations of O<sub>3</sub> exceed the NAQS level of 50 ppb at the rural monitoring sites (Table 4.4). Concentrations of O<sub>3</sub> exceeded thresholds for effects on vegetation and human health in many areas of the UK, particularly in rural areas.

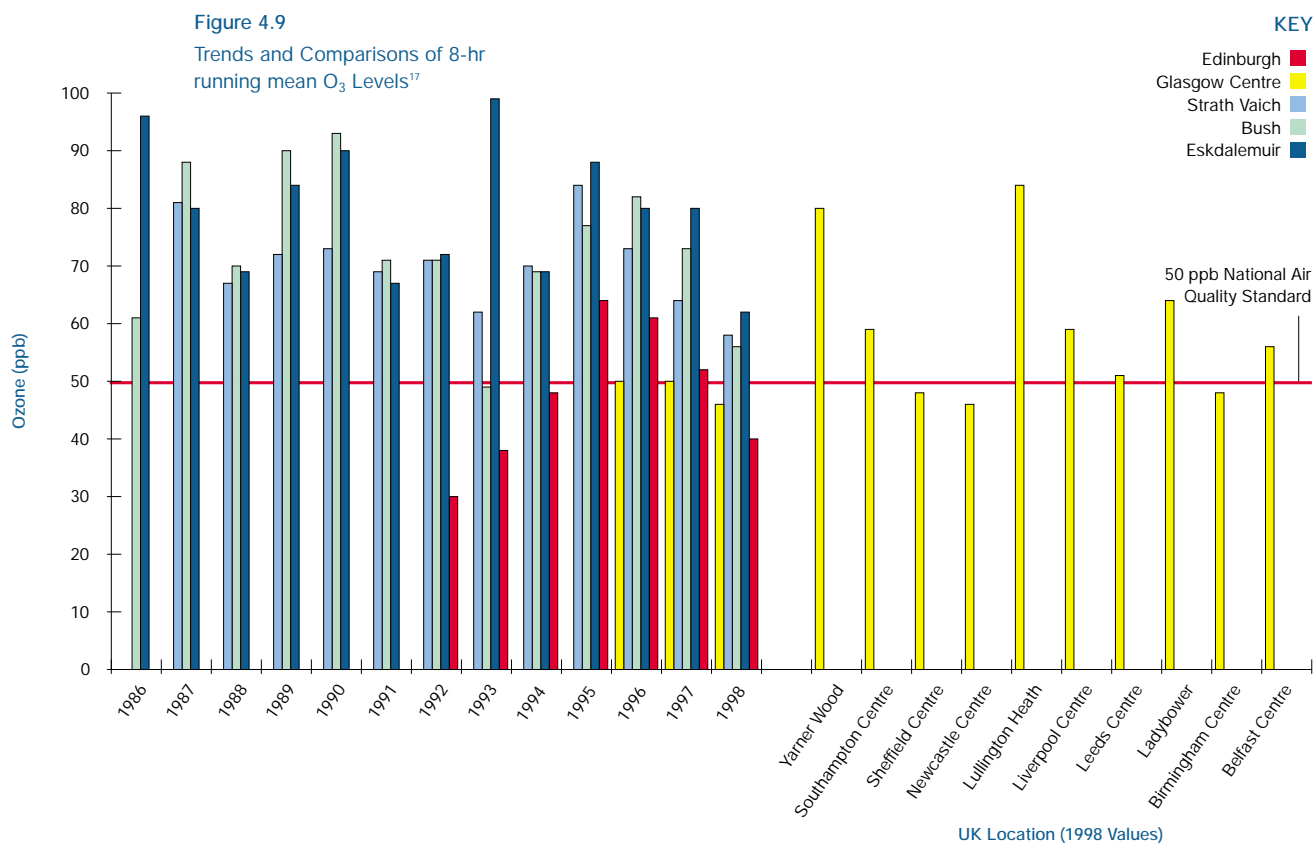


Table 4.4

O <sub>3</sub> Levels (ppb) for Selected UKAMN Sites (1998) <sup>17</sup>		
Site	1-hr max	8-hr max
Edinburgh Centre	52	40
Glasgow Centre	60	46
Bush Estate	69	56
Eskdalemuir	74	62
Strath Vaich	72	58
UK AQS		50 <sup>a</sup>

a) Not to be exceeded more than 10 times a year

Table 4.5

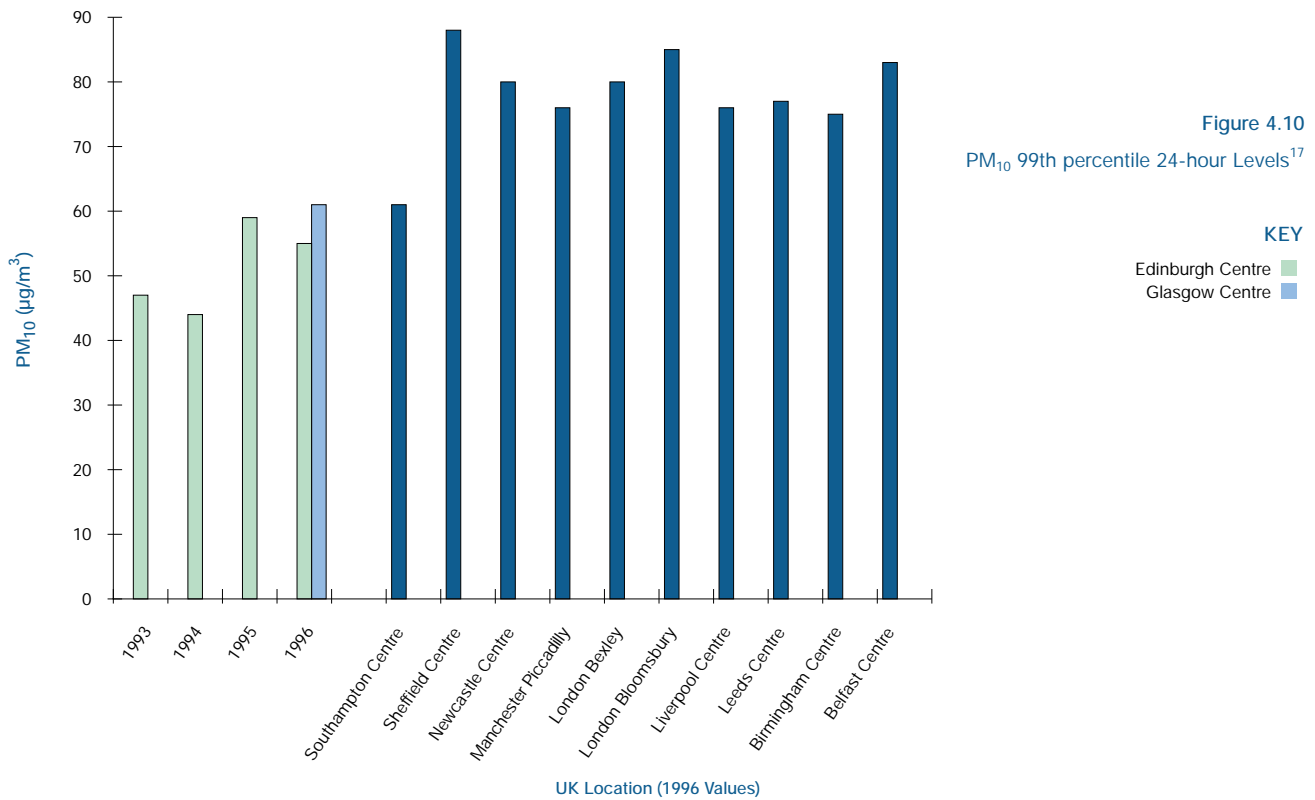
PM <sub>10</sub> Levels (µg/m <sup>3</sup> ) for Selected UKAMN Sites (1998) <sup>17</sup>		
Site	Annual Mean	24-hr max
Edinburgh Centre	15	44
Glasgow Centre	20	54
Glasgow Kerbside	27	122
UK AQS	40	50 <sup>a</sup>

a) Not to be exceeded more than 35 times per year

Thus, O<sub>3</sub> represents a major phytotoxic air pollutant throughout the UK. Maps show exceedance of the NAQS O<sub>3</sub> standard from 1990 to 1995 throughout approximately 98% of the UK<sup>46</sup>. The 1-hour mean concentrations are within the current EC Directive Threshold Information value of 90 ppb. Current maximum 8-hour concentrations for 1998 were comparable to concentrations found elsewhere in the UK (Figure 4.9). The Scottish sites show no significant trend although Bush, Eskdalemuir and Strath Vaich indicate a possible small increase in mean concentrations<sup>47</sup>.

### Particulates

Ambient concentrations of PM<sub>10</sub> are measured at four UKAMN sites in Edinburgh, Aberdeen and Glasgow. PM<sub>10</sub> is also monitored continuously at other locations in Scotland, such as Falkirk. The UKAMN results demonstrate that ambient levels of PM<sub>10</sub> concentrations have exceeded the NAQS level of 50 µg/m<sup>3</sup> (Table 4.5). The highest exceedances were recorded in Glasgow, demonstrating the contribution of traffic to overall levels of PM<sub>10</sub>. Annual average PM<sub>10</sub> levels since 1992 for Edinburgh have declined. Recent PM<sub>10</sub> levels for were comparable to other UK sites (Figure 4.10).



### Sulphur Dioxide

SO<sub>2</sub> concentrations are monitored at two locations as part of the UKAMN, Edinburgh Centre and Glasgow Centre, and until recently, at one site as part of the UK Automatic Rural network, Strath Vaich. The UKAMN data shows that SO<sub>2</sub> average levels are within the current EC limits (Table 4.6). No UKAMN site in Scotland currently exceeds the 15-minute UK AQS of 100 ppb. Results from Edinburgh since 1993 show that peak (15-minute) SO<sub>2</sub> levels have declined. In addition to the UKAMN, SO<sub>2</sub> is continuously monitored at several other sites including Falkirk. The automatic monitoring station at Falkirk has recorded elevated values (see Section 5.2). Concentrations of UKAMN sites in Scotland are generally less than those found for other UK sites (Figure 4.11).

In addition, daily average concentrations of smoke and SO<sub>2</sub> are monitored at nearly 50 sites as part of the smoke and SO<sub>2</sub> UKAMN. Concentrations of SO<sub>2</sub> and smoke tend to be highly seasonal with significantly higher concentrations in winter than in summer months. Average 1997 SO<sub>2</sub> and smoke levels for active sampling sites in Scotland were 6.4 ppb and 5.2 µg/m<sup>3</sup> respectively. In addition, daily and weekly average ambient concentrations of SO<sub>2</sub> are monitored at a number of sites as part of the Rural Sulphur Dioxide Network. Information collected from this network is primarily used to assess the level of acid deposition (see Section 5.1), but the results may also be used to assess general air quality. At all the monitoring sites the recorded SO<sub>2</sub> concentrations were below the current EC Directive limit and guide values (Table 4.7).

Table 4.6

SO <sub>2</sub> Levels (ppb) for Selected UKAMN Sites (1998) <sup>17</sup>		
Site	Mean	15-minute max
Edinburgh Centre	2.0	97
Glasgow Centre	3.0	81
Strath Vaich	0.8 <sup>a</sup>	7.3
EC and UK AQS	15-22.6	100 <sup>b</sup>

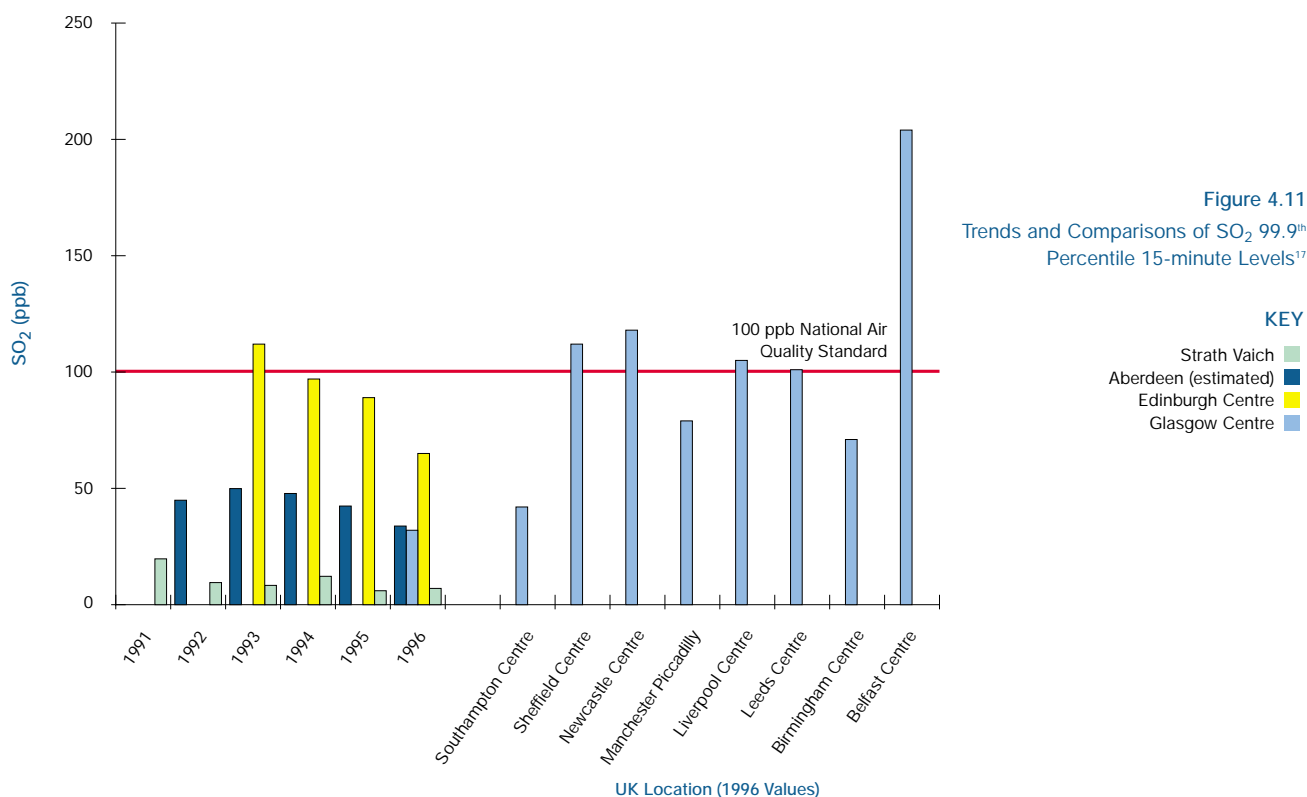
a) 1997 data

b) Not to be exceeded more than 35 times per year

### Summary of Air Quality

#### Benzene

Annual mean concentrations of benzene recorded in Edinburgh are already well below the 5 ppb UK AQS. Potential hotspots may arise in areas near to major industrial sources or petrol stations where elevated concentrations of fugitive emissions may occur, particularly when in combination with adjacent busy roads<sup>1</sup>. Preliminary modelling around petrol stations suggests that levels in these locations are also below 5 ppb<sup>18, 19</sup>. Studies forecasting the concentrations of individual pollutants against the NAQS objectives for



2005 suggest that existing policy measures should result in the objective being achieved by 2003<sup>18,19</sup> at all roadside and urban background locations.

Table 4.7

Comparison of Rural SO <sub>2</sub> Network Monitoring Results (ppb) (1997) <sup>17</sup>		
Site	Sampling Period	Annual Mean
Glen Dye	Daily	2.2
Eskdalemuir	Daily	2.2
Bush	Daily	1.4
Strath Vaich	Daily	0.4
Pitlochry	Weekly	0.5
Loch Leven	Weekly	1.8
Fort Augustus	Weekly	0.3
Forsinaird <sup>a</sup>	Weekly	0.4
Corpach	Weekly	0.9
Camphill	Weekly	1.2

a) 1996

### 1,3-Butadiene

Annual mean concentrations of 1,3-butadiene are already well below the UK AQS of 1 ppb. Studies forecasting the levels of individual pollutants against the NAQS objectives for 2005 suggest that existing policy measures should result in the objective being achieved by 2003<sup>18,19</sup> at all roadside locations.

### Carbon Monoxide

The major concentrations of CO emission sources occur in the principal urban and industrial areas. The 8-hour mean concentrations of CO being recorded at these sites are already below the 10 ppm UK AQS. An assessment of likely 8-hour concentrations at roadside locations suggest that the policy measures already in place should lead to concentrations at all roadside locations falling to below 10 ppm by 2003<sup>18,19</sup>.

### Lead

Lead-in-air levels monitored in Scotland are well below the UK AQS of 500 ng/m<sup>3</sup> (0.5 µg/m<sup>3</sup>). It is assumed that leaded petrol will continue to contribute to a small extent to the levels of lead in 2005. The ban on the sale of leaded petrol from 2000 will mean that levels of lead will continue to decrease<sup>18, 19</sup>.

### Nitrogen Dioxide

The major concentrations of emission sources are the main urban areas where emissions from heavy traffic are likely to combine with those from industrial processes. Total annual emissions of NO<sub>x</sub> have reduced by 25% between 1990 and 1996<sup>18</sup>. There has been a similar reduction in road transport emissions over the same period<sup>18, 19</sup>. Annual mean concentrations of NO<sub>2</sub> recorded at intermediate and background locations have reduced by 21% and 39% respectively during 1993 to 1998<sup>17</sup>. Despite these reductions, hourly average and annual average concentrations in excess of the levels of the UK AQS are being recorded at many background and roadside locations in Scotland. Although current measures are in place to reduce NO<sub>x</sub> emissions it is likely that NO<sub>2</sub> levels may remain elevated.

### Ozone

Concentrations of O<sub>3</sub> show that levels are elevated during summer periods. Typically, the highest concentrations of O<sub>3</sub> are found in rural areas, at some considerable distance from the potential pollutant sources although levels could rise in urban areas as NO concentrations decline. Areas of high concentration are very dependent on the prevailing weather conditions. Although current measures are in place to reduce NO<sub>x</sub> and VOC emissions, it is likely that O<sub>3</sub> levels may remain elevated<sup>18, 19</sup>.

### PM<sub>10</sub>

Concentrations of particulates recorded at monitoring stations across Scotland show that the 24-hour NAQS level of 50 µg/m<sup>3</sup> may be exceeded at several locations. There are likely to be exceedances at urban roadside sites and in the vicinity of industrial sites<sup>18, 19</sup>. The main concentration of emission sources occurs in similar locations as those for NO<sub>2</sub>, namely the main urban and industrial areas. Given the significance of industrial sources to PM<sub>10</sub> emissions, the highest concentrations would be expected to occur where roads carrying heavy traffic flows occur in conjunction with industrial sources. Elevated PM<sub>10</sub> concentrations would also be expected for the major urban areas, where traffic sources predominate and near mineral extraction processes.

### Sulphur Dioxide

SO<sub>2</sub> concentrations for most areas in Scotland are within the UK AQS. The major concentration of emission sources of SO<sub>2</sub> is expected to occur in Edinburgh, Glasgow and Falkirk (particularly the Forth Valley and Grangemouth) (see Section 5.3). In addition,

there are a number of isolated industrial sources in a narrow band along the east and northeast coast. The locality most likely to exceed the UK AQS is around Grangemouth due to the large emission sources from the refineries and adjacent power stations.

Comparison of the monitoring results for benzene, 1,3-butadiene, CO and lead, with the relevant air quality limit and guide levels, suggests that ambient concentrations are likely to be within the recommended limits throughout Scotland. Available NO<sub>2</sub> monitoring results demonstrate that exceedance of the current EC guide value, proposed annual EC Standard and UK AQS may occur at kerbside locations adjacent to heavily trafficked roads. Exceedance of the UK annual mean AQS may be more widespread, occurring in many urban areas (see Section 5.2 and 5.4). Highest levels of O<sub>3</sub> occur in rural areas. Ozone concentrations exceed the UK NAQS level of 50 ppb. In addition, exceedances of the critical levels for the protection threshold for vegetation is widespread, particularly in rural areas. Some exceedance of the EC Directive Health Protection level may also arise. The monitoring results demonstrate that ambient concentrations of PM<sub>10</sub> are close to or exceed the proposed EC standards and UK AQS. The highest level of exceedances is to be expected in urban areas close to heavily trafficked roads. SO<sub>2</sub> concentrations are within the current and proposed EC limits, but exceedance of the UK AQS may be experienced where high levels of emissions coincide with periods of poor dispersion in localities of concentrated SO<sub>2</sub> emissions, such as at Grangemouth.

## 4.3 Overview of Local Authority Stage 1 Reviews

Air quality monitoring is not new to Local Authorities. Many of them have monitored SO<sub>2</sub> and smoke as part of their smoke control responsibilities since the introduction of 1956 Clean Air Act (see Section 2.6). A large number have also monitored dust deposition using the British Standard Deposit Gauge, although few continue to do so today.

The Environment Act 1995 made wide-ranging provision for the management and improvement of air quality, whereby Local Authorities are required to review and assess air quality in their respective areas. For many Local Authorities this has led them to enter a new phase in air quality monitoring. With the exception of the principal urban and industrial areas, the Local Authorities Stage 1 Reviews show that air quality information is limited in many areas to only a few key

pollutants such as NO<sub>2</sub>, SO<sub>2</sub>, smoke and particulates. With the exception of SO<sub>2</sub> and smoke, historical records are also limited. Rural Local Authorities have the greatest deficiency of information.

For those Local Authorities that participate in the UKAMN, their air quality archives are gradually becoming more extensive. However, few Local Authorities like Edinburgh and Glasgow can demonstrate a continuous monitoring data programme stretching unbroken over 40 years. Indeed, one particular monitoring programme in Glasgow (see Section 4.1) can be traced back to the First World War (Figure 4.1). For many Local Authorities the level of monitoring, other than smoke and SO<sub>2</sub>, has grown considerably in the past 5 to 10 years.

Local Authorities have now submitted their First Stage Reviews (see Section 2.3) and these are currently being reviewed by SEPA and the Scottish Executive. An overview of submitted reports shows that the principal issues now facing Local Authorities are:

- *Deficiency of baseline air quality data against which to confirm compliance with all NAQS objectives*
- *Air quality data records are, for most Local Authorities, limited to SO<sub>2</sub> and smoke and NO<sub>2</sub>*
- *A general recognition that the NAQS objectives are likely to be complied with for lead-in-air, CO, benzene and 1,3-butadiene for most areas*
- *An acknowledgement that air quality concerns may exist for PM<sub>10</sub>, SO<sub>2</sub> and NO<sub>2</sub>*
- *Principal pollutant source emission concerns relate to motor vehicles*
- *Few Local Authorities have significant large-scale industrial complexes causing large-scale air pollution concerns, however, most local authorities recognise that localised concerns may exist with regard to industrial emissions*

## 4.4 Effects of Air Quality

Air quality can affect human health, cause damage to crops and materials and degrade sensitive ecosystems. The severity of impact is dependent upon the concentration of the pollutant, the duration of exposure and the susceptibility of the sensitive receptor, human, plant, animal or building, to the pollutant. Inevitably the focus of attention is for the protection of human health. However, SEPA is responsible for the protection of the environment. The environment is our surroundings. Therefore equal consideration is given to

all receiving systems whether they be ecological, the built environment or human health.

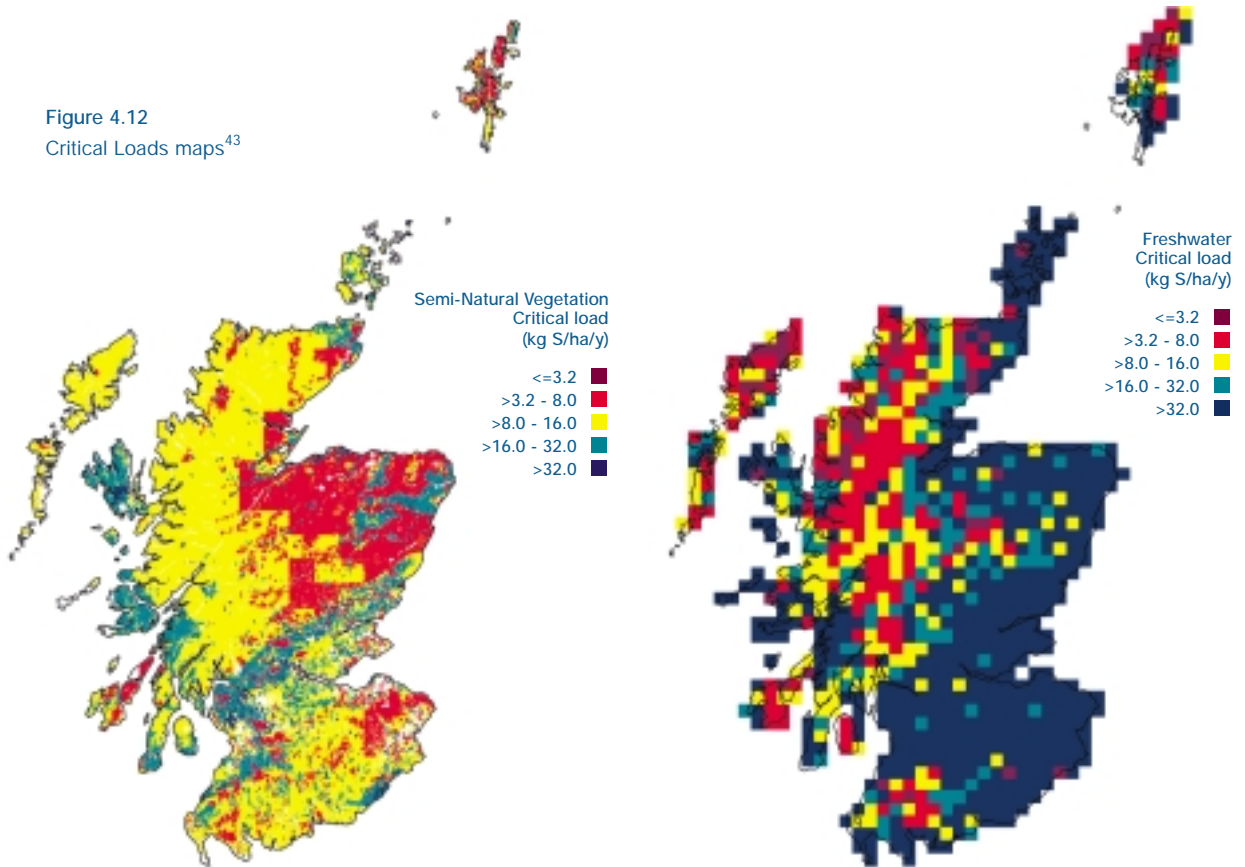
### Ecosystems

The effects of air pollution on ecosystems ranging from forests to freshwaters are well known (see Section 5.1). However, to gain a broader appreciation of the effects of air pollution the UK Government set up the Critical Loads Advisory Group (CLAG) to develop a national critical loads and levels programme. CLAG reviewed the impacts of air pollutants on specific parts of the environment including soils, freshwater, vegetation, buildings and materials to provide information about input fluxes and estimates of pollutant exposure. Their aim was to assess the sensitivity of each receptor across the UK and hence define the environmental capacities to absorb pollutant loads or to withstand gaseous concentration levels for critical pollutants. Effectively, the group assessed the level of pollutant that a receptor, such as ecosystem or plant, can tolerate without suffering long-term adverse effects according to current knowledge<sup>20</sup>. Critical load maps now cover Scotland showing levels of deposition at which ecosystems are vulnerable to acidity (see Figure 4.12).

For many years, there has been considerable concern about the effects of acid deposition on parts of the EU<sup>6, 25</sup>. Various measures aimed at reducing discharges of pollutants, such as NO<sub>x</sub> or SO<sub>2</sub>, thought to contribute to the problem have been established (see Annex C). They provide a framework for reducing industrial air pollution and propose specific emission limits for these pollutants. Following the 5th Environmental Action Programme (5EAP) the EC confirmed the political long-term goal of no exceedance of the critical loads and levels (see Annex B). The objectives of the strategy were to reduce beyond existing commitments emissions of SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub>. The EC proposed to reduce the area of ecosystem in the EU at risk from acid rain from 6.5%, on the basis of existing commitments, to 3.3% by 2010. The EC's study showed that even with the most ambitious abatement programmes for reducing acidifying pollutants, the ultimate target of never exceeding critical loads could not be achieved by 2010. The EC therefore followed the 'gap closure' approach which aims to reduce the difference between the level of ecosystem protection in 1990 and the 100 percent ecosystem protection by the year 2010. The EC decided that the most appropriate interim target was a 50% gap closure<sup>24, 25</sup>. EMEP regularly updates these predictions using revised emission inventory values to evaluate progress.



Figure 4.12  
Critical Loads maps<sup>43</sup>



## Vegetation

Air pollution injury and damage to plant communities is a combination of a range of physical, chemical and biological stresses which may affect a plant's physiology. The visible symptoms produced by these various stresses would need to be distinguished, as do the very different symptoms which can be produced in different plant species by the same factor. In addition plants are commonly subjected to more than one stress, either simultaneously or successively, and that their sensitivity to a particular stress may be altered by other environmental factors. Air pollution impacts involve a combination of factors including the concentration and duration of exposure, plant species, plant's age, etc. It is therefore difficult to identify a direct cause and effect relationship between a pollutant and its effect on vegetation<sup>51,2</sup>.

The air pollutants of principal concern for vegetation are O<sub>3</sub>, NO<sub>2</sub> and SO<sub>2</sub>. Critical levels of these pollutants are presently exceeded in locations throughout Scotland. The greatest exceedance is seen for O<sub>3</sub>.

For O<sub>3</sub> the critical levels are defined using the AOT40 index - the cumulative exposure over 40 ppb during the growing season. The Kuopio Workshop in Finland (1996) revised critical levels of O<sub>3</sub> to prevent damage to most sensitive crops, forests and semi-natural vegetation. This has provided the necessary basis to quantify the spatial patterns of exceedance of these critical levels in

the UK<sup>46</sup>. The area in exceedance of the critical level represents 81% of UK land area, 91% of UK area of arable crops, and 76% of UK area of semi-natural vegetation. Exceedance of the critical level does not mean that there will be damage to vegetation, but only that the risk of damage exists for sensitive species and conditions<sup>46</sup>.

## Buildings

The effects of air pollution on buildings provide some of the clearest examples of atmospheric pollution related damage. The effect can be either erosion due to acidic deposition or soiling from particle deposition. For most materials dry deposition of SO<sub>2</sub> has the strongest corrosive effect with wet deposition, formed from SO<sub>2</sub> and NO<sub>x</sub> emissions, having a generally weaker effect. Particles can also act as a catalyst for stone erosion, and may have synergistic effects with NO<sub>2</sub> and SO<sub>2</sub>.



Stone Erosion

Table 4.8

Metal Loss Due to Air Pollution ( $\mu\text{m}$ ) (1987-95) <sup>21</sup>				
	Mild steel	Galvanised steel	Copper	Aluminium
Glasgow	32	9.2	4	1
Clatteringshaws	46	21.5	5	1
Eskdalemuir	-	11	4	1
Strath Vaich Dam	30	9.4	3	1

- no data

O<sub>3</sub> is known to damage some polymeric materials such as paints, plastics and rubbers.

Soiling of buildings by particles (e.g. smoke) is one of the most obvious signs of pollution. Soiling results primarily from the deposition of particles on external surfaces and includes residential dwellings, commercial premises and historic buildings.

As part of the National Material Exposure Programme (NMEP)<sup>21</sup> several sites in Scotland have been used to assess the rates of corrosion (metal loss) for bare mild steel, galvanised steel, copper and aluminium. Results show variable rates of corrosion depending on the metal and location. Corrosion rates can be up to 46  $\mu\text{m}$  over an eight year period (Table 4.8).

### Visibility

Visibility, in terms of visual range, is reduced by primary particles, secondary particles such as nitrate and sulphate aerosols, and NO<sub>2</sub>. It is one of the more obvious effects of air pollution. Historically, visibility due to smog events (Section 4.1) was an acute problem. Reductions in particulate matter resulting from pollution control measures have led to substantial improvements in city centre winter sunshine levels. For example, between 1947 and 1981 the average hours of winter sunshine for Edinburgh increased from 1.35 to 1.70 hours per day<sup>52</sup>. Whilst winter visibility in urban areas has generally improved, summer visibility has deteriorated. 'Milky' hazes, attributed to light scattering by photochemically generated sulphates and nitrates, are now not uncommon in cities like Edinburgh and Glasgow and have also become a regional phenomenon, affecting rural amenity.

### Human Health

Air pollution may damage human health (see Annex E). However, a major purpose of the NAQS is to ensure a high degree of protection against such risks. Healthy individuals are not thought to be at significant risk from present levels of air pollution in the UK, although studies have shown associations which persist at relatively low levels, between daily variations in levels of some pollutants and daily variations in mortality and hospital admissions for acute respiratory conditions. In some cases, the mechanisms are not yet known, but the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP) has advised that it would be imprudent not to regard the associations as causal. An assessment of the likely health benefits due to reductions in air pollutant concentrations as a result of implementing existing policies is therefore an important component of the NAQS<sup>22</sup>.

Air pollutants can have a range of effects on human health (see Annexes B and E). Studies undertaken by COMEAP have shown that numbers of deaths and respiratory hospital admissions brought forward by current levels of PM<sub>10</sub>, O<sub>3</sub> and SO<sub>2</sub> are significant. It should be noted, however, that they comprise only a small percentage (<2%) of the total deaths and hospital admissions occurring each year in the UK (Table 4.9). A sensitivity analysis suggests that 1996 levels of NO<sub>2</sub> might contribute to around 8700 respiratory hospital admissions (brought forward or additional)<sup>53</sup>.

Table 4.9

Number of Deaths and Hospital Admissions for Respiratory Diseases Per Year <sup>53</sup>		
	Health Outcomes (brought forward)	
	Deaths (all cause)	Hospital admissions (respiratory) and additional
PM <sub>10</sub>	8100	10500
SO <sub>2</sub>	3500	3500
O <sub>3</sub>	700-12500	500-9900
NO <sub>2</sub>	-	8700

- no data

## 5. Air Quality Issues

Emission sources and existing air quality data have been used to identify potential pollution issues for each of the NAQS pollutants. Pollution concerns are those areas where it is considered likely that ambient air quality may exceed or is close to the NAQS objectives. In addition to these, pollutant effects or concerns also exist for the indirect impacts caused by them. Many NAQS pollutants contribute to the formation of secondary air pollution problems, such as acid deposition and ozone formation and depletion. Secondary pollution problems tend to be large scale or regional in nature compared to the localised impacts of primary pollutants from low-level emission sources.

### 5.1 Strategic Air Pollution Issues

The principal strategic air pollution issues presently relate to acidification, ozone depletion and climate change. The pollutants that contribute to their formation are prescribed substances regulated by SEPA.

#### Acidification

Acidification (see below) is a transboundary problem, which calls for a combination of national and international initiatives. These initiatives include reduced emissions, particularly from motor vehicles and coal and oil fired power stations, such as the EC Large Combustion Plant and motor vehicle emissions control Directives (see Section 3 and Annex A). SO<sub>2</sub> and NO<sub>x</sub> emissions arise mostly from burning fossil fuels in power stations, industrial processes, homes or in transport. NH<sub>3</sub> emissions are principally from agriculture sources. It is these emissions that cause acidification.

#### ACIDITY OF RAINWATER

The acidity of rainwater is determined by the balance between cations (positively charged ions) and anions (negatively charged ions) in precipitation. In Europe the main cations are H<sup>+</sup> and NH<sub>4</sub><sup>+</sup> and to a lesser extent, Ca<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup> and Mg<sup>2+</sup> and the main anions are SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup> and Cl<sup>-</sup>. It has been argued that the natural acidity of unpolluted rainfall is pH 5.6<sup>54</sup>.

A Scotsman, Angus Smith, the first Alkali Inspector, first used the term Acid Rain in the 19th century whilst studying the composition of rain water across the UK.

SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub> emitted to air return to the surface as dry deposition on vegetation or other surfaces or as wet deposition attached to precipitation, or indirectly in a dry or wet form following chemical transformation. SO<sub>2</sub> and NO<sub>x</sub> are oxidised to form sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) and nitric acid (HNO<sub>3</sub>), either in the atmosphere or after deposition. NH<sub>3</sub> may react with H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub> to form ammonium sulphate and ammonium nitrate particles<sup>43, 23</sup>.

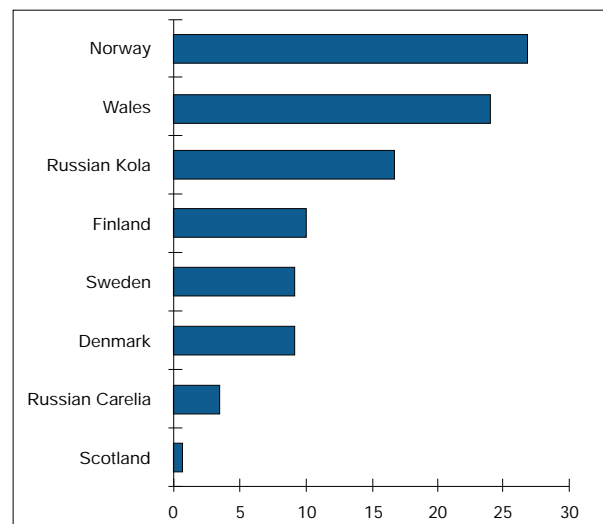


Figure 5.1  
Percentage of Lakes with Exceedance of the Critical Load for Sulphur<sup>25</sup>

The largest deposition of sulphur occurs in areas with the largest emissions (see Section 3) and is mainly due to the dry deposition of SO<sub>2</sub>. High rates of sulphur deposition also occur in areas of high precipitation. Similar patterns are found for the deposition of oxidised nitrogen, although relatively smaller amounts are deposited close to the emission sources. Nitrogen oxides are transported over longer distances and contribute to the tropospheric O<sub>3</sub> problem because NO<sub>x</sub> is a major precursor in its formation. The deposition of reduced nitrogen compounds, which originate from NH<sub>3</sub> emissions, is to a larger extent than sulphur dominated by high deposition rates near the sources. There is, therefore, less long-range transport of NH<sub>3</sub> than for SO<sub>x</sub> or NO<sub>x</sub><sup>24, 25</sup>. Most acid precipitation falling on Scotland arises from outside sources. For example, 33% of sulphur deposition comes from England and Wales, and 44% from elsewhere in Europe<sup>43</sup>. The majority of acid precipitation compounds emitted in Scotland are likewise deposited elsewhere<sup>43</sup>.

Studies have also shown that Northern Ireland accounts for about 4% of the total sulphur deposition in Scotland<sup>43</sup>. In light of the prevailing south-westerly winds, this is not surprising. Changes in emissions from the Northern Ireland electricity supply industry, due to the introduction of gas, will have a detectable impact on critical load exceedances in western Scotland<sup>50</sup>.

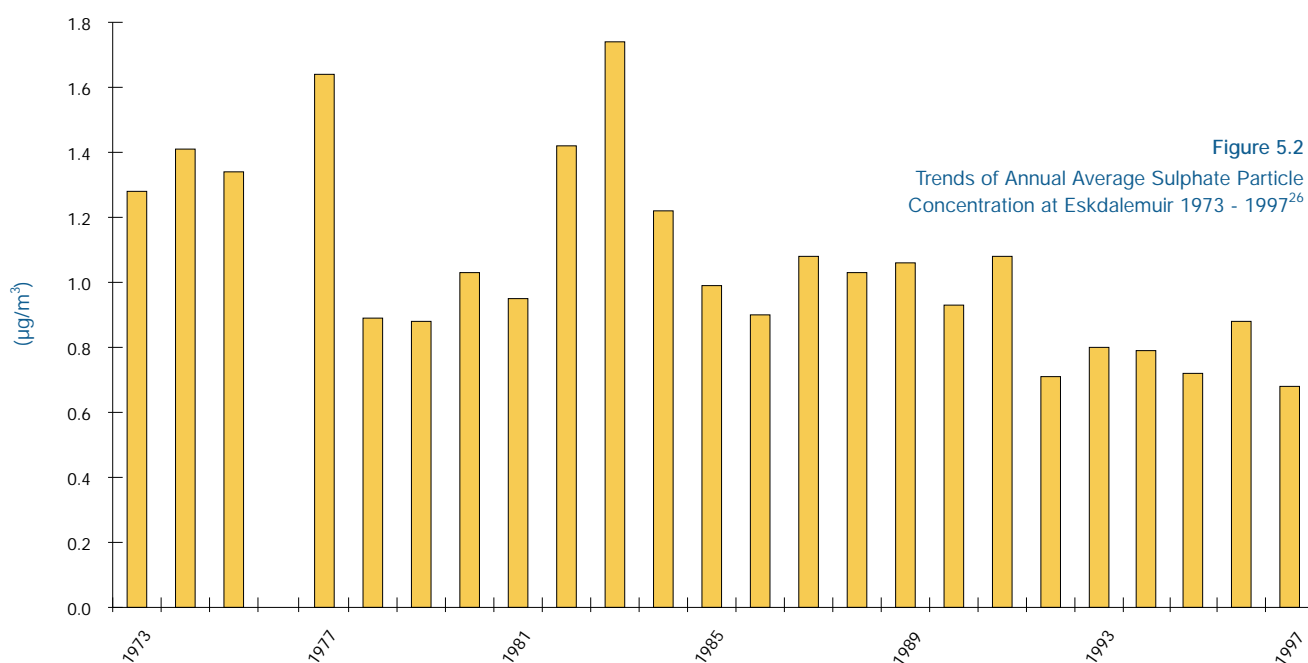
Areas of high sulphur deposition in Scotland are in the south west Highlands (from wet deposition), the central belt (from dry deposition) and Galloway and the Borders (from a combination of wet and dry deposition) where deposition rates are over 15 kg S/ha/yr. Deposition rates in the hill and mountain areas of the eastern Borders, Central Highlands and on the Cairngorm and Grampian Mountains can reach about 12 kg S/ha/yr. Deposition rates for sulphur to many areas of Scotland are less than 6 kg S/ha/yr<sup>43</sup> (Figure 3.4). Wet deposition of sulphate accounts for about two thirds and dry deposition of SO<sub>2</sub> about one third of total deposition of sulphur to Scotland as a whole<sup>43</sup>. Wet deposition has declined with emission reductions from power stations in the UK and elsewhere in Europe and this trend continues. Dry deposition dropped markedly in the 1980s but there is little evidence of a continued downward trend.

Extensive damage to trees, in the form of defoliation and discolouration, has been reported<sup>24, 25</sup>. However, the damage does not necessarily relate to acidification as other environmental stresses, weather or intrinsic features will also lead to defoliation and reduced

growth. A causal link cannot, therefore, be established between an input of acid deposition in excess critical load and observed foliage reduction, even in areas where the neutralising capacity of the soil is likely to be an important influence on the growth and ageing of forest stands. Despite pollutant emission reductions for NO<sub>x</sub> and SO<sub>2</sub> studies show a general increase in defoliation<sup>24</sup>. For the UK, 13.9% and 15% of conifer and deciduous trees had more than 25% to 100% needle or leaf loss<sup>24</sup>.

Many lochs in Scotland have been affected by acid deposition (see SEPA Report *Improving Scotland's Water Environment*). The effects of acid deposition can be direct, because of toxicity, or indirect, because of acid sensitive prey or plant food or because of complex changes in water chemistry caused by increased acidity. The percentage of lakes with exceedance of the critical load for sulphur varies for different European countries. For Scotland, the figure is just over 1%, for Wales it is approximately 24% and Norway 27%<sup>24</sup> (Figure 5.1). Acid deposition is of particular importance in the Galloway area where there are 400 km of rivers classified as polluted due to this cause.

The reported reductions in the effects of acid deposition in Europe are the result of reductions in SO<sub>2</sub> and NO<sub>x</sub> emissions. Sites across Scotland have shown substantial reductions of airborne sulphate particle levels. A similar pattern is seen for other sites in northern Europe<sup>25</sup> (Figure 5.2).



## WHAT IS THE GREENHOUSE EFFECT?

Like a window pane in a greenhouse, a number of gases in the earth's atmosphere let the visible part of solar radiation pass to the surface of the earth while trapping infrared radiation, also known as heat radiation, that is re-emitted by the surface of the earth. This heat radiation would have otherwise escaped to space. It is the trapping of infrared radiation that is referred to as the greenhouse effect<sup>28</sup>.

The gases that influence the surface-atmosphere-radiation balance are also called radiatively active or greenhouse gases. These include carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>)<sup>28</sup>.

## Climate Change

There is now sufficient evidence that human activity is having an effect on the earth's climate, mostly as a result of greenhouse gas emissions. The most recent forecasts in 1998 by the UK Impacts Programme of Climate Change are that in Scotland by 2050<sup>27</sup>:

- *Mean temperature will have increased by between 0.8 and 2.0 °C*
- *Annual precipitation will have increased by between 3 and 6%, although the winter increases may be up to 13%*
- *The intensity of precipitation will have increased.*
- *Net sea level will have risen by somewhere between 5 and 65 cm*
- *Storm damage, flooding and erosion in coastal zones will have increased*

SEPA has identified climate change as one of the most important environmental issues facing Scotland today, but accepts that its ability to influence global warming is very limited. Despite this, SEPA has developed a set of environmental indicators with key Scottish partners in support of its environmental strategy, which includes eleven indicators for climate change in Scotland.

Through the application of environmental standards, SEPA is able to control greenhouse gas emissions from authorised industrial processes. Whilst it does not currently impose any specific standards for CO<sub>2</sub> emissions, these are partly controlled through the IPC and LAPC systems. It is anticipated that the intergovernmental commitments agreed in Kyoto, and possible reduction of carbon, or energy tax in the UK, would require knowledge of current emission levels. SEPA is therefore requiring some industries to maintain records of their CO<sub>2</sub> emissions. The introduction of

IPPC will provide a framework for including energy efficiency requirements for industry. It will also enable SEPA to regulate methane emissions from the largest livestock holders, providing a further opportunity to control the emission of greenhouse gases in Scotland. In addition, the new Landfill Directive, to be regulated by SEPA, proposes to reduce the amount of biodegradable waste to landfill which will reduce both methane and CO<sub>2</sub> emissions. Methane is 60 times more damaging than CO<sub>2</sub> per unit mass. The principal sources of CO<sub>2</sub> emissions are from unregulated sources such as domestic heating and road transport.

## Ozone Depletion

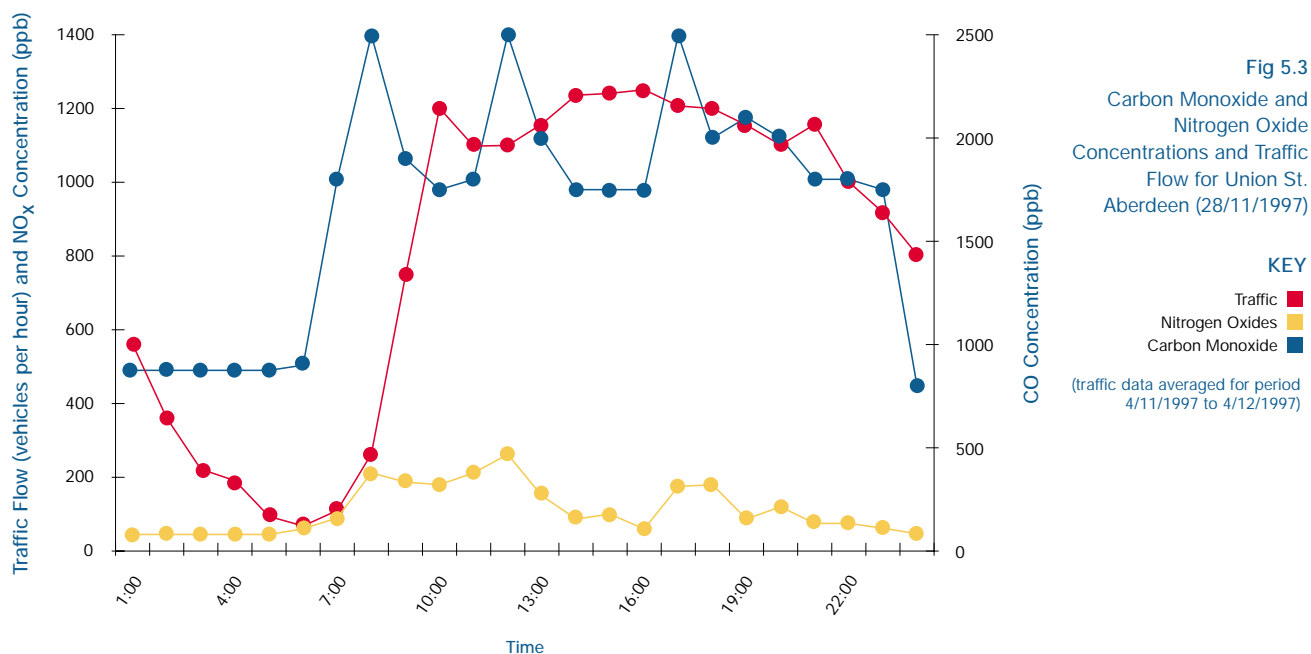
During the 1960s industrialised countries manufactured increasing quantities of compounds containing chlorine and bromine, which were used for refrigeration, aerosols, fire extinguishers and the manufacture of foam. Once released into the atmosphere some of these chemicals including chlorofluorocarbons (CFCs) and other halocarbons (HCFCs) reacted with the O<sub>3</sub> layer and caused it to deplete. The O<sub>3</sub> depletion has caused a hole to form over the Antarctic during September and October when up to 60% of the total O<sub>3</sub> is depleted. Satellite observations show that total atmospheric ozone levels over Scotland have declined by around 10% over the past 20 years<sup>29</sup>.

SEPA currently controls the disposal of materials containing O<sub>3</sub> depleting substances through the scheme of Waste Management Licensing. However, the implementation of the New EC Regulation on Ozone Depletion Substances later this year (2000) provides the opportunity for SEPA to extend this control to IPC and LAPC processes. SEPA also plays its part in furthering understanding of the process, extent and implications of O<sub>3</sub> depletion. This will include the extent of banks of O<sub>3</sub> depleting chemicals held in Scotland, and the possible environmental implications of compounds developed as alternatives to CFCs and HCFCs.

## WHAT IS THE OZONE LAYER?

O<sub>3</sub> is a naturally occurring form of oxygen, which forms a layer in the upper levels of the earth's atmosphere (the stratosphere). The O<sub>3</sub> screens out a high proportion of the ultra-violet (UV) in sunlight and prevents it reaching the lower levels of the atmosphere (the troposphere). Without this protection, the surface of the earth would be exposed to levels of UV solar radiation, which would be harmful to almost all forms of life.

The increased levels of UV light have been linked to the recent growth in skin cancers being detected<sup>29</sup>.



## 5.2 Localised Pollution Issues

Measurements show that for many areas air quality levels are likely to be within the NAQS objectives. However, localised elevated air pollution levels will require particular attention and resources to resolve. This is particularly the case for heavily trafficked and large industrial areas.

### Benzene and 1,3-Butadiene

An assessment of the national monitoring results for both benzene and 1,3-butadiene show that both pollutants are well within the UK AQS. It is anticipated that existing policies are expected to meet the air quality objectives for both pollutants by 2003<sup>18, 19</sup>.

Therefore, based on the premise that the UK AQS for both benzene and 1,3-butadiene will be met adjacent to heavily trafficked roads, the areas which may potentially be of concern are major industrial sources, in particular in combination with adjacent busy roads.

A significant amount of benzene monitoring, using diffusion tubes, has been carried out around refinery and oil terminal installations in Scotland, such as at Grangemouth and Nigg. Diffusion tube measurements are useful for area wide surveys. Studies in the Grangemouth area show that levels were less than the UK AQS of 5 ppb and most concentrations were less than 1 ppb. Levels around Nigg were also well within the UK AQS. Annual average 1,3 butadiene levels at Grangemouth were also less than 1 ppb. Continued monitoring around these facilities will ensure that the NAQS objectives are being achieved.

Table 5.1

CO 1-hr Levels for Selected Automatic Monitoring Sites <sup>17</sup>		
Site	ppm	mg/m <sup>3</sup>
Edinburgh Centre	4.6	5.3
Glasgow Centre	4.2	4.8
Glasgow City Chambers	5.2	6.0
Glasgow Kerbside	5.8	6.7
Aberdeen	6.4	7.1
WHO guideline		30

### Carbon Monoxide

A review of current monitoring data shows that the UK AQS is being met at UKAMN sites in Scotland. Existing Government policies are generally expected to meet the UK AQS without additional measures being required at local or national level, although possible exceptions may arise near heavy traffic.

Since the main source of CO is motor traffic (see Annex A), concentrations are highest near to heavily trafficked roads. Concentrations fall rapidly with distance from roads so that it is a local, rather than a transboundary pollutant. A typical example of the effect of road traffic on CO levels is seen for Union Street in Aberdeen (Figure 5.3). CO and NO<sub>x</sub> concentrations were seen to

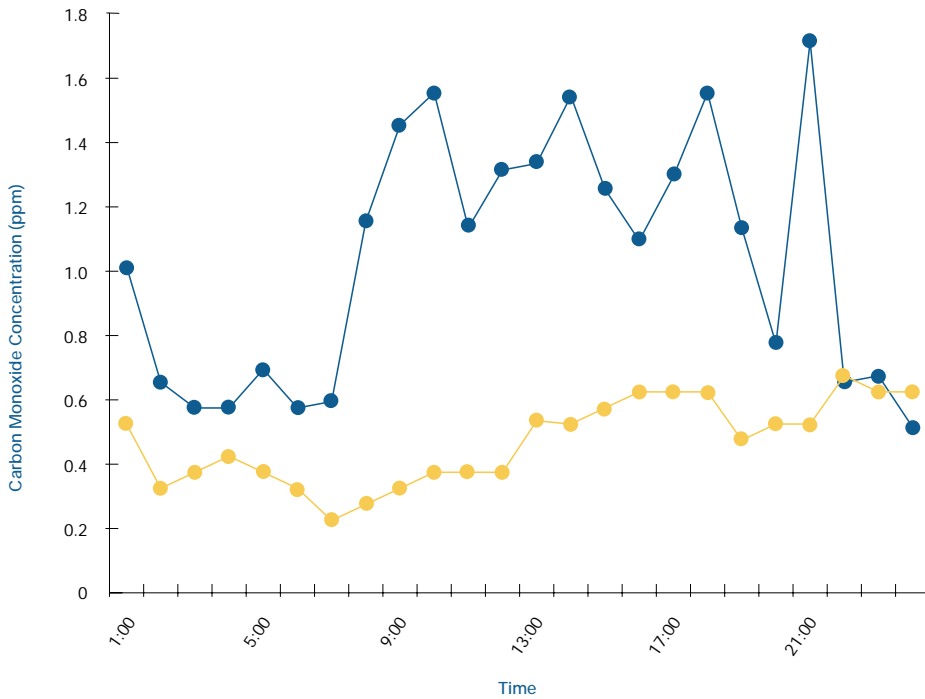


Figure 5.4  
Carbon Monoxide  
Concentrations at a Roadside in  
Glasgow for a Weekday (11/01/1998)  
and a Weekend (16/01/1998)

KEY  
Weekday ■  
Weekend ■

increase throughout the daytime period against increased traffic levels. CO and NO<sub>x</sub> levels increased to over 2000 ppb and 263 ppb respectively, against significantly reduced night time levels<sup>30</sup>.

A comparison of weekday and weekend CO levels in Glasgow shows that average concentrations may be up to 2 to 3 fold greater for weekdays than weekends due to increased traffic levels<sup>17, 31</sup> (Figure 5.4).

Peak 1-hour CO measurements at sites in Scotland have been found to be elevated, although they are below the WHO 1-hour guideline value of 26.1 ppm (30 mg/m<sup>3</sup>)<sup>17</sup> (Table 5.1).

### Lead

During the 1970s and early 1980s the lead content of petrol was gradually reduced. At the end of 1985 the maximum permitted content of petrol was significantly reduced from 0.4 g/l to 0.15 g/l, and in 1987 unleaded petrol was introduced. Lead-in-air monitoring results for Glasgow show a very pronounced reduction in concentrations<sup>31</sup>. Average concentrations have reduced from 750 ng/m<sup>3</sup> in 1977 to 40 ng/m<sup>3</sup> in 1997 (Figure 5.5). The reduction in concentrations is less discernible for the remote Eskdalemuir site (Figure 4.6).

Although motor vehicles are the principal source of lead emissions, industrial process may still cause localised problems. Foundries are one such concern. SEPA has carried out investigations of air quality adjacent to SEPA regulated sites. Deposit gauge monitoring was carried out at a foundry in Larbert, which had been the subject of public complaint. The results did not confirm any significant extra local fallout attributable to the foundry<sup>32</sup>.

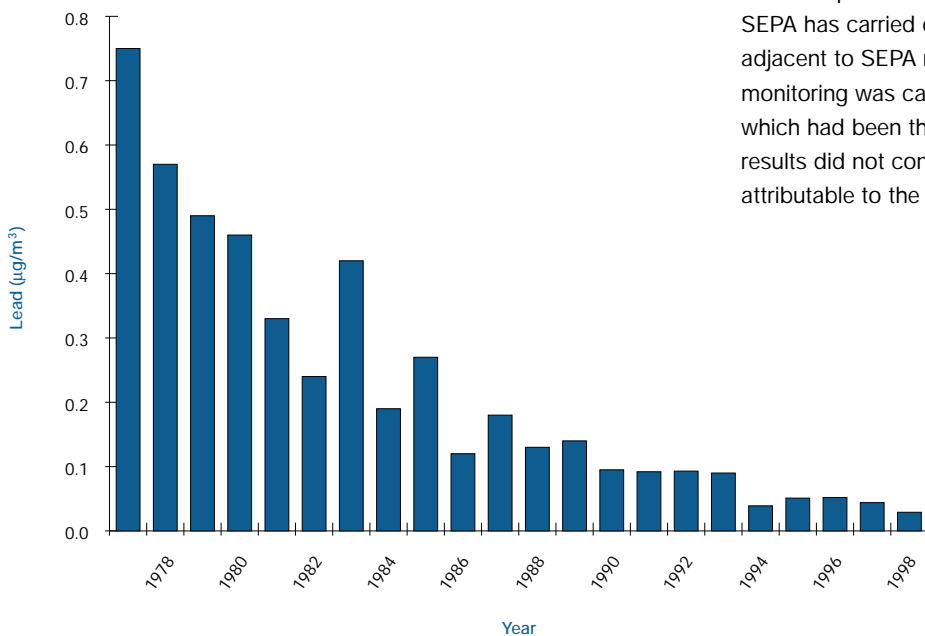


Figure 5.5  
Lead-in-air Levels for Glasgow  
(St Mungo's Academy)

### Nitrogen Dioxide

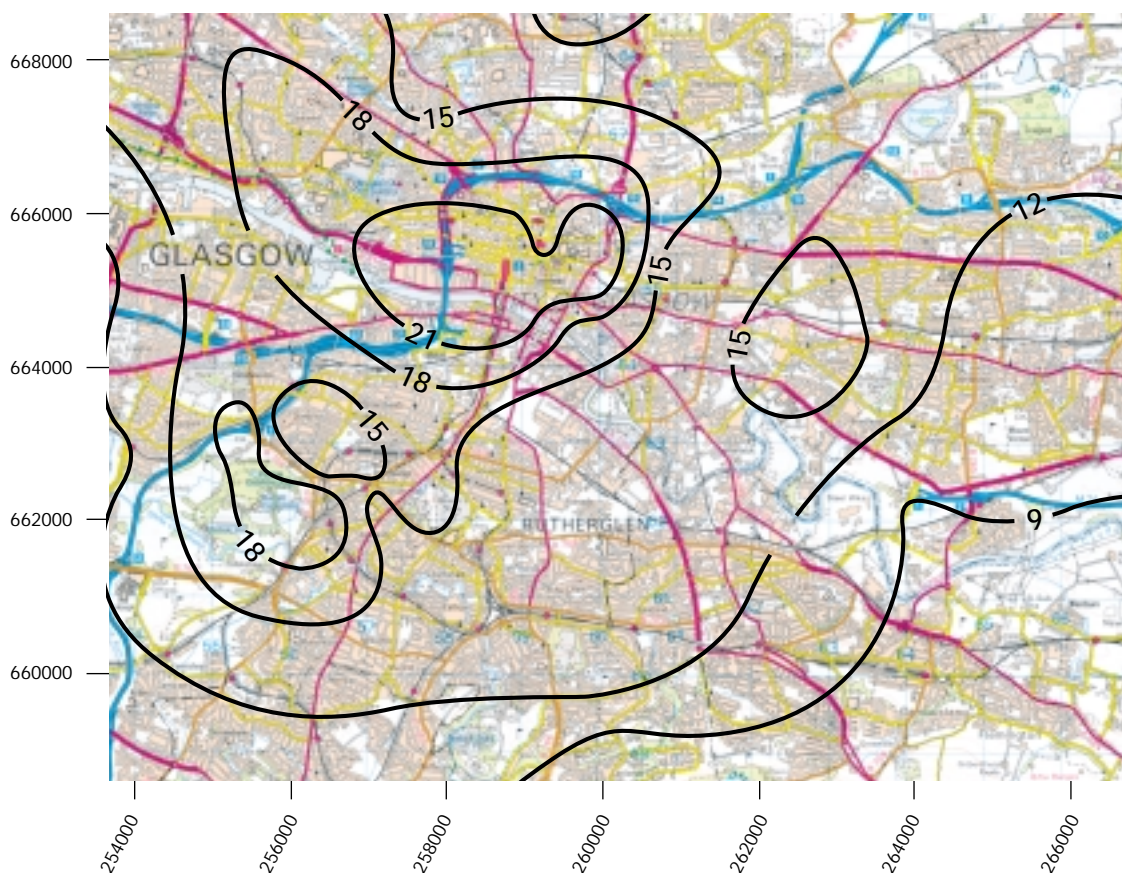
A review of current monitoring data shows that, whilst the EC Directive limit value is generally complied with at UKAMN sites, the UK AQS annual mean and 1-hour level have been exceeded.

Nationally motor vehicles are the principal source of NO<sub>x</sub> emissions accounting for nearly half of UK emissions<sup>19</sup> (see Annex A). In urban areas the percentage contribution increases significantly, for example 76% for Glasgow and 96% for Edinburgh, compared to other sources (see Table 3.2). The greater percentage of low lying emission sources will further exacerbate elevated NO<sub>2</sub> levels in city areas and by busy roads. A contour plot of NO<sub>2</sub> average levels for 1997 and 1998 for sites in Glasgow illustrates the extent of the area that may exceed the annual UK AQS of 21 ppb<sup>31</sup> primarily due to motor vehicle emission (see Figure 5.6). Similar patterns are likely to be found in other cities in Scotland. Although motor vehicles are a principal source of NO<sub>x</sub> many IPC and LAPC processes may be a dominant local emission source. SEPA closely monitors these emissions to ensure compliance with the NAQS objectives.

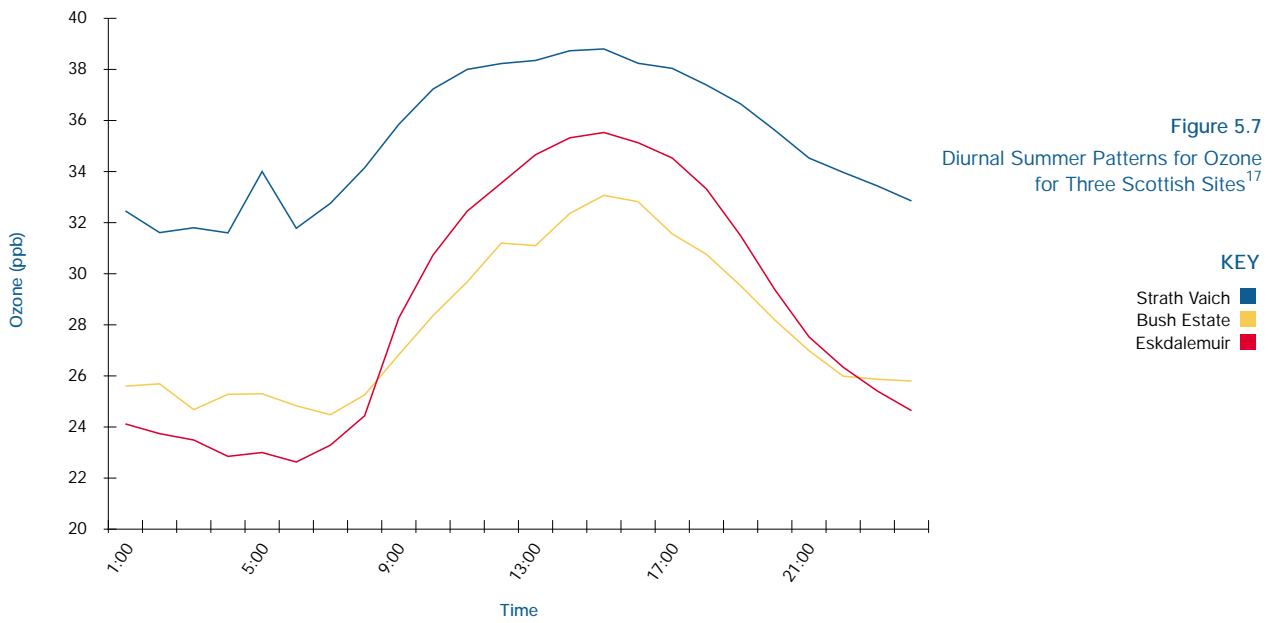
### Ozone

Current monitoring data shows that ambient concentrations of O<sub>3</sub> exceed the UK AQS of 50 ppb at all rural monitoring sites within Scotland. In addition, exceedance of the current EC Directive protection level for vegetation is also prevalent. The greatest number of exceedances occurs in remote rural areas. Exceedance of the current EC Directive Health Protection level also occurs at rural monitoring sites. As the formation of O<sub>3</sub> needs sunlight, monitoring station results show a distinct diurnal pattern. (Figures 5.7 and 5.9). However, the cycle is not primarily a consequence of photochemistry. The diurnal cycle arises because during the night the calm stable air close to the ground loses its O<sub>3</sub> by deposition to the surface, thus, in the morning, the O<sub>3</sub> mixes down from higher levels in the atmosphere. The smaller cycle at Strath Vaich is due to the windier conditions experienced at the location.

Figure 5.6  
Annual NO<sub>2</sub> Levels for the Centre of Glasgow







**PM<sub>10</sub>**

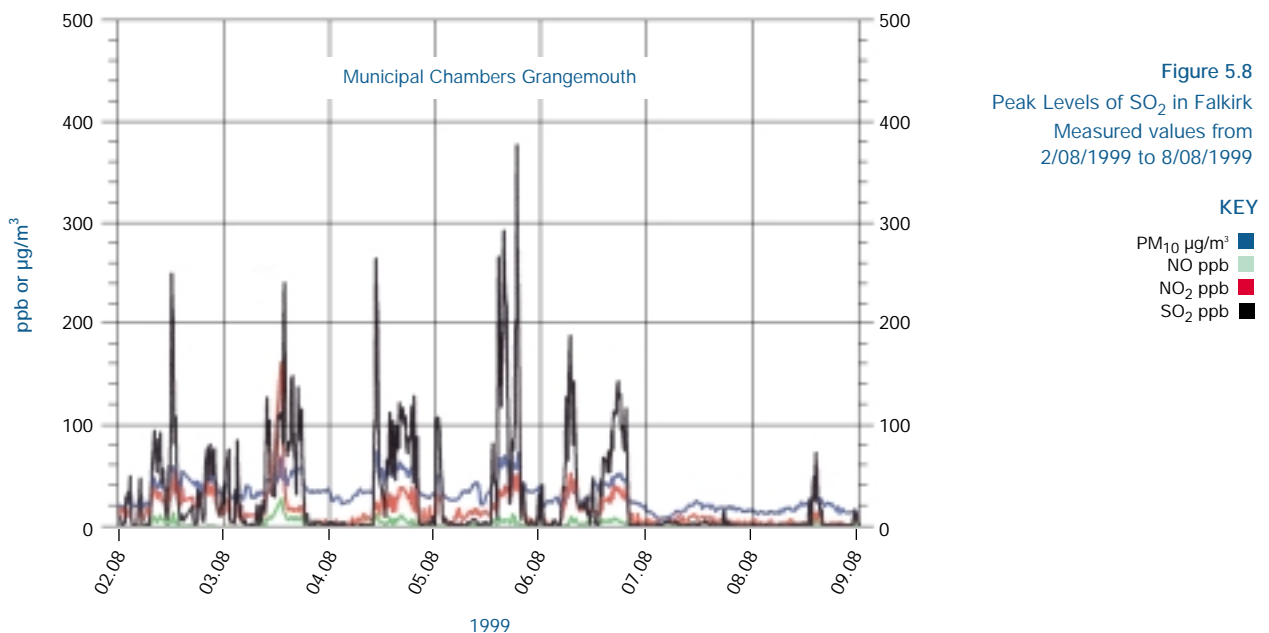
Available results show elevated levels of PM<sub>10</sub> at several UKAMN sites in Scotland. The highest level of exceedances was recorded at the Glasgow Kerbside site, demonstrating the contribution of traffic to overall levels of PM<sub>10</sub>. Elevated particulate levels may also arise from mineral extraction activities regulated by SEPA. Many activities are closely monitored to ensure that particulate levels are below recommended AQS and are not contributing to a nuisance.

**Sulphur Dioxide**

Current data shows that the EC Directive limit and guide values are not exceeded at either the UKAMN smoke and SO<sub>2</sub> sites or the automatic monitoring stations. However, these limit and guide values date back to

when the significance of domestic and small scale industrial emissions of smoke and SO<sub>2</sub> were far greater and are now considered to be out of date. SO<sub>2</sub> concentrations, monitored at the automatic sites, also show compliance with the proposed EC Directive limits, although elevated levels have been recorded at Grangemouth since the installation of Falkirk Council's monitor.

Elevated SO<sub>2</sub> levels are expected in areas of concentrated emissions of SO<sub>2</sub> like Grangemouth. Levels have exceeded 100 ppb on a number of occasions and the maximum UK AQS for NO<sub>2</sub> of 105 ppb has also been exceeded. An example of these high pollution episodes occurred during the week 2/8/99 to 8/8/1999 when peak SO<sub>2</sub> levels reached 380 ppb<sup>33</sup> (Figure 5.8).





Grangemouth

### 5.3 Forth Valley

Some of the most important and largest industrial processes in Scotland are situated in the Forth Valley, where they are under the control of the SEPA East Region. SEPA is evaluating the impact of SO<sub>2</sub> emissions from IPC processes in the area. The principal emission sources are Longannet Power Station and Grangemouth BP refinery in the west and Cockenzie Power Station to the east<sup>34</sup>. An air quality model of the Forth Valley is being developed by SEPA East Region, to study the atmospheric discharges from this heavily industrialised area. The model will provide SEPA with a valuable decision-making tool for LAPC, IPC and IPPC applications submitted in future. Initial air dispersion

modelling studies of Longannet Power Station, undertaken by SEPA, show that the UK AQS SO<sub>2</sub> 15-minute 99.9th percentile value may be exceeded in a small area adjacent to the site under full load conditions, with an assumed coal sulphur content. SEPA has been working with Scottish Power to refine the model input data, and SEPA has recently agreed with the company that flue gas desulphurisation will be fitted and operational on one unit by the year 2003. However, the complexity of the valley's topography and meteorology and distribution of principal emission sources means that emissions sources have to be modelled collectively as some of the emissions plumes may overlap. SEPA has begun this process by modelling the emissions of Longannet together with 18 sources emitting SO<sub>2</sub> from the BP Grangemouth complex. Studies show that the SO<sub>2</sub> AQS may be exceeded in a general north east and south west direction from the plants. SEPA is now comparing the combined effects of 12 other IPC processes in the area including Cockenzie Power Station.

### 5.4 Scotland's Cities

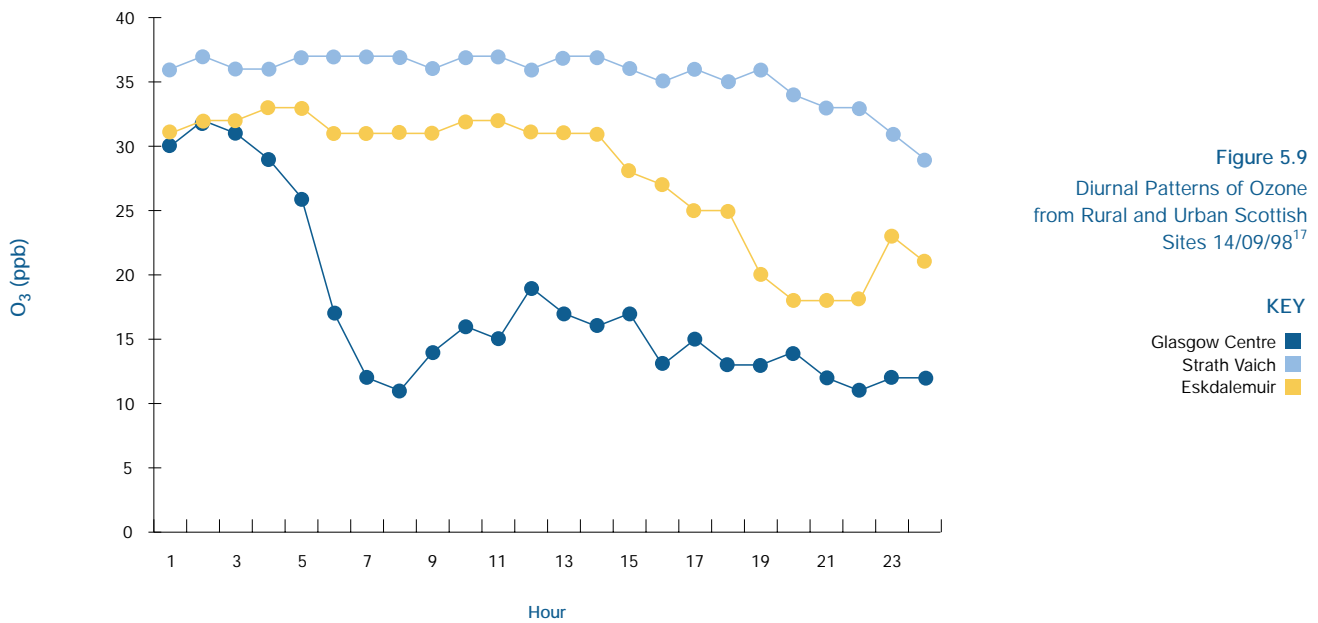
The UKAMN and NAEI show that major air pollution concerns relate to urban areas. Edinburgh, Glasgow and Aberdeen City councils identified these concerns in their local air quality management First Stage Reviews. Motor vehicles were the principal source of air pollution. New statistics for 1998 in Scotland show that there

Table 5.2

Comparison with Urban and Rural Air Quality Levels (1998) <sup>17</sup>					
Annual Average	NO <sub>2</sub> ppb	SO <sub>2</sub> ppb	CO ppm	O <sub>3</sub> ppb	PM <sub>10</sub> µg/m <sup>3</sup>
Aberdeen	34	4	1.1	-	21
Glasgow Centre	22.9	3	0.5	15.7	20
Edinburgh	24.8	2	0.6	16.0	15
Strath Vaich	1.8 (1997)	0.8	-	35.5	-
<b>Peak</b>	<b>1-hr</b>	<b>15-min*</b>	<b>1-hr</b>	<b>1-hr</b>	<b>24-hr</b>
Aberdeen	143	33.8	6.4	-	53
Glasgow Centre	184	32	4.2	60	54
Edinburgh	87	65	4.6	52	44
Strath Vaich	8.5 (1997)	7	-	72	-

- no data

\* 99.9th percentile (1996)



were around 2,073,000 vehicles licensed, 2% more than in the previous year and about 28% more than 10 years ago<sup>49</sup>. Air pollution problems experienced in these cities are similar to those found elsewhere, although localised industrial processes may also be a concern.

Cities experience both primary, emitted directly in the atmosphere, and secondary, formed by chemical reaction in the atmosphere, pollution problems. Motor vehicles are responsible for both types of pollution. In particular with regard to primary pollutants, most of the

CO, NO<sub>x</sub> (NO and NO<sub>2</sub>) (Figure 5.4) and hydrocarbons, such as benzene and 1,3-butadiene, are emitted from traffic, together with a significant proportion of airborne particles, PM<sub>10</sub>. The precursors of the two principal secondary pollutants O<sub>3</sub> and NO<sub>2</sub> in the UK, hydrocarbons (VOCs) and NO<sub>x</sub>, come predominantly from motor vehicles.

As O<sub>3</sub> is formed by chemical reactions in the atmosphere it is less dependent on emission patterns and tends to be more strongly influenced by meteorology. Ultra violet radiation causes these reactions and, as a result, O<sub>3</sub> formation is greatest in hot, sunny weather<sup>48</sup>. The process can take several days to complete so that O<sub>3</sub> can be formed considerable distances from the primary pollutant emission source(s). Concentrations in cities are reduced by O<sub>3</sub> scavenging, when reaction with vehicle emissions results in removal from the atmosphere. The net result is that the highest O<sub>3</sub> concentrations are seen in rural areas (Figure 5.9)<sup>48</sup>.

NO<sub>2</sub> concentrations offer a different perspective. Although some NO<sub>2</sub> is emitted from vehicles or other sources, most is formed by rapid chemical reaction. NO is emitted from vehicles and is oxidised to NO<sub>2</sub> by reaction with O<sub>3</sub> and oxygen. Concentrations of NO<sub>2</sub> tend to be highest in urban areas where traffic densities are high<sup>48</sup>. Air quality in urban areas is discernibly worse than in rural areas. Previous problems of domestic emissions of SO<sub>2</sub> and smoke causing smog have diminished. However, for many cities the nature of the smog is now photochemical resulting from motor vehicle emissions (Table 5.2).



City Traffic

## 5.5 Diffuse Pollution Inputs to Land and Sea

Whilst air quality effects in Scotland can often be traced to a definable emission source, air quality impacts may also be caused by diffuse sources and activities which cover a wide area. One such concern is the diffuse pollution between land and sea.

Review studies<sup>6</sup> have shown that on a global scale, oceans are a major source of natural sulphur accounting for around 15% of emissions<sup>35</sup>. For the EMEP region (Europe) independent estimates suggest yearly contributions from marine sources of 600 - 1000 kt/a<sup>36</sup>. Accounting for the majority of oceanic reduced sulphur<sup>37</sup>, dimethylsulphide (DMS) is considered to be the main biogenic compound contributing to atmospheric marine sulphate<sup>38</sup>. Studies suggest that approximately two thirds of atmospheric DMS is oxidised to SO<sub>2</sub> within hours of release<sup>39</sup>.



Emissions from Ships have been Under-estimated

Studies of anthropogenic emissions sources have concentrated on terrestrial emissions, but it is now recognised that they have under-estimated the contribution from marine sources, such as ships<sup>40</sup>. Attention has now focused on ship emissions largely because land based emission levels are being reduced through existing and proposed environmental legislation. Emissions of SO<sub>2</sub> and NO<sub>x</sub> from ships may now represent a significant proportion of the remaining emissions contributing to acidification in Europe<sup>4</sup>.

This concern is highlighted by the higher estimates of SO<sub>x</sub> and NO<sub>x</sub> that ship emissions assumed when the Second UNECE Sulphur Protocol was negotiated. Recent studies have found total NO<sub>x</sub> and SO<sub>x</sub> emissions from ships to be comparable in magnitude with the largest energy consuming nations<sup>40</sup>. The total emissions of SO<sub>2</sub> and NO<sub>x</sub> for the North Sea and N E Atlantic Ocean are 1080 and 1550 kt/a<sup>42</sup> respectively (Table 5.3). North Sea international shipping contributed 5 to 10% to the total NO<sub>x</sub> deposition in the UK<sup>42</sup>. The relative contribution for SO<sub>x</sub> from international shipping is 2.5%.

Other studies have estimated the atmospheric deposition of nitrate to the North Sea of 183 t/a NO<sub>3</sub>-N<sup>44</sup> for 1993. These deposition levels coupled with estimated direct and riverine inputs to the North Sea of 625 kt/a<sup>45</sup> are playing a significant part in its eutrophication. At present it is not possible to evaluate Scotland's contribution to this loading.

Table 5.3

Total SO <sub>x</sub> and NO <sub>x</sub> from International Shipping (kt/a)		
	SO <sub>x</sub>	NO <sub>x</sub>
NE Atlantic	641	911
North Sea	439	639
Total	1080	1550

## 6. SEPA's Goals and Targets for Improving Air Quality

SEPA aims to enhance and maintain the quality of Scotland's air. This chapter defines a number of goals and targets for achieving this over the next few years. Several approaches are adopted using three interlinked tools for initiating change and achieving continuous improvement. These are:

- *statutory functions including laws and regulation*
- *education*
- *influencing and advising*

SEPA plays a part in all these areas and may adopt all three simultaneously. In addition, SEPA's Environmental Strategy identifies 'strategy statements' for air quality which will direct the future of the Agency's policy and operations in this area.

### 1. Statutory Functions including Laws and Regulation

#### *IPC, LAPC and IPPC: the BAT(NEEC) duty*

The most significant anthropogenic sources of air pollution include transport and industrial emissions, notably those derived from fossil fuels. SEPA currently regulates emissions to air from some 1,800 LAPC processes and regulates releases to air, land and water at around 200 IPC sites. This will be further extended with the introduction of IPPC from summer 2000 onwards, where up to 500 additional processes will require permits by 2007.

A fundamental component of these pollution control regimes is the requirement for each process to demonstrate the use of Best Available Techniques (Not Entailing Excessive Cost) known as BAT(NEEC) or BAT in the case of IPPC, to reduce the impact of pollution on the environment.



Lichens can indicate good air quality

Section 7 of EPA 1990 requires that BATNEEC will be used to prevent, minimise or, where this is not practical, render harmless the release of prescribed substances into the environment. Moreover, BATNEEC must be adopted to render harmless the release of any substance, prescribed or otherwise, which may cause harm to the environment. Consequently, the operator has a duty to ensure that BATNEEC is used to achieve these aims, with the emphasis being on means of preventing a potentially detrimental release to the environment in the first instance. Under both IPC and LAPC, and ultimately IPPC, this BATNEEC duty is an implied condition of every authorisation and permit.

A BATNEEC hierarchy can be established on the premise that prevention is better than cure.

#### BATNEEC HIERARCHY

##### 1. Prevention Techniques



##### 2. Technical Control and Operational Practices



##### 3. Abatement Equipment and Recycling within Process



##### 4. Abatement Equipment with Release to Environment

The enforcement of BATNEEC is a key tool which SEPA can use to reduce atmospheric emissions. Emissions of SO<sub>2</sub> and NO<sub>x</sub> from large combustion plant in Scotland have been reduced by some 20% and 10% since 1996 respectively through the installation of additional abatement plant and changes to the use of plant. Additionally, under IPPC, SEPA will have controls on energy efficiency which could make a significant contribution to the reduction in emissions of CO<sub>2</sub>. The Government's plans for negotiated agreements in relation to the Climate Change Levy could also be effective in reducing CO<sub>2</sub> emissions.

#### *Operator Performance Assessment*

As a regulator, SEPA has a key role to play in offering advice to industry and influencing behaviour to achieve emission reductions. To do this, it is important to have a clear view of how industry are performing and working to the conditions in their authorisations. SEPA introduced its OPA system in 1998 as a means of monitoring progress towards satisfactory operation of IPC and LAPC processes. As data from this scheme are acquired, it will allow SEPA to identify those operators who are most effective in managing their processes. This will allow SEPA to target its resources effectively.

For example, it provides useful information on whether inspection frequencies should be increased or decreased for a particular sector. SEPA has set a target of 85% of all IPC and 80% LAPC processes achieving satisfactory status in their OPA over the next year.

In the longer term, SEPA aims to ensure that at least 90% of IPC, LAPC and IPPC processes demonstrate satisfactory operator performance.

### *Air Emissions Database*

To provide high quality advice, SEPA must be aware of the origin of the main emissions to atmosphere and what trends can be identified. SEPA East Region has piloted an emissions inventory to quantify emissions from IPC processes. Similar studies are also being undertaken in SEPA North Region. This exercise will be extended across SEPA in 2000 and will allow the Agency to plan and develop future monitoring strategies, identify main pollutant sources and assess trends in air emissions. Where appropriate, SEPA will use the information to set targets for reductions in regulated emissions of particular pollutants.

### *Having Regard to the UK National Air Quality Strategy*

The NAQS sets objectives for improving air quality, particularly in urban and industrial areas. Where air quality standards are not met, or are unlikely to be met, Local Authorities must establish Local Air Quality Management Areas and develop action plans to improve air quality in those areas. Local authorities are required to consult SEPA on their reviews and assessments and in developing any subsequent action plans. SEPA is required to have regard to the objectives of the Strategy in exercising its regulatory functions.

Where modelling indicates that emissions regulated by SEPA may be contributing to breaches of the NAQS standards, SEPA will work closely with local authorities to identify cost effective solutions. SEPA will provide the Local Authorities with data on emissions from industrial processes and liaise closely in the development of their Stage 2 and 3 Review and Assessment reports. These will determine where future Air Quality Management Areas are to be established. In line with the revised NAQS, industry will not be required to make a disproportionate contribution to meeting NAQS objectives, and standards in excess of BAT will not normally be applied.

### *Other Statutory controls*

In addition to EPA 1990, IPPC and the revised NAQS, there are other statutory measures for controlling atmospheric emissions which must be implemented in Scotland over the next few years. For example, Stage I

Petrol Vapour Recovery has been in force since 1996, and by December 2004 all petrol stations with a petrol throughput of more than 100m<sup>3</sup>/year will be affected by this legislation. The threshold is 500m<sup>3</sup>/year where the service station is in a derogated area and was in operation, or had received planning permissions for construction before 31 December 1996. UK wide, these regulations will prevent 30 billion litres of carcinogenic benzene vapour being emitted to the atmosphere every year.

The EC Solvents Directive seeks to reduce VOC emissions by two thirds by 2007 from 20 industrial sectors identified in Annex I of the Directive. This will require up to 500 dry cleaners in Scotland being regulated for the first time under LAPC, to reduce their emissions of organic solvents to atmosphere.

## **2. Education**

The education of SEPA staff and those who operate regulated processes is an important aspect of securing and maintaining good air quality. SEPA does much during its ordinary day to day activity of regulation to promote best practice and good housekeeping techniques for reducing emissions, but it is recognised that there is always potential for improvement and further proactive work.

Further training in best practice techniques is required in both SEPA and regulated industries. SEPA has been involved with several DETR and Scottish Executive funded Environmental Technology Support Unit training initiatives for best practice in issues such as solvent management and vehicle respraying. There has also been significant involvement with waste minimisation clubs throughout Scotland and internal SEPA training for waste minimisation which has focused on the importance of good housekeeping and process design in preventing or reducing emissions to atmosphere.

### *Promotion of internal environmental management system*

SEPA recognises that an effective form of influencing others is to lead by example. SEPA adopted an internal environmental policy early in its existence and has been building an environmental management system to put the policy into effect. This ensures that the Agency's daily business has the least possible environmental impact. SEPA has been collating information on the amount of energy used within its offices so that targets can be set for increasing energy efficiency and reducing emissions.

### 3. Influencing and Advising

#### *Sustainable Development*

SEPA is interested in the environmental and human health impacts of the emissions it regulates. It is axiomatic that good regulation should adequately protect the environment and human health and is fundamental to sustainable development. While there is now generally good information on air quality and links to human health, far less work has been undertaken on some of the environmental impacts of poor air quality. Where concerns exist, SEPA will apply the precautionary principle. SEPA will also continue to develop its understanding of environmental impacts such as acidification, eutrophication, and vegetation damage from O<sub>3</sub>.

As part of its sustainable development duty, SEPA will also continue to proactively seek emissions reductions from regulated processes to reduce pressure on air quality and to support waste minimisation.

The detection of potential climate change impacts in Scotland depends on the availability and analysis of long-term environmental data. SEPA holds valuable records on river flows and rainfall which can indicate long-term changes in weather patterns associated with climate change. SEPA will continue to collect such data and make them available for analysis.

#### *Working in partnership with other organisations*

Improving air quality is a task which involves several organisations and SEPA recognises the need to work with other relevant groups in order to achieve a common aim. As such, SEPA will continue to develop beneficial partnerships with all those organisations that have an interest in air quality, including the Scottish Executive, DETR, Local Authorities, Scottish Natural Heritage, NETCEN, the Institute of Terrestrial Ecology, the Environment Agency for England and Wales and the Northern Ireland Environment and Heritage Service.

It is also important to develop good links with the industrial sectors that are regulated under IPC and LAPC. SEPA is represented on a number of trade bodies including the Chemical Industries Association and the Association for Petroleum and Explosives Administration. This provides an ideal forum for working in partnership and improving relationships with those involved in meeting specific air quality targets and limit values.

#### *Air Quality Database*

In addition to its work on an air emissions database, SEPA has also been gathering information for an air quality database. This will be a comprehensive database of all the main air quality monitoring

information currently available in Scotland. It will include data collated by NETCEN for the UK Automatic Monitoring Network, and data originating from the Local Authorities and SEPA.

#### Summary of goals and targets

SEPA will:

- *continue to reduce atmospheric emissions through the use of BAT(NEEC)*
- *work to secure at least 90% satisfactory operator performance for regulated processes by 2003*
- *establish an atmospheric emissions inventory which characterises and quantifies all significant emissions from SEPA regulated processes by 2003*
- *work with the Scottish Executive to establish a CO<sub>2</sub> emissions reduction target and take forward relevant and cost effective steps to achieve it*
- *establish as appropriate, regulated emissions reductions targets for other key pollutants*
- *monitor the changes in future energy production which could significantly impact on emissions of CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>2</sub> over the next 10 to 15 years*
- *continue to develop beneficial relationships with regulated industries, trade bodies and associations*
- *support the revised UK NAQS, including the achievement of its objectives for the eight priority pollutants set for 2003 and 2005*
- *further develop beneficial relationships with other organisations that have responsibility for improving air quality, notably local authorities*
- *establish an air quality database*
- *remain informed on transport issues and continue to encourage the development of a Scottish Transport Strategy which will achieve reductions in vehicle emissions*
- *monitor progress in achieving predictions for the reduction of areas exceeding critical loads for acidification*
- *continue to develop SEPA's understanding of the impact of air emissions and poor air quality on the environment and human health*
- *continue to collect and make available, long-term monitoring data relevant to the assessment of climate change impacts*

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# Annexes

## A. NAQS Pollutants

The NAQS identifies the principal pollutants of present concern to health. These include:

### Benzene

Benzene is a VOC and a minor constituent of petrol (typically between 2% and 5% by volume). It has a half-life in the environment of less than one day and consequently does not travel significant distances from its source. It is readily washed from the atmosphere by precipitation, but can easily re-evaporate<sup>1</sup>.

Motor vehicles are the main source of emission. They account for 63.7% of total UK emissions, although the contribution from traffic to emissions may be greater in urban areas (Figure A1). Emissions of benzene from existing petrol storage and handling facilities will come under increasing control by the introduction of an EC Directive (94/63/EC) on controlling VOC emissions resulting from storage and distribution of petrol to service stations<sup>1</sup>. EC Directives will further reduce motor vehicle emissions for cars, light vehicles and heavy goods vehicles (HGVs) sold from 2001 and 2006 as part of the EC Auto-Oil programme. The programme agrees to reduce the amount of benzene and aromatics in petrol from 2000 and to reduce the sulphur content of fuels from 2000 and again from 2005. The reduction of fuel sulphur content will reduce the deterioration in catalyst performance with age and therefore help to abate benzene emissions<sup>18</sup>. It is estimated that benzene levels will decline by almost 40% by 2010 on a 1995 base<sup>55</sup>.

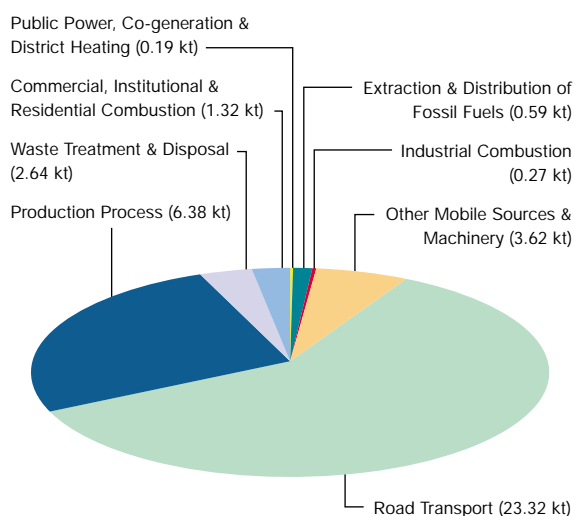


Figure A1  
UK Emission Sources for Benzene (kt/a)<sup>4</sup>

### 1,3-Butadiene

1,3-butadiene is also a VOC arising from the combustion of petroleum products. It disperses relatively rapidly within the atmosphere<sup>1</sup>. Motor vehicles account for 68% of total UK emissions and industrial chemical processes 18.3% (Figure A2). Emissions of 1,3-butadiene will also be reduced by the introduction of EC Directive (94/63/EC) and the Auto-Oil programme<sup>18</sup>. Petrol engine motor vehicles emissions are expected to decline by about 55% by the year 2000 on 1992 values and by 73% by the year 2010<sup>55</sup>.

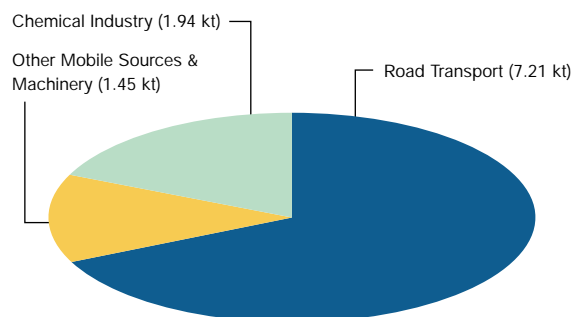


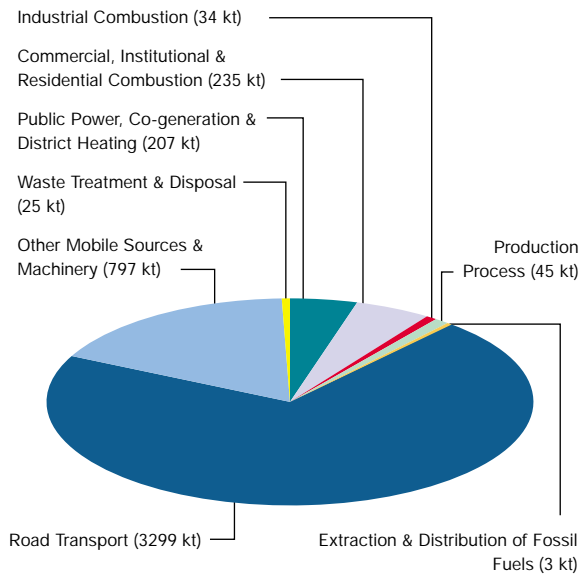
Figure A2  
UK Emission Sources for 1,3-Butadiene (kt/a)<sup>4</sup>

### Carbon Monoxide

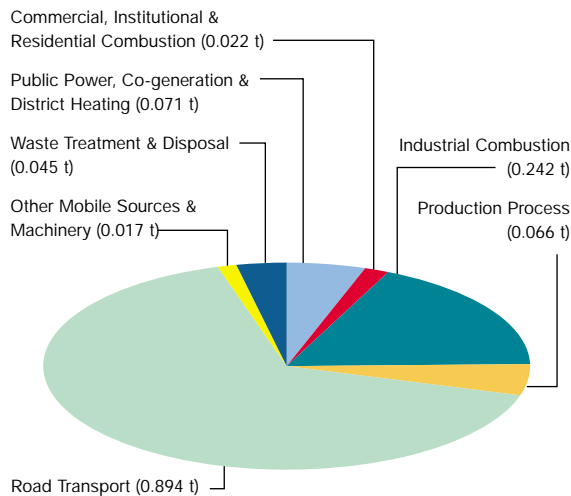
CO is a colourless, odourless gas formed during the incomplete combustion of carbon containing materials. CO is a relatively stable compound, which converts to CO<sub>2</sub> within the atmosphere as a result of reaction with hydroxyl radicals<sup>1</sup>. The main source of CO is road traffic, which accounts for 71% of UK emissions (Figure A3). Reduced CO emission levels for motor vehicles as part of the Auto-Oil programme will result in a further reduction of emissions<sup>18</sup>. Although road traffic contributes to the majority of CO emissions, large industrial combustion plants may also contribute significantly at a local level. It is estimated that UK emissions of CO will reduce by 32% in 2000, 48% in 2005 and by 54% in 2010 compared with 1995 levels<sup>55</sup>.

### Lead

Motor vehicles are the most significant source of lead to the atmosphere due to tetraethyl lead being used as a petrol additive to enhance the octane rating. Motor vehicles account for 65.9% of UK emissions (Figure A4). Few significant industrial sources of lead exist in Scotland, except for a few isolated metal smelters and large coal combustion sources<sup>1</sup>. Since the introduction



**Figure A3**  
UK Emission Sources for Carbon Monoxide (kt/a)<sup>4</sup>



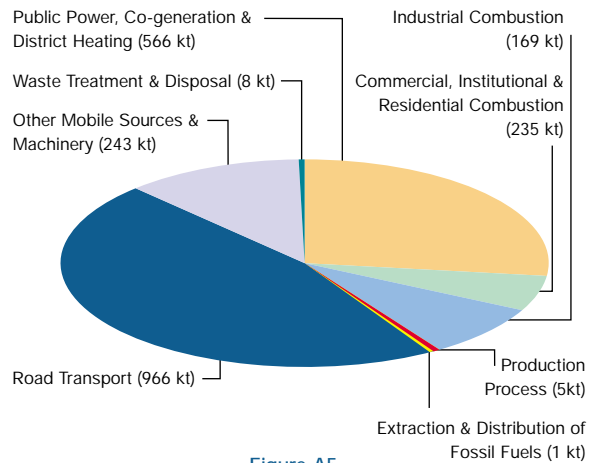
**Figure A4**  
UK Emission Sources for Lead (t/a)<sup>4</sup>

of unleaded fuel in the late 1980s, lead emissions have decreased markedly. The agreement reached between the European Parliament and the Environment Council on the Directive on the Quality of Petrol and Diesel fuels (part of the Auto-Oil programme) bans the sale of leaded petrol from 1 January 2000<sup>18</sup>. The increasing numbers of catalyst-equipped cars will ensure that emissions of lead from petrol vehicles decrease by over 80% by 2005 compared with 1995 levels and result in a very small amount by 2015<sup>55</sup>.

### Nitrogen Dioxide

NO<sub>2</sub> is a secondary pollutant, formed from the action of chemically active oxidising species such as O<sub>3</sub> upon NO. Together the two oxides (NO and NO<sub>2</sub>) are generally referred to as nitrogen oxides (NO<sub>x</sub>). NO<sub>x</sub> is emitted from combustion activities, although NO is produced in the majority of ambient situations and is rapidly oxidised to NO<sub>2</sub>. The rate of conversion depends on the amount of oxidising pollutant available<sup>1</sup>.

The main UK emissions sources of NO<sub>2</sub> are motor vehicles (49.6%); power generation (27.4%); large-scale industrial combustion processes (8.2%); domestic and commercial sources (5.5%); and other mobile sources (11.8%) (Figure A5).



**Figure A5**  
UK Emission Sources for Nitrogen Dioxide (kt/a)<sup>4</sup>

The EC's Acidification Strategy aims to reduce far beyond existing commitments emissions of NO<sub>x</sub> in the EU by 2010. The main measures proposed are a Directive setting National Emission Ceilings for 2010 and a Large Combustion Plant Directive. In addition further reductions in emission levels for motor vehicles as part of the Auto-Oil programme have been agreed.

This programme has led to an agreement to reduce the sulphur content of fuels from 2000 and 2005, which will lead to some reductions in emissions of NO<sub>x</sub>. It is estimated that current policies should deliver reductions of NO<sub>x</sub> of about 38% by 2005 based on 1995 values<sup>18, 55</sup>.

### Ozone

O<sub>3</sub> is an acidic colourless gas, which acts as a very strong oxidising agent. There are no significant anthropogenic sources as it is a secondary pollutant formed from the reaction between NO<sub>x</sub> and VOCs in sunlight<sup>1</sup>. O<sub>3</sub> can be formed at considerable distances from its component parts and consequently control of its formation requires provision at national or even

international levels. For this reason, O<sub>3</sub> has not been included as one of the pollutants which Local Authorities must consider when carrying out their local air quality assessments.

Reductions in the emissions of O<sub>3</sub> precursors (NO<sub>x</sub> and VOCs) have been agreed in emission levels for motor vehicles as part of the Auto-Oil programme. In addition O<sub>3</sub> formation will be reduced by the introduction of EC Directive (94/63/EC) on controlling VOC emissions resulting from the storage and distribution of petrol (see Section 2.1).

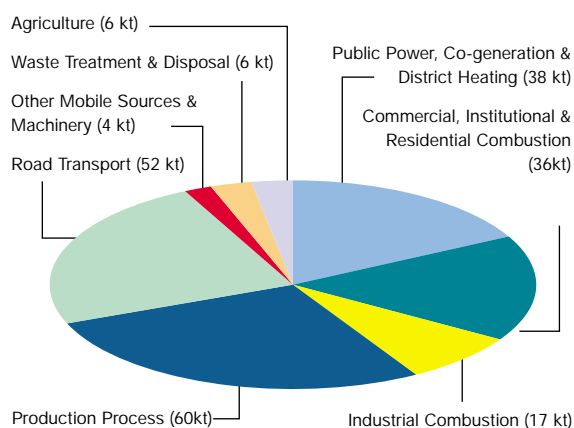


Figure A6  
UK Emission Sources for PM<sub>10</sub> (kt/a)<sup>4</sup>

### Particulates

PM<sub>10</sub> can be emitted from a considerable range of sources, both natural like pollen, fungal spores or sea salt and anthropogenic such as agriculture, combustion, construction and quarrying and can comprise a wide variety of materials<sup>1</sup>.

Re-suspension of particles may also occur in very windy and dry conditions. The main UK emission sources of particulate matter include motor vehicles (23.7%); general industrial combustion plants (7.8%) including large power plants (17.4%); uncontrolled domestic coal burning; and major mining, quarrying and construction activities (production processes) (27.4%) (Figure A6). Secondary sources of particles, those made by photochemical reactions in the atmosphere, such as aerosols of sulphates and nitrates, can also make a significant contribution to overall concentrations, particularly during summer months.

EC Directives will further reduce motor vehicle emissions as part of the Auto-Oil programme. This programme has led to an agreement to reduce the sulphur content of fuels, which will lead to some reductions in emissions of PM<sub>10</sub> from all vehicles.

The EC's Acidification Strategy, aims to reduce emissions of SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub> in the EU by 2010. The main measures will be a Directive setting National Emission Ceilings for 2010; a Directive on the Sulphur Content of Liquid Fuels and a large Combustion Plant Directive. These instruments will each have an impact on the levels of secondary particles, which are formed by chemical reaction in the atmosphere<sup>18</sup>. Policies in place are expected to deliver particulate reductions of about 40% by 2005 compared with 1995 values<sup>55</sup>.

### Sulphur Dioxide

SO<sub>2</sub> is a gaseous emission, soluble in water, which is washed from the atmosphere by precipitation as acid rain<sup>1</sup>. The main UK source of SO<sub>2</sub> is from the combustion of sulphur containing fossil fuels<sup>1</sup>. Large combustion plants, in particular power stations, are the main industrial source of SO<sub>2</sub> (71.5%) (Figure A7), although oil refining can also be a significant emitter in the Forth Valley. Unregulated industrial boilers of insufficient size to require authorisation by SEPA can also make a significant contribution to SO<sub>2</sub> concentrations particularly in urban areas.

Motor or diesel vehicles also contribute to SO<sub>2</sub> concentrations, but in comparison to other sources their contribution is relatively minor.

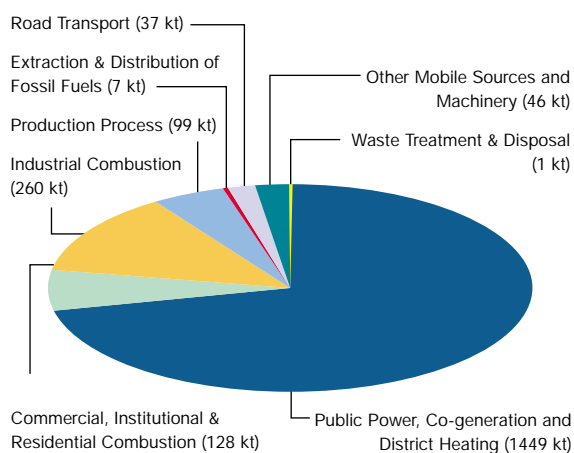


Figure A7  
UK Emission Sources of Sulphur Dioxide (kt/a)<sup>4</sup>

The EC's Acidification Strategy aims to reduce emissions of SO<sub>2</sub> by 2010. The main measures will be a Directive setting National Emission Ceilings for 2010; a Directive on the Sulphur Content of Liquid fuels setting a maximum permissible sulphur content of HFO of 1% from 2003 and gas oil (0.1% from 2008) and a Large Combustion Plant Directive. In addition further reductions have been agreed in emission levels for motor vehicles as part of the Auto-Oil programme.

This programme has also led to an agreement to reduce the fuel sulphur content from 2000 and 2005<sup>18</sup>.

Total UK emissions of SO<sub>2</sub> are the subject of the Second Sulphur Protocol under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP). The UK has committed itself to reducing emissions by 50% by 2000, 70% by 2005 and 80% by 2010 compared to 1980<sup>55</sup>.

## B. Air Quality Standards & Guidelines for Human Health & Flora

### Human Health

#### United Kingdom Air Quality Standards

The NAQS set out a national framework to improve UK ambient air quality and ensure that it will not cause significant harm to human health and the environment (see Section 2.5). The Strategy adopted air quality standards for eight of the key air pollutants, including those covered in the EC Directives. Specific objectives were included in the Strategy detailing the degree of compliance for each pollutant to be reached by 2005.

The DETR also describes air pollution qualitatively in four bands, based on health effects as 'low', 'moderate', 'high' and 'very high' levels of pollution (Table B1).

Table B1

Pollutant	Standard threshold			
	Low	Moderate	High	Alert threshold
SO <sub>2</sub> (ppb) 15-minute average	<100	100-199	200-399	>400
O <sub>3</sub> (ppb)	<50 8-hr running average	50-89 1-hr running average	90-179 1-hr running average	>180 1-hr running average
CO (ppm) 8-hr running average	<10	10-14	15-19	>20
NO <sub>2</sub> (ppb) 1-hr average	<150	150-299	300-399	>400
Fine particles (µg/m <sup>3</sup> ) 24-hour running average	<50	50-74	75-99	>100

*Low:* Effects unlikely to be noticed even by individuals who know they are sensitive to air pollution.

*Moderate:* Mild effects unlikely to require action, may be noticed amongst sensitive individuals.

*High:* Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed.

*Very High:* The effects on sensitive individuals described for 'high levels' of pollution may worsen

### European Union Air Quality Standards

EC air quality standards presently exist for the following pollutants (Table B2):

- SO<sub>2</sub> and suspended particulates (80/779/EEC)
- NO<sub>2</sub> (85/203/EEC)
- O<sub>3</sub> (92/72/EEC)
- Lead-in-air (82/884/EEC)

These Directives detail limit values, which should not be exceeded, and guide values for each of the pollutants. In addition, the Directives set out procedures for the monitoring of pollutant ambient concentrations.

The EC Air Quality Framework & Daughter Directives (96/62/EC) identifies 12 pollutants for which limit and target values will be set in subsequent Daughter Directives. The main aim of the Directive is to protect human health and the environment through the following measures:

- Fixing limit values and alert thresholds for airborne pollutants
- Specifying common methodologies to assess ambient air quality in EU Member States
- Obtaining adequate information on ambient air quality and making this information publicly available
- Maintaining ambient air quality where it is good and improving it where necessary

Table B2

EU Air Quality Standards ( $\mu\text{g}/\text{m}^3$ )		
	Time	Standard
SO <sub>2</sub> <sup>b</sup>	1-year <sup>a</sup>	Limit value 120 if smoke < 40
		Limit value 80 if smoke > 40
	98 <sup>th</sup> percentile	Limit value 350 if smoke < 150
		Limit value 250 if smoke > 150
	24-hr mean	Guide value 100-150
	1-year mean	Guide value 40-60
Smoke <sup>b</sup>	1-year	Limit value 80
	98 <sup>th</sup> percentile	Limit value 250
NO <sub>2</sub>	98 <sup>th</sup> percentile	Limit value 200
	98 <sup>th</sup> percentile	Guide value 135
	50 <sup>th</sup> percentile	Guide value 50
Lead	Annual	Limit value 2
O <sub>3</sub>	8-hr	Health protection 110
	1-hr	Population information 180
	1-hr	Population warning 360

a) Median of daily values

b) Daily values

Table B3

Proposed EU Air Quality Standards ( $\mu\text{g}/\text{m}^3$ )				
	Time	Level	Objective date	Eppcy
SO <sub>2</sub>	Hourly	350	2005	24
	24-hr	125	2005	3
NO <sub>2</sub>	Hourly	200	2010	18
	Annual	40	2010	
Lead	Annual	0.5	2005	
PM <sub>10</sub> <sup>a</sup>	24-hr	50	2005	35
	Annual	40	2005	

a) The Directive also includes indicative values for PM<sub>10</sub> for 2010 which are subject to review

Eppcy: Exceedences permitted per calendar year

The first Daughter Directive covers SO<sub>2</sub>, NO<sub>2</sub>, lead and PM<sub>10</sub> and provides limit values for the protection of human health (Table B3), as well as annual limit values for SO<sub>2</sub> and NO<sub>2</sub> for the protection of vegetation. The requirements of these Daughter Directives will supersede earlier directives covering the same pollutants. Additional Daughter Directives are proposed for other pollutants.

### World Health Organisation (WHO)

The WHO provides air quality guidelines for more than twenty pollutants. The guidelines are intended to provide background information and guidance to national or international authorities in making risk assessment and risk management decisions. In providing pollutant levels below which exposure, for lifetime or for a given period of time, does not constitute a significant public health risk, the guidelines form the basis of setting national and international standards or limit values for air pollutants (Table B4). The WHO guidelines include the NAQS pollutants.

### Flora

#### Critical Levels

The EU, WHO and UNECE have each proposed air quality guidelines for the protection of vegetation (Table B5). These guidelines are sometimes referred as critical levels. A critical level is the concentration in the atmosphere above which direct adverse effects on receptors, such as plants, ecosystems or materials may occur<sup>20</sup>. The principal pollutants of concern are SO<sub>2</sub>, NO<sub>2</sub> and O<sub>3</sub>.

#### Critical Loads

Critical loads are a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur. Critical loads and levels are conveniently represented on maps and this allows the combined effects of physical, chemical, ecological, geological and hydrological factors on sensitivity to pollutant inputs to be quantified. Once a critical loads or levels map is available for a particular receptor-pollutant combination, comparison with current deposition loads or exposure levels for that pollutant provides the spatial distribution of areas of exceedance, which may also be mapped<sup>20</sup>. Critical loads are calculated for sulphur, acidifying nitrogen and eutrophying nitrogen.

Table B4

WHO Air Quality Guidelines ppb ( $\mu\text{g}/\text{m}^3$ )		
	Time	Level
SO <sub>2</sub>	10-min	188 (500)
	24-hr	47 (125)
	Annual	19 (50)
CO	15-min	85.9 ppm (100 mg/m <sup>3</sup> )
	30-min	51.5 ppm (60 mg/m <sup>3</sup> )
	1-hr	25.8 ppm (30 mg/m <sup>3</sup> )
	8-hr	8.6 ppm (10 mg/m <sup>3</sup> )
Lead	Annual	0.5
NO <sub>2</sub>	1-hr	105 (200)
	Annual	21 (40)
O <sub>3</sub>	8-hr	60 (120)

Table B5

Critical Levels for Vegetation $\mu\text{g}/\text{m}^3$ (ppb)			
	Source	Time	Level
NO <sub>2</sub>	WHO	Annual	30
	UNECE	Annual	29 (15)
	EU	Annual	30 <sup>a</sup>
SO <sub>2</sub>	WHO	Annual	10-30
	UNECE	Annual	20 (7.5)
	EU	24-hr	70 (26)
Annual		20 <sup>a</sup>	
O <sub>3</sub>	WHO	3-mth (crops)	3 <sup>b</sup>
		6-mth (forests)	10 <sup>b</sup>
		3-mth (semi-natural)	3 <sup>b</sup>
	UNECE EU	5-days visible injury	0.2-0.5 <sup>b</sup>
		24-hr running mean	65
		1-hr running mean	200

a) Proposed

b) AOT40 in ppm-h

AOT40 = Accumulated exposure over a threshold of 40 ppb

## C. Legislation, Protocols & Initiatives

The UK is subject to international responsibilities and rights in air pollution management and control. This is because the passage of air does not confine itself within national boundaries. The principal legislative instruments that reflect on air quality management in the UK and therefore Scotland include:

### UNECE

The CLRTAP was adopted in 1979 and came into force in 1983. It has been followed by a series of protocols that have laid down more specific commitments:

- *The protocol on Long-term Financing of Co-operative Programme for Monitoring and Evaluating Long-range Transmission of Air Pollutants in Europe (EMEP) was adopted in 1984 and came into force in 1988. It commits parties to mandatory annual contributions to the EMEP budget approved by the Conventions Executive Body*
- *The protocol of the reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30% (Helsinki Protocol or 30% club) was adopted in 1985 and came into force in 1987. It commits parties to a 30% cut in total national emissions by 1993 based on 1980 levels. Although it did not become a party to the Protocol, the UK achieved a reduction of 37% by the end of 1993*
- *The protocol concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes (Sofia Protocol) was adopted in 1988 and came into force in 1991. It commits parties to bring NO<sub>x</sub> emissions back to their 1987 levels by 1994. The UK met this target*
- *The protocol concerning the Control of Emissions of Volatile Organic Compounds (VOCs) or their Transboundary Fluxes was adopted in 1991 and came into force 1997. It commits most parties to secure a 30% reduction in VOC emissions from 1988 levels by 1999*
- *The Second Protocol on the Further Reduction of Sulphur Emissions was adopted in 1994 and came into force in 1998. The protocol requires different percentage reductions from parties depending upon the quantity of their emissions, but importantly takes into account the nature of the impact upon the environment. This is based upon the concept of critical loads and requires the UK to make reductions in sulphur emissions against 1980 levels of 80% by 2010*

### Other International Initiatives

- *The Framework Convention on the Atmosphere (Climate Treaty), endorsed at the 1992 Earth Summit in Brazil, required developed countries to take measures aimed at returning greenhouse gas emissions, such as CO<sub>2</sub> to 1990 levels by the year 2000 and provide assistance to developing countries*
- *The Montreal Protocol (1987) on substances that deplete the ozone layer committed industrialised nations to reducing their consumption of*

chlorofluorocarbons (CFCs) by 50% by 1999 and freezing the production of halons in 1992.

The protocol has subsequently been revised and strengthened in the light of further scientific evidence

## European Union

- *Air Quality Framework & Daughter Directives (96/62/EC) identifies 12 pollutants for which limit target values will be set in subsequent Daughter Directives*
- *Auto-Oil vehicle and fuel quality directives will result in a significant reduction in emissions of particulates, NO<sub>2</sub>, CO, lead, benzene, hydrocarbons and VOCs from road transport by 2005*
- *EU Acidification Strategy's objective is to reduce beyond existing commitments emissions of SO<sub>2</sub>, NO<sub>x</sub> and NH<sub>3</sub>*
- *Directive on the Sulphur Content of Certain Liquid Fuels sets maximum levels for the sulphur content of HFO and gas oil. This is expected to lead to a reduction in SO<sub>2</sub> emissions from plants using these fuels*
- *Revision of existing Large Combustion Plant Directive (88/609/EEC) will further reduce emissions of SO<sub>x</sub>, NO<sub>x</sub> and particles from new large combustion plants. This applies to power stations, large industrial boilers and gas turbines. Proposed revisions will include a drive to combined heat and power plant, emission limit values will be set for new plant and a national plan approach to reducing emissions will be introduced*
- *National Emission Ceilings Directive (NECD) & Daughter Directive (Ozone) proposes to set ceilings for national emissions of SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub> and VOCs to be attained by 2010 as a means of implementing the EU Acidification Strategy. Limits will be consistent with attainment of 50% gap closure target for the European Acidification Strategy and achievement of agreed air quality objectives. Ceilings will apply to all sources, stationary, mobile and domestic*
- *EC Solvents Directive aims to reduce emissions of VOCs from certain industrial installations by around 57% by 2007, compared with a 1990 baseline. Impact on Scotland is likely to be less significant due to existing LAPC controls. The Directive was adopted in 1999, but is yet to be implemented into UK legislation*
- *Integrated Pollution Prevention and Control Directive reflects the principals underlying IPC and LAPC in that it requires site specific permits which take account of the characteristics of each plant, its location and the state of the local environment. However, there are a number of important differences, the most important of which are the wider range of installations covered and the wider range of environmental impacts to be considered by the regulator in considering authorisations*
- *Incineration of Waste Directive replaces existing and new Municipal Waste Directives (89/429/EEC and 89/369/EEC) and also replaces Incineration of Hazardous Waste Directive (94/67/EC)*
- *New EC Regulation on Ozone Depleting Substances updates and replaces existing regulations made under the Montreal Protocol 1987. Main controls under the new regulations include:*
  - *HCFC production to be phased out by 2025*
  - *general ban on supply and use of all controlled substances except HCFCs and methyl bromide*
  - *supply and production of methyl bromide to be phased out by 2005 with interim cuts of 60% in 2001 and 80% in 2003*
  - *new HCFC controls*
  - *ban on import and export of controlled substances*



## D. Measuring Air Quality

Air pollution can be measured in many ways, from simple physical and chemical measurements to sophisticated electronic techniques. However, in Scotland three principal methods of measurement are most widely employed<sup>1</sup>. The DETR and NETCEN describe these methods as follows:

### *Passive Sampling Methods*

Diffusion tubes or badges provide a simple and inexpensive technique of screening air quality in an area, to give a general indication of average pollution concentrations over a period of weeks or months. These are simple plastic tubes or discs, open at one end to the atmosphere and with a chemical absorbent at the other end. They are exposed over a period between a week and a month and then analysed in the laboratory. The method allows a large number of sampling points to be used highlight hotspots of high concentrations, near, for example, major roads or industry, where more detailed studies may be needed. The method is mainly used in Scotland to measure NO<sub>2</sub> levels, although the method is also used for monitoring other pollutants, such as SO<sub>2</sub>, benzene, NH<sub>3</sub>.

### *Active Sampling Methods*

These methods collect pollutant samples either by physical or chemical means for subsequent analysis in a laboratory. Typically, a known volume of air is pumped through a collector such as a filter or chemical solution for a known period of time, which is then removed for analysis. Samples can be taken daily, thereby providing detailed information about pollutant levels. There is a long history of using active sampling methods in Scotland, providing valuable baseline data for trend analyses and comparison for SO<sub>2</sub> and smoke.



Stack Monitoring by SEPA

### *Automatic Methods*

These methods produce high-resolution measurements, typically hourly averages or better, at a single point for pollutants such as O<sub>3</sub>, NO<sub>x</sub>, SO<sub>2</sub>, CO and PM<sub>10</sub>. Methods used include a variety of sophisticated methods such as infrared or ultra-violet absorption, ultra-violet fluorescence, chemiluminescence, or for particulates, a variety of sophisticated filtration techniques. Gas chromatography analysers also provide high-resolution data on benzene, 1,3-butadiene and other speciated hydrocarbon concentrations. These methods are now being used by a growing number of Local Authorities in Scotland, such as Glasgow, Edinburgh, Falkirk, Aberdeen.

## E. Health Effects of NAQS Air Pollutants

Details on the health effects of the NAQS air pollutants are provided in booklets compiled by the EPAQS as well as in the NAQS itself. A summary is provided below:

### *Sulphur Dioxide*

SO<sub>2</sub> is formed by the combination of one atom of sulphur and two atoms of oxygen. At normal temperature and pressure it is a gas. It dissolves in water to give an acidic solution which is readily oxidised to sulphuric acid. SO<sub>2</sub> is present in the atmosphere from both natural and anthropogenic activities. In industrialised countries it is mainly derived from the combustion of fuels that contain sulphur.

Exposure stimulates nerves in the lining of the nose, throat and airways of the lungs. It is an irritant when it is inhaled, because of its acidic nature, and high concentrations may cause breathing difficulties in people exposed to it. Recent studies have shown that people suffering from asthma may be especially susceptible to the adverse effects of SO<sub>2</sub> and that, within the range of concentrations that occur in pollution episodes, it may provoke attacks of asthma.

### *Nitrogen Dioxide*

The term NO<sub>x</sub> is used to indicate the sum of nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), the only significant NO<sub>x</sub> air pollutants. The other NO<sub>x</sub> compounds are either inert or present in such small concentrations that they contribute little to air pollution. NO<sub>2</sub> is the more important of these two pollutants, being a respiratory irritant. The principal sources of NO<sub>x</sub> are combustion and industrial processes.

Exposure can bring about reversible effects on lung function and airway responsiveness. It may also increase reactivity to natural allergens. Exposure to NO<sub>2</sub>

may put children at an increased risk of respiratory infection and may lead to poorer lung function in later life.

At relatively high concentrations  $\text{NO}_2$  causes acute inflammation of the airways. Short-term exposure can affect the immune cells of the airways in a manner that might predispose people to an increased risk of respiratory infections.



Flaring at Grangemouth Refinery

### Ozone

$\text{O}_3$  is a naturally occurring gas, generated in the higher layers of the earth's atmosphere, the stratosphere, by the action of ultra violet light from the sun on oxygen molecules.  $\text{O}_3$  is not emitted from any anthropogenic source in any significant quantities. In the lower layers of the atmosphere, the troposphere it is primarily generated as a pollutant by a complicated series of chemical reactions driven by sunlight. In these  $\text{NO}_x$  and hydrocarbons react in the atmosphere to produce  $\text{O}_3$ .

Exposure to high concentrations may cause slight irritation to the eyes and nose. If very high exposure occurs over several hours, damage to the airway lining followed by inflammatory reactions may occur. There is also evidence that minor changes to the air passages may occur at lower levels.

### Particulates

Although many of the obvious effects of air pollution disappeared with earlier smogs, research over the last few years has suggested that, even at the much lower levels now found in the UK, particulate air pollution appears to be associated with a range of measures of ill health including effects on the respiratory and cardiovascular systems, asthma and mortality.

### Carbon monoxide

CO is a product of incomplete combustion. It diminishes the oxygen carrying capacity of blood. The CO is produced in the process of combustion, be it a motor vehicle engine, domestic heating, etc.

The primary health effect is to starve the body of oxygen. This occurs as a result of the preferential, but reversible, binding of haemoglobin to CO to form carboxyhaemoglobin. At very high concentrations prolonged exposure can result in death.

### Lead

Lead is a silvery white or greyish metal. The most significant source of lead to the atmosphere is motor vehicles due to tetraethyl lead being used as a petrol additive to enhance the octane rating of petrol.

Lead exhibits toxic biochemical effects in humans, which are manifest in the synthesis of haemoglobin, acute or chronic damage to the nervous system, effects in the kidneys, gastrointestinal tract, joints and reproductive system.

### Benzene

Benzene is a chemical consisting of six atoms each of carbon and hydrogen arranged in a ring structure. At normal ambient temperatures it is a liquid, but readily evaporates. The principal source of benzene is from the combustion of petroleum fuel by motor vehicle engines.

Benzene is accepted as a human carcinogen. The effect of long-term exposure, which is of most concern, is leukaemia and in particular several types of this disease known collectively as non-lymphocytic leukaemia. It is not possible to demonstrate a level at which there is zero risk of exposure to benzene.

### 1,3-Butadiene

1,3-butadiene is a chemical compound, the molecule of which comprises four carbon and six hydrogen atoms. At normal temperatures it is a gas. The principal source of 1,3-butadiene is from the combustion of petroleum in motor vehicle engines and from other sources of combustion such as fossil fuels.

Studies have shown that 1,3-butadiene causes a variety of cancers in rodents and damages the genetic structure of the cell. It is thus a genotoxic carcinogen and as such absolute safe levels cannot be defined.

The EPAQS, nevertheless, believe that standards could be set at which for practical purposes the risks are exceedingly small and unlikely to be detectable by any practical method.

## F. Glossary

<b>AS</b>	Active Sampling	<b>IPC</b>	Integrated Pollution Control
<b>AQS</b>	Air Quality Standards	<b>IPPC</b>	Integrated Pollution Prevention and Control
<b>BAT</b>	Best Available Techniques	<b>LAPC</b>	Local Air Pollution Control
<b>BATNEEC</b>	Best Available Techniques Not Exceeding Excessive Costs	<b>LCP</b>	Large combustion plant as defined under the Large Combustion Plant Directive (88/609/EEC)
<b>BPEO</b>	Best Practicable Environmental Option	<b>NAEI</b>	National Atmospheric Emissions Inventory
<b>BPM</b>	Best Practicable Means	<b>NAQS</b>	National Air Quality Strategy
<b>CO</b>	Carbon Monoxide	<b>NECD</b>	National Emission Ceilings Directive
<b>CO<sub>2</sub></b>	Carbon Dioxide	<b>NETCEN</b>	National Environmental Technology Centre, AEA Technology
<b>CO<sub>x</sub></b>	Oxides of Carbon	<b>NH<sub>3</sub></b>	Ammonia
<b>CFCs</b>	Chlorofluorocarbons	<b>NMEP</b>	National Material Exposure Programme
<b>COMEAP</b>	Committee on the Medical Effects of Air Pollutants	<b>NO<sub>2</sub></b>	Nitrogen Dioxide
<b>COMAH</b>	Control of Major Accident Hazard Regulations	<b>NO<sub>x</sub></b>	Nitrogen Oxides
<b>CLRTAP</b>	Convention on Long-range Transboundary Air Pollution	<b>OPA</b>	Operator Performance Assessment
<b>COSLA</b>	Convention of Scottish Local Authorities	<b>O<sub>3</sub></b>	Ozone
<b>Critical Level</b>	The concentration in the atmosphere above which direct adverse effects on receptors, such as plants, ecosystems or materials may occur to present knowledge.	<b>PAHs</b>	Polycyclic Aromatic Hydrocarbons
<b>Critical Loads</b>	The threshold for the deposition of a given pollutant above which significant harmful effects may occur to soils, freshwater and plants.	<b>Pb</b>	Lead
<b>CLAG</b>	Critical Loads Advisory Group	<b>PS</b>	Passive Sampling
<b>DETR</b>	Department of the Environment, Transport and the Regions	<b>PM<sub>10</sub></b>	Particulate matter 10 microns in diameter
<b>EC</b>	European Commission	<b>PM<sub>2.5</sub></b>	Particulate matter 2.5 microns in diameter
<b>EU</b>	European Union	<b>SEPA</b>	Scottish Environment Protection Agency
<b>EMEP</b>	European Monitoring and Evaluation Programme	<b>SO<sub>2</sub></b>	Sulphur Dioxide
<b>EPA 1990</b>	Environmental Protection Act 1990	<b>SO<sub>x</sub></b>	Oxides of Sulphur
<b>EPAQS</b>	Expert Panel on Air Quality Standards	<b>WHO</b>	World Health Organisation
<b>HCFCs</b>	Halocarbons	<b>UNECE</b>	United Nations Economic Commission for Europe
<b>HSE</b>	Health & Safety Executive	<b>UKAMN</b>	UK Air Monitoring Network
<b>HFO</b>	Heavy Fuel Oil	<b>VOCs</b>	Volatile organic compounds are a collective term for many molecular configurations of hydrogen and carbon atoms. Many of these compounds contribute to atmospheric chemical reactions and give rise to secondary contaminants.
<b>HRS</b>	Heat Recovery Steam Generators		

## G. Conversion Tables

Pollutant	WHO 25°C and 1013 mb	EC 20°C and 1013 mb
Ozone	1 ppb = 1.96 µg/m <sup>3</sup>	1 ppb = 2.00 µg/m <sup>3</sup>
Nitrogen dioxide	1 ppb = 1.88 µg/m <sup>3</sup>	1 ppb = 1.91 µg/m <sup>3</sup>
Carbon monoxide	1 ppm = 1.15 mg/m <sup>3</sup>	1 ppm = 1.16 mg/m <sup>3</sup>
Sulphur dioxide	1 ppb = 2.62 µg/m <sup>3</sup>	1 ppb = 2.66 µg/m <sup>3</sup>
Benzene	1 ppb = 3.2 µg/m <sup>3</sup>	
1,3-Butadiene	1 ppb = 2.2 µg/m <sup>3</sup>	

## H. Units

kt/a	kilotonnes per annum
g/l	grammes per litre
mg/m <sup>3</sup>	milligrammes per cubic metre
mg/Nm <sup>3</sup>	milligrammes per normalised cubic metre
ng/m <sup>3</sup>	nanogrammes per cubic metre
MWe	megawatts of electricity
ppb	parts per billion (by volume)
ppm	parts per million (by volume)
t	tonnes
t/a	tonnes per annum
µm	micron (1 millionth of a metre)
µg/m <sup>3</sup>	microgrammes per cubic metre
%	Percentage

## I. Percentiles

In formulating the NAQS objectives, it is sometimes appropriate that, for a standard with a short averaging time, the objective for the pollutant in question should be expressed in terms of percentile compliance. It is an approach that has been used in setting European air quality limit values. For example, if the objective is to be complied with a 99.9th percentile, then 99.9% of measurements at each measuring point in the relevant period (e.g. 1-year) must be at or below the level specified.

## J. Internet Sites of Interest

- Scottish Environment Protection Agency (SEPA): <http://www.sepa.org.uk>
- UK Department of the Environment, Transport and the Regions (DETR): <http://www.detr.gov.uk>
- UK Department of Health: <http://www.doh.gov.uk>
- National Environmental Technology Centre, AEA Technology (NETCEN): <http://www.aeat.co.uk/netcen>
- DETR The National Air Quality Information Archive: <http://www.aeat.co.uk/netcen/airqual/>
- DETR Air Quality and Environment Quality Information: <http://www.environment.detr.gov.uk/airq/eqinfo.html>
- DETR Air Quality Research Programme: <http://www.aeat.co.uk/netcen/airqual/reports/research/index.html>
- World Health Organisation (WHO): <http://www.who.dk>
- European Environment Agency (EEA): <http://www.eea.eu.int>
- COSLA: <http://www.championinternet.com/cosla/index.shtml>
- Environment Agency: <http://www.environment-agency.gov.uk/>

## K. Useful Addresses and Contacts

<i>Local Authority</i>	<i>Contact</i>	<i>Address</i>
<a href="#">Aberdeenshire</a>	Director of Environmental Health and Consumer Protection Service	Woodhill House, Westburn Road, Aberdeen, AB16 5GB
<a href="#">Aberdeen City</a>	Director of Environmental & Consumer Protection	St Nicholas House, Broad Street, Aberdeen, AB10 1BX
<a href="#">Angus</a>	Director of Environmental & Consumer Protection	Municipal Buildings, Forfar, DD8 3LG
<a href="#">Argyll and Bute</a>	Director of Development & Environmental Services	Headquarters, Kilmory, Lochgilphead, PA31 8RT
<a href="#">Clackmannanshire</a>	Executive Director, Environmental & Contract Services	Lime Tree House, Castle Street, Alloa, Clackmannanshire, FK10 1EX
<a href="#">Comhairle nan Eilean Siar</a>	Director of Environmental Services	Council Offices, Sandwich Road, Stornoway, Isle of Lewis, HS1 2BW
<a href="#">Dumfries &amp; Galloway</a>	Chief Environmental Health Officer	Cannonwalls, High Street, Kirkcudbright, DG6 4JG
<a href="#">Dundee City</a>	Director of Environmental & Consumer Protection	Tayside House, 28 Crichton Street, Dundee, DD1 3NH
<a href="#">East Ayrshire</a>	Director of Community Services	Council Headquarters, London Road, Kilmarnock, KA3 7BU
<a href="#">East Dunbartonshire</a>	Head of Environment & Consumer Services	2 Grange Avenue, Milngavie, G62 8AQ
<a href="#">East Lothian</a>	Director of Environment	John Muir House, Haddington, EH41 3HA
<a href="#">East Renfrewshire</a>	Director of Environment	Council Offices, Eastwood Park, Rouken Glen Road, Glasgow, G46 6UG
<a href="#">City of Edinburgh</a>	Director of Environmental & Consumer Services	Chesser House, 500 Gorgie Road, Edinburgh, EH11 3YJ
<a href="#">Falkirk</a>	Head of Environmental & Regulatory Services	Municipal Chambers, Grangemouth, FK1 8AH
<a href="#">Fife</a>	Corporate Manager (Environmental & Development Strategy)	County Buildings, Cupar, KY15 4TA
<a href="#">Glasgow City</a>	Director of Protective Services	Nye Bevan House, 20 India Street, Glasgow, G2 4PF
<a href="#">Highland</a>	Director of Protective Services	Glenurquhart Road, Inverness, IV3 5NX
<a href="#">Inverclyde</a>	Executive Director of Community & Protective Services	Wallace Place, Greenock, PA15 1LU
<a href="#">Midlothian</a>	Director, Community Services	Fairfield House, 8 Lothian Road, Dalkeith, EH23 3ZP
<a href="#">Moray</a>	Chief Environmental Protection Officer	Council Offices, High Street, Elgin, Moray, IV30 1BX
<a href="#">North Ayrshire</a>	Assistant Chief Executive (Legal & Regulatory)	Cunninghame House, Irvine, KA12 8EE

North Lanarkshire	Director of Planning & Environment	Fleming House, Tryst Road, Cumbernauld, G67 1JW
Orkney Islands	Chief Environmental Services Officer	Council Offices, Kirkwall, Orkney KW15 1NY
Perth and Kinross	Director of Environmental & Consumer Services	Business Park, Whitefriars Crescent, Perth, PH2 0XA
Renfrewshire	Director of Environmental Services	Council Headquarters, South Building, Cotton Street, Paisley, PA1 1BR
Scottish Borders	Director of Protective Services	Scott House, Sprouston Road, Newton St. Boswells, Melrose, TD6 0QD
Shetland Islands	Director of Environment & Transportation	Grantfield, Lerwick, Shetland, ZE1 0NT
South Ayrshire	Director of Community Protection	Town Buildings, 5-9 High Street, Ayr, KA7 1LX
South Lanarkshire	Executive Director (Community Resources)	Council Buildings, Almada Street, Hamilton, ML3 0AA
Stirling	Head of Environmental Operations	Viewforth, Stirling, FK8 2ET
West Dunbartonshire	Director of Economic Planning & Environmental Services	Council Offices, Garshake Road, Dumbarton, G82 3PU
West Lothian	Corporate Manager for Environmental & Protective Services	County Buildings, High Street, Linlithgow, EH49 7EZ

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- *Glasgow City Council, Environmental Health Department*
- *The City of Edinburgh Council, Environmental and Consumer Services*
- *Falkirk Council, Community Services, Environmental & Regulatory Services*
- *Aberdeen City Council, Environmental and Consumer Protection Services Department*
- *Institute of Terrestrial Ecology, Bush Estate, Penicuik*

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