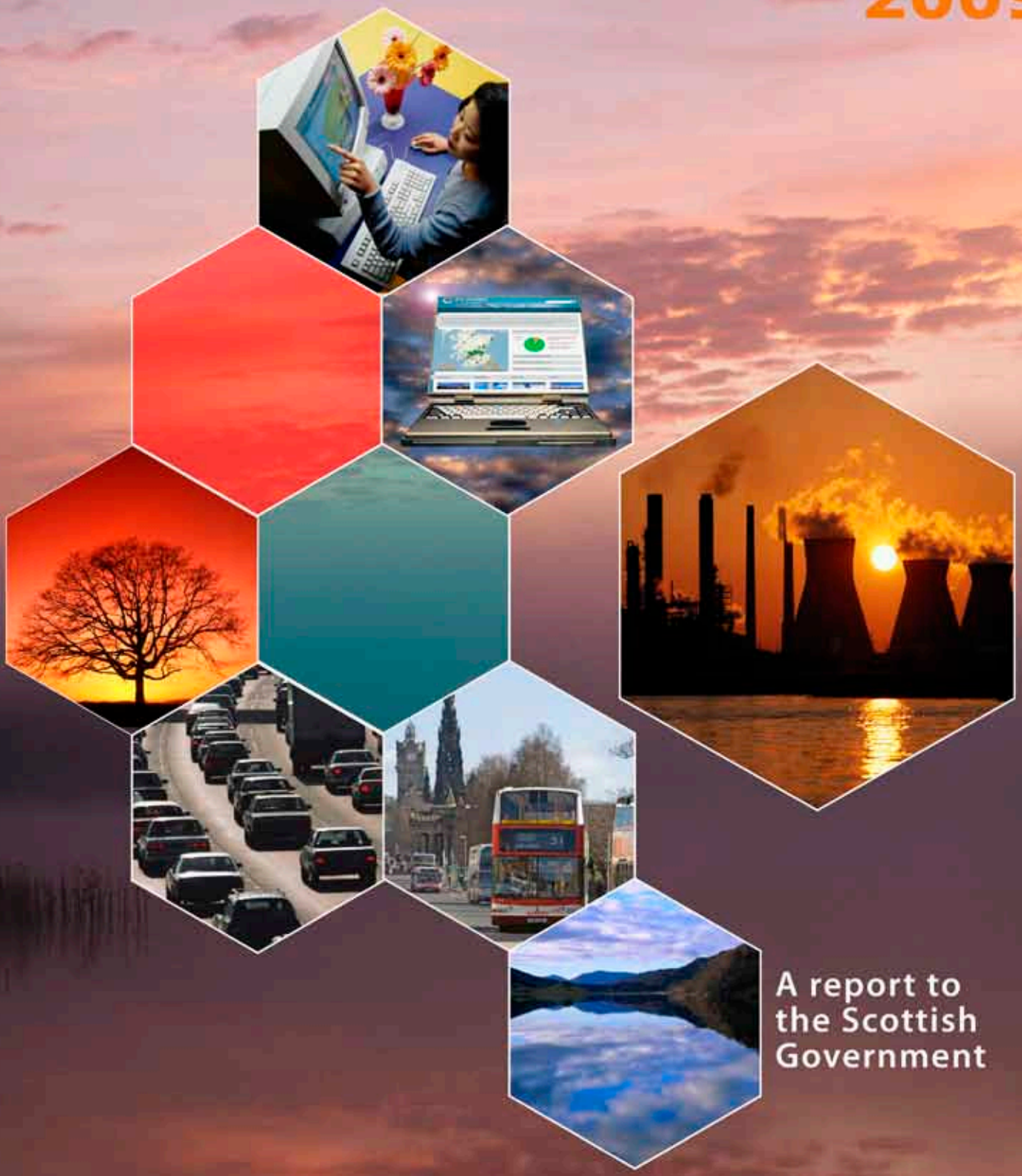
Air Pollution in Scotland 2009



A report to the Scottish Government

AEA

The Scottish Government

1. Introduction

This annual Newsletter is the third in a series on air quality in Scotland. Produced by AEA on behalf of The Scottish Government, it is intended to provide a summary of air quality monitoring carried out on behalf of Government and Local Authorities during 2009.

Section 2 of this Newsletter reviews the continuing developments in air quality legislation and policy affecting Scotland. Section 3 summarises the main national air quality monitoring programmes, together with locations of monitoring sites and a summary of the provisional data. In Section 4, CEH Edinburgh has provided a short summary of the recent government funded Review of Transboundary Air Pollution (RoTAP) report. In Section 5, we review long-term trends in air quality, followed by spatial patterns of pollution in Section 6. Finally, for readers wanting to find out more, additional web-based and published sources of information on Scotland's air quality issues are summarised in Section 7. A more detailed Annual Report on the Scottish Air Quality Database Project will also be available on the Air Quality in Scotland website in April 2010.

At present, the Scottish Air Quality Database consists of about eighty monitoring stations; this is twenty more than the number operational in 2008. As the body of data from this network accumulates, it will provide a valuable resource for assessment of air quality trends and spatial distribution within Scotland, together with a vital source of information for the general public, health professionals, academics and other air quality stakeholders.

The UK Air Quality Strategy reports that current levels of man-made particulate pollution are estimated to reduce life expectancy by up to eight months. Continued effort to reduce air pollution is therefore vital, together with careful monitoring to assess progress.

2. Legislation and policy

The management of air quality is based on a series of statutory measures and policy programmes originating from Europe, the UK and within Scotland. Together, these form the basis of a strong framework for managing air quality over the coming years.

2.1 The European Union Process

Much of the foundation for managing air quality in Scotland can be traced back to the objectives and provisions contained within the series of Air Quality Directives adopted by all Member States of the European Union.

One of the most recent developments in European policy will affect the way that we manage fine particulate matter in the air, known as PM. Currently, PM is most commonly monitored as PM_{10} (fine particles with an aerodynamic diameter less than or equal to a nominal 10 micrometer). However, evidence from a number of epidemiological studies and from the World Health Organisation (WHO) suggests that major health impacts of PM are associated with the fraction below 2.5 microns in size (known as $PM_{2.5}$). As a direct result of this, a new Air Quality Directive* has recently been published which incorporates - for the first time – a range of requirements related to $PM_{2.5}$. For $PM_{2.5}$, the Directive includes:

1. ***Average Exposure Indicator***: The Average Exposure Indicator expressed (AEI) is based on measurements in urban background locations in zones and agglomerations throughout the territory of Member States. It is assessed as a three-calendar year running annual mean concentration averaged over all measurement stations for 2009, 2010 and 2011. The required reduction by 2020 is based on the level of the 3-year AEI as follows (Table 1):
2. ***Exposure Concentration Obligation***: requires AEI reduction to 20µgm^{-3} by 2015

* *Directive 2008/50/EC of 21 May 2008 on ambient air quality and cleaner air for Europe* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

Table 1: Average Exposure Indicators

Initial Concentration, µg m^{-3}	Reduction target, percent
<8.5 – 8.5	0%
>8.5 - <13	10%
13 - <18	15%
18 - <22	20%
³ 22	All appropriate measures to achieve 18µg m^{-3}

3. ***Target Value:*** This is 25µg m^{-3}, to be met by 1 Jan 2010.
4. ***Limit Value***: the Stage 1 limit value for all stations is 25µg m^{-3}, to be met by 1 Jan 2015. The Stage 2 limit value is 20µg m^{-3} for all stations, to be met by 1 Jan 2020.

The UK National Network for monitoring PM – the Automatic Urban and Rural Monitoring Network (AURN) – has been re-configured to incorporate monitoring of $PM_{2.5}$ at a number of locations, in compliance with the new Directive. Three of these sites are in Scotland; a summary of results for the first year of monitoring (2009) is presented in Section 3.1.

At present, the Scottish Government is consulting on the transposition into law of Directive 2008/50/EC on ambient air quality and cleaner air for Europe. The Directive entered into force on 11 June 2008 and must be transposed into national legislation before 11 June 2010. The Scottish Government is inviting written responses to this consultation paper by 20 April 2010 – see www.scotland.gov.uk/Publications/2010/01/25153504/0.

2.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, first published in 1997, establishes a strong framework for tackling air pollution. It was based on strong scientific evidence and a science-based understanding of the effects of air pollutants on health and the environment. The Strategy sets objectives for a series of pollutants to be met within the UK. The scientific basis, the objectives set and provisions contained within the Strategy are closely associated with the corresponding standards set within European Air Quality Directives, as described above. However, provisions and corresponding objectives for some pollutants differ from those in the Directives; these differences relate to scientific evidence and expert opinion that is specific to the UK situation.

A major revision of the Strategy was published in July 2007. This includes a detailed update of the effectiveness of current provisions and objectives, as well as proposing a series of new regulatory measures and objectives to be adopted. The key outcomes from the Strategy revision are that all current objectives for pollutants will be maintained. Additional objectives have been adopted for $PM_{2.5}$ to protect human health (12mgm^{-3} annual average in Scotland), and for ozone to protect ecosystems - based on accumulated ozone dose. In addition, a series of policy measures has been considered for adoption, following detailed cost-benefit analysis. The full revised Air Quality Strategy and its extended series of associated technical annexes can be seen at: www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116

The Air Quality (Scotland) Regulations 2000 and the Air Quality (Scotland) Amendment Regulations 2002 prescribe the air quality objectives to be considered for review and assessment purposes. The Air Quality Standards (Scotland) Regulations 2007, which came into operation on March 29th of that year, cover EU Limit Values. Other relevant legislation includes The Road Traffic (Vehicle Emissions) (Fixed Penalty) (Scotland) Regulations 2003, which enable local authorities to check vehicles at roadside to ensure that emissions limits are not exceeded; and The Sulphur Content of Liquid Fuels (Scotland) Regulations 2000, which limit the permissible sulphur content of liquid fuel oils such as those used for domestic heating, and thus helps to reduce emissions of sulphur dioxide.

2.3 Local Air Quality Management

Local Air Quality Management (LAQM) provides a robust and comprehensive framework within which air quality is managed by Local Authorities in Scotland. LAQM requires Local Authorities to review and assess a range of air pollutants against the objectives set out within the Air Quality Strategy, using a range of monitoring, modelling, observations and corresponding analyses. For locations where objectives are not expected to be met by the relevant target date, Local Authorities are required to:

- Declare an Air Quality Management Area (AQMA), and
- Develop an Action Plan to address the problem.

The Scottish Government Policy Guidance on LAQM - PG(S)(09) - has recently been revised and republished at http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116.

The new LAQM Technical Guidance - LAQM TG (09) - and associated practice guidance notes are also available at the same location.

At the time of preparing this Newsletter, 12 of Scotland's 32 Local Authorities have declared Air Quality Management Areas. Since the previous Newsletter, one additional air quality management area has been declared in North Lanarkshire, making a total of 21 management areas in the 12 Local Authorities. Of these 12, three have declared an AQMA for PM_{10} alone, five have declared AQMAs for NO_2 and PM_{10} together, three have declared an AQMA for NO_2 only and one for SO_2. Table 1 shows the locations of these AQMAs, and what pollutants they deal with.

All Authorities with AQMAs have either prepared, or are currently preparing, Air Quality Action Plans for their AQMAs.

Table 2: Air Quality Managements Areas declared by Authorities in Scotland

Council	Pollutant	Source	Date Declared	AQMAs
Aberdeen	NO_2 & PM_{10}	Roads	July 2006, December 2008	3
Edinburgh	NO_2	Roads	Dec 2000, 2006 and March 2009	3
Glasgow City	NO_2 & PM_{10}	Roads	January 2002, July 2007	3
Dundee City	NO_2	Roads	July 2006	1
East Dunbartonshire	NO_2 & PM_{10}	Roads	December 2005	1
Falkirk	SO_2	Industry	November 2005	1
Fife	NO_2 & PM_{10}	Roads	October 2008	1
Midlothian	PM_{10}	Domestic	April 2008	1
North Lanarkshire	PM_{10}	Roads	December 2005, June 2008	4
Perth	NO_2 & PM_{10}	Roads	May 2006	1
Renfrewshire	NO_2	Roads	September 2005	1
South Lanarkshire	PM_{10}	Roads	November 2008	1

A recent report by Audit Scotland* reviewed air quality in Scotland, together with other environmental media. The report highlights that, although air quality in Scotland was generally good, there are a number of areas with poor air quality identified by the AQMAs discussed above. The report makes the following recommendations:

- The Scottish Government should improve the co-ordination of policies on air quality and road transport at a national level.
- In councils with poor air quality caused by pollution from road transport, air quality teams should work with transport and planning colleagues to identify and implement actions to reduce emissions from road transport.
- Councils with AQMAs should review their action plans, identify funding to implement actions to tackle poor air quality and set timescales for when they expect to be able to revoke their AQMAs.

*Audit Scotland, Protecting and improving Scotland's environment, Jan 2010 http://www.audit-scotland.gov.uk/docs/central/2010/nr_100114_environment_overview.pdf

3. Networks and data

A wide range of air quality monitoring activities is carried out in Scotland. Some monitoring sites are run as part of UK-wide monitoring networks; others are operated by Local Authorities in order to meet local objectives. The following Air Quality Strategy pollutants were monitored in Scotland during 2009:

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO_x) and Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Particles (as PM_{10} and $PM_{2.5}$)
- Ozone
- Benzene
- 1,3-Butadiene
- Polycyclic Aromatic Hydrocarbons (PAH)
- Lead

The locations of automatic monitoring sites are shown in Figure 1; they provide high-resolution hourly information on a wide range of pollutants. Data from national network monitoring sites are updated hourly in near-real time on the Scottish Air Quality Database, whilst data from Local Authority operated monitoring sites are updated either hourly or daily, depending on the station configuration. Photographs of two monitoring sites recently included within the Scottish Air Quality Database are shown in Figure 2.

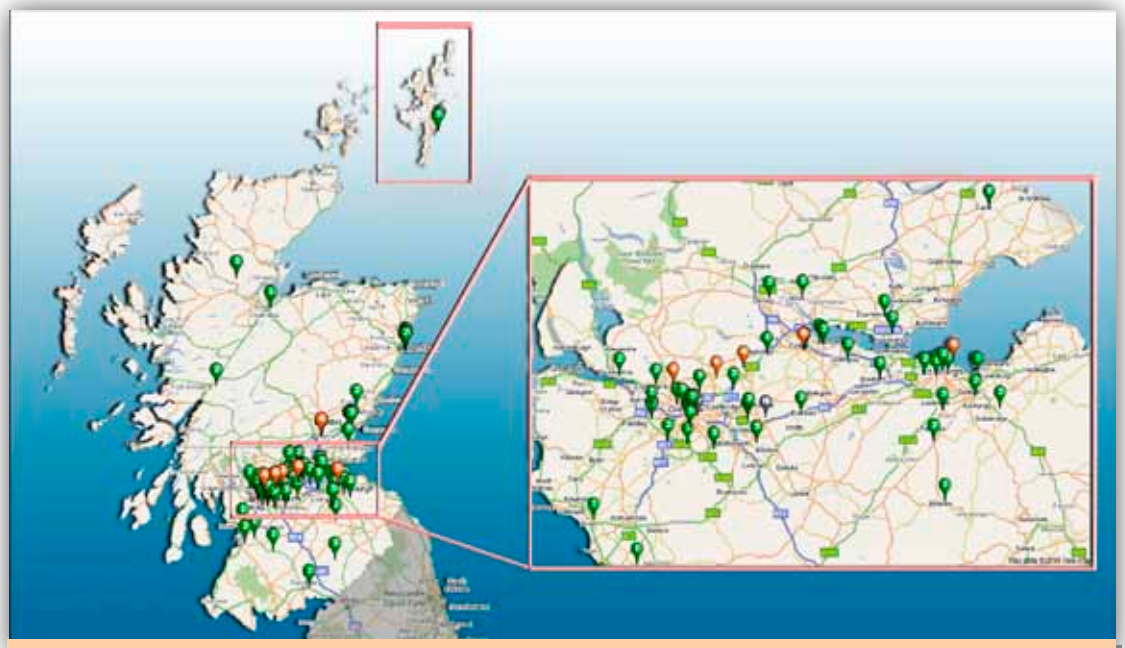


Figure 1. Automatic monitoring stations in Scotland

Please note that spot colours just refer to air quality banding when the screenshots used to generate this map were taken

Scotland's automatic sites are supplemented by a large number of non-automatic pollutant sampling locations, which use less expensive techniques to provide additional information on air quality. The majority of these are diffusion tubes: low cost single-use samplers that absorb specific pollutants directly from the air and need no power supply. These measure average concentrations over a specified sampling period (typically one month) instead of instantaneous concentrations, but still provide invaluable data for screening purposes, 'hot-spot' identification, local impact assessment and mapping overall levels of pollution across the country as a whole.

Air quality data for Scotland are stored in a comprehensive database that is available on-line at www.scottishairquality.co.uk. A summary of the pollutants, number of monitoring sites and areas covered by the database in 2009, is provided in Table 3. The database provides comprehensive and rapid communication of air quality information to the public.

Figure 2. Two new monitoring stations – Forfar (L) and Peebles (R)

Monitoring of a range of important pollutants for which no specific UK Objective has been set is also routinely undertaken within national networks in Scotland. These include Heavy Metals (urban and rural), Ammonia, Black Smoke and Acid Deposition.

Table 3: Summary of automatic air quality monitoring data available in the Scottish Air Quality Database www.scottishairquality.co.uk

Pollutant	Major sources	Sites with data in the AQ Database	Areas covered
Nitrogen Dioxide (NO_2)	Road transport and industry	67	Mostly urban
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	11	Urban & rural
Particles (PM_{10}, $_{2.5}$)	Road transport, industry, construction, soil and natural sources	62 (PM_{10}) 7 ($PM_{2.5}$)	Mostly urban
Sulphur dioxide (SO_2)	Industry and fuel combustion	15	Mostly urban
Carbon Monoxide	Road transport	6	Urban
Benzene	Road transport and industry	2	Urban and Rural
1,3 butadiene	Mostly industrial	2	Urban and rural

Since 2008, the number of monitoring sites for NO_2 has increased by 14, PM_{10} by 8 and sulphur dioxide by 4. The number of CO sites has increased by 1 whilst benzene and 1,3-butadiene have remained the same. $PM_{2.5}$ monitoring is now undertaken at 6 sites with automatic monitors and one site with a daily sampler monitor. These $PM_{2.5}$ sites are all part of national networks and will provide data to assess concentrations within Scotland. Three of these sites also provide data to calculate the UK Average Exposure Indicator for $PM_{2.5}$ (see Section 2.1).

The following section provides a summary of results from both automatic and non-automatic monitoring in Scotland in 2009, and will be supplemented by further information and data to be published in the full Annual Report later this year.

3.1 Automatic Monitoring - key results for 2009

Note that automatic data for 2009 are not yet fully ratified; there may therefore be subsequent changes to the data which may affect the results presented here.

This section provides a summary of Scotland's air quality monitoring results in 2009, including analysis of compliance with Air Quality Strategy Objectives. Further information is provided on the Scottish Air Quality website at www.scottishairquality.co.uk.

Carbon monoxide was monitored using automatic techniques at six sites during 2009. Three of these were in Glasgow, one in Edinburgh, one in North Lanarkshire (Harthill West, commencing in April 2009) and one in East Ayrshire (Kilmarnock, site closed June 2009). All achieved the Air Quality Strategy (AQS) Objective for this pollutant.

Nitrogen dioxide data from 67 sites utilising automatic monitoring are available for all or part of 2009. Twelve of these sites had less than 75% data capture, either because of instrument faults or because the site commenced or closed part-way through the year. Thirteen sites had annual average concentrations exceeding the AQS Objective for the annual mean (40μg m^{-3}). These were sites located in Aberdeen, Dundee, East Dunbartonshire, Edinburgh, Glasgow, Paisley and Perth. Six of these sites also exceeded the AQS Objective of 200μg m^{-3} for the hourly mean on more than the permitted 18 times.

All of the Local Authorities with monitoring sites exceeding the AQS Objectives for NO_2 have declared, or are in the process of declaring, Air Quality Management Areas. The highest NO_2 concentrations, based on provisional data, were measured at Paisley Central Road, Glasgow Kerbside and Edinburgh St Johns. The Glasgow Kerbside and Edinburgh St John's sites are both located very close to extremely busy roads. The Paisley Central Road site is a special case, where the roadway is a covered entrance to a bus station. The road infrastructure at this location is currently being remodeled.

Sulphur dioxide data from 15 sites utilising automatic monitoring are available for all or part of 2009. At the Falkirk Grangemouth Moray site, the AQS Objective for the 15-minute average was exceeded more than the permitted 35 times. All other sites in Scotland met the requirements of the AQS for 15-minute, 1-hour and 24-hour mean SO_2 in 2009.

Particulate matter – PM_{10} Gravimetric equivalent PM_{10} data are available from 62 sites - 61 utilising automatic monitoring and one Partisol daily sampler, at Inverness. Of these, sites, 13 have less than 75% data capture. All data from Tapered Element Oscillating Microbalance (TEOM) analysers have been adjusted using the Volatile Correction Model (VCM) to provide gravimetric equivalent data. Five sites changed from TEOM analysers to Filter Dynamics Measurement System (FDMS) analysers during the year. In these cases, the VCM-corrected TEOM data have been merged with data from the replacement monitor to produce an overall summary for the full year from all available data.

Overall, 16 sites exceeded the annual average PM_{10} Objective of 18µgm^{-3} and a further 6 equalled this Objective. Seven of these also exceeded or equalled the daily Objective of less than 7 exceedences of 50µgm^{-3}. No site, however, exceeded the UK AQS Objective of 40µgm^{-3} for the annual mean PM_{10} or the daily objective of 35 exceedences of 50µgm^{-3}.

Particulate matter – $PM_{2.5}$ For compliance with the EC Directive, three $PM_{2.5}$ urban background monitoring sites are required in Scotland. These have been established, as part of the national network, in Edinburgh, Glasgow and Aberdeen. In addition, for research purposes, additional sites have been established at the kerbside site in Glasgow and at the rural site at Auchencorth Moss. Also, with support from the Scottish Government, daily gravimetric monitoring of $PM_{2.5}$ monitoring continues at Inverness. Data from seven sites in Scotland are therefore available for all or part of 2009.

The Scottish AQS Objective of 12µg m^{-3} was met at 5 of these sites, equalled at Glasgow Centre and exceeded at Glasgow Kerbside. Over the whole of the UK, the provisional $PM_{2.5}$

AEI for 2009 was 12.7µg m^{-3} - borderline between a required reduction of 10 or 15% (see Section 2.1). The final AEI will to be calculated as a average over 2009, 2010 and 2011.

Ozone. Data are available from 11 sites with automatic analysers in 2009. Ozone may persist for several days and be transported over long distances. This means that Local Authorities have little control over ozone levels in their area. The target value for the 8-hour running mean Objective was exceeded on more than the permitted ten days at Eskdalemuir and Lerwick and equalled at the Fort William site.

Benzene and 1,3-Butadiene are monitored at the rural Auchencorth Moss site and at Glasgow Kerbside. Both sites continue to meet the AQS objectives for these pollutants.

Summary: Data are available from about 20 more monitoring sites in Scotland in 2009 compared to 2008. However, the general picture of air pollutant concentrations throughout the country is similar. Provisional results from Scotland's network of automatic air quality monitoring stations in 2009 show that the Air Quality Strategy Objectives for carbon monoxide, benzene and 1,3-Butadienehave been met by the due dates.

However, in 2009, there remained a number of sites close to busy roads in urban areas that did not meet AQS Objectives for nitrogen dioxide and/or particulate matter as PM_{10}, together with several rural sites that did not meet the AQS Objective for ozone. The Scottish Objective for $PM_{2.5}$ was met or equalled at urban background sites, but not at sites close to busy roads. At the Falkirk Grangemouth Moray site the AQS Objective for the 15-minute average was exceeded more than the permitted 35 times.

As a result of these measurements, a number of Air Quality Management Areas have been declared or are in the process of being declared throughout Scotland (see Section 2.3).

3.2 Non-Automatic Monitoring in 2009

Sampler-based pollution monitoring can provide a powerful and cost-effective way of determining overall pollution levels over large areas. Scotland's automatic monitoring sites are therefore supplemented by more than 800 Local Authority-operated sites using non-automatic sampling methods. The most widely used of these techniques is passive sampling, using diffusion tubes. The main programmes of sampler-based monitoring in Scotland are as follows:

1) Diffusion tubes These measure periodic (typically monthly) concentrations of nitrogen dioxide (NO_2). Diffusion tubes are easy to use and relatively inexpensive, so they can be deployed in large numbers over a wide area, giving good spatial coverage. They may also be used to complement detailed measurements made at automatic monitoring sites, or in circumstances where hourly measurements from automatic analysers are not required.

Although there is no longer a national monitoring network based upon NO_2 diffusion tubes, these samplers are still widely used by the Local Authorities for the purpose of Local Air Quality Management (LAQM). NO_2 is monitored at several hundred locations in Scotland in this way. Moreover, Scottish Government continues to provide a central web-based NO_2 diffusion tube data collation facility, together with QA/QC support for this monitoring.

The majority of Scotland's diffusion tube sites monitor NO_2. As well as this pollutant, however, diffusion tubes are also used to provide indicative monitoring of ozone, sulphur dioxide and a range of hydrocarbons including benzene.

2) Non-automatic Hydrocarbon Monitoring Pumped tube samplers for benzene and 1,3-butadiene continue to be operated as part of the UK network (run by National Physical Laboratory) in Edinburgh and Grangemouth.

4. Review of transboundary air pollution

During 2009, Defra commissioned the Centre for Ecology and Hydrology (CEH) to produce a Review of Transboundary Air Pollution (RoTAP) for the UK. The RoTAP report aims to review the current state of rural air pollution issues in the UK, evaluate the extensive measurements and recent research into the main short lived atmospheric pollutants and their effects, and produce a synthesis of current understanding which will be used to develop air quality policy. The report also proposes recommendations for further research or monitoring to answer outstanding questions.

A first draft of the RoTAP report, compiled by a group of relevant scientific experts, including input from advisors representing Scottish Government, was circulated for peer review by stakeholders, and is currently available at www.rotap.ceh.ac.uk. In addition to the main scientific report, there is a stand-alone Summary for Policy Makers, which draws together all of the relevant policy findings on acidification, eutrophication, ground level ozone and heavy metals.

The review focuses on the pollutants causing acid deposition, eutrophication, ground level ozone and heavy metal pollution in the UK, namely sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), aerosols (particulate matter), heavy metals, nitric acid (HNO_3) and ozone (O_3). The RoTAP report reviews the current data available to the group on these pollutants and provides an evaluation of the response to changes in emissions of pollutants over the last 30 years. In particular, the report assesses changes in concentrations, deposition and environmental effects following the large reductions in emissions of sulphur, nitrogen, volatile organic compounds and metals, and the extent of recovery of ecosystems from the effects observed. Key messages of the report include:

Acidification

Acidification of soils and water is caused by the deposition of sulphur, nitrogen, and hydrochloric acid. Emission controls have reduced emissions of SO_2 by over 90% since their peak in the 1950s, with a subsequent decline in sulphur concentrations and levels of acidity in the atmosphere, soils and freshwater. Ecological recovery of affected habitats is underway, with the reappearance of acid-sensitive species of lichen and bryophytes. It is unlikely that full recovery to the pre-acidification state will be achieved. In fact, in some regions of the UK, the effects of acidification remain due to the legacy of previous emissions and other factors which affect recovery, including land use and climate change. Further reductions in sulphur emissions may be required to aid ecological recovery.

Nitrogen deposition also has the ability to acidify the environment. Most of the deposited nitrogen is believed to be accumulating in soils and vegetation, and relatively little is currently contributing directly to acidification. However, it has the potential to leach to surface waters. Currently, 58% of all habitat areas sensitive to acidification exceed the Critical Load for acidity, and this is predominately due to the deposition of nitrogen. In the coming decade, nitrogen deposition is likely to be an ongoing significant threat to the achievement of favourable conservation status of sensitive habitats, a requirement of the Habitats Directive.

Eutrophication

Eutrophication occurs from atmospheric deposition of oxidised and reduced nitrogen. Since 1970, emissions of NO_x have declined by 50%, with a corresponding 50% reduction in NO_x concentrations in air. Data on the emissions of NH_3 are only reliable since 1990, and currently show a 24% decrease. However, concentrations of NH_3 have changed little over the last decade, with spatial and temporal variability masking any overall trend. Despite the large reductions in emissions of nitrogen, deposition of total nitrogen (including oxidised and reduced forms) has changed little. This surprising result is due to changes in

atmospheric chemistry, with nitrogen compounds now removed from the UK atmosphere at a faster rate than occurred 20 years ago. As nitrogen compounds emitted from the UK now spend less time in the atmosphere, the main benefit of emission controls is a reduction in the amount of atmospheric nitrogen compounds which are exported from the UK. Effects of eutrophication include stimulated algal growth and a subsequent change in species composition. There is strong evidence that atmospheric nitrogen has reduced the diversity of plant species in a range of habitats of high conservation value across the UK. Currently 60% of habitat areas sensitive to eutrophication exceed the Critical Load for nutrient nitrogen. This figure is predicted to decrease to 49% by 2020. Reducing ammonia concentrations is a high priority, and remedial action may also be required to allow full recovery of damaged plant communities.

Ground Level Ozone

Ozone is formed in the atmosphere by chemical reactions between pre-cursors including NO_x, volatile organic compounds (VOCs) and sunlight. Emissions of ozone precursors have been successfully reduced in the UK, and more widely throughout Europe, with a subsequent 30% decrease in peak ground level ozone concentrations since the 1980s. However, emissions from elsewhere in the Northern Hemisphere have led to a 10% increase in background ozone concentrations between 1987 and 2007. Current ozone exposures exceed critical thresholds for effects on crops, forests and semi-natural vegetation over substantial areas of the UK. For example, in a typical recent summer, the effects of ozone were calculated to reduce the wheat yield of Southern Britain by between 5 and 15%. It is therefore necessary to increase controls on emission of ozone precursors, with the hemispheric scale being the most appropriate.

Heavy Metals

UK emissions of heavy metals have decreased in the UK since 1990, achieving compliance with the 1998 UNECE Protocol on Heavy metals. The decline in emissions is mainly due to reductions in the consumption of coal, the decline of heavy industry in the UK and the withdrawal of leaded petrol. Calculations of total metal deposition in the UK, available for the first time, exceed the total reported emissions, with some metals having a discrepancy of an order of magnitude. Deposition measurements include material from natural sources and re-suspended material, neither of which are included in the emissions inventory. However, further work is required to improve the emissions inventory for heavy metals. At some sites in the UK, the concentrations of heavy metals in soil are high enough to cause ecological damage. However the source of metals in these cases is likely to be from local point sources, and legacy deposition rather than transboundary air pollution per se, although some sites such as the Lochnagar catchment have high metal concentrations in soils and sediments following long term deposition of metals.

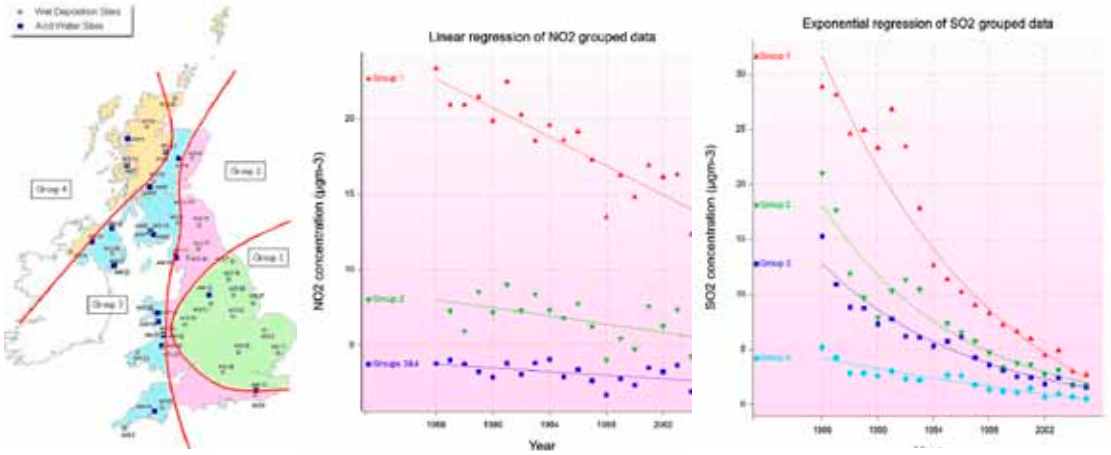


Figure 3. UK Concentrations of SO_2 and NO_2 measured in rural air, (1986-2005), classified by regional group. The groups were determined by regression analysis of changes in concentrations. Concentrations of SO_2 have shown an exponential decline, whereas those of NO_2 have shown a linear decrease.

5. Air quality trends

In general, recent years have seen a marked improvement in Scotland's air quality. In particular, levels of pollutants associated with motor vehicle and industrial emissions have reduced significantly over the past decade.

Here we examine how overall, mainly urban, pollution levels in Scotland have changed over the last 20 years. To an extent, these analyses are affected by changes in monitoring site numbers. Since these were relatively low for background monitoring sites up until 2000, and for roadside/kerbside sites up until 2002, trends in the earlier years should be regarded with caution. Recent research has indicated that for reasonably robust annual mean trends analysis, at least four monitoring sites with good annual data capture should be available.

For the purpose of this analysis, we will concentrate on those pollutants where we have identified that Air Quality Strategy Objectives are currently not being met in Scotland, namely nitrogen dioxide, particulate matter as PM_{10} and ozone. We will examine the trends in annual mean statistics which reflect the effects on health of long-term exposure to elevated levels of pollution.

5.1 Nitrogen Dioxide and Oxides of Nitrogen

Within Scotland (and elsewhere across the UK) the largest numbers of AQMAs are currently declared based on exceedences of the annual mean NO_2 objective of 40 μgm^{-3}. This is also reflected in the number of monitoring stations recording an exceedence of this objective (see Section 3). It is therefore important to understand how trends in this pollutant are varying with time, and whether concentrations are improving or deteriorating.

Trends in NO_2 cannot be considered without also taking into account the variations in total NO_x concentrations, since a large proportion of NO_2 is formed from the oxidation of NO subsequent to its emission from the motor vehicle tailpipe or chimney stack. At roadside locations, direct emissions of NO_2 are also important; the effect of these is discussed in more detail overleaf.

Figure 4 below presents the annual mean variation in measured NOx concentrations at roadside/kerbside and urban background monitoring stations since reliable measurements began in Scotland in 1987. Despite a limitation in the number of monitoring stations in the early years, there is a clear long-term improvement in NOx concentrations, due to the reductions in emissions from combustion sources which UK and EC policies have delivered.

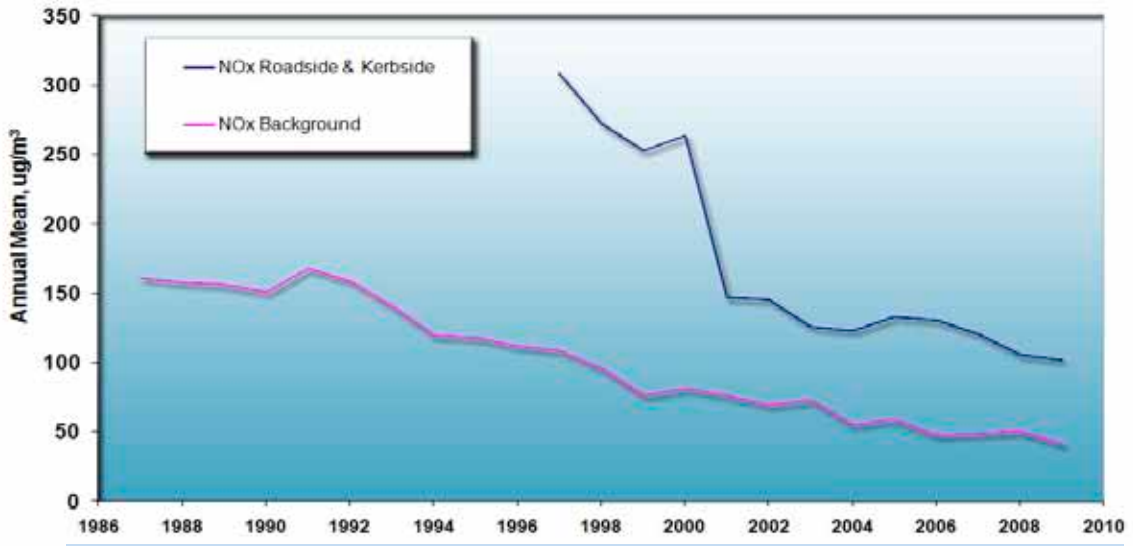


Figure 4 . Trends in NO_x annual means at urban background and roadside sites in Scotland: 1987 – 2009 (provisional data)

Figure 5 below shows the corresponding trends for NO_2, and also demonstrates a long-term decline in concentrations of this pollutant. In this case, however, the progression is less smooth, principally due to the dependence of NO_2 concentrations on atmospheric ozone chemistry and hence the predominant weather conditions from year-to-year. Provisionally 2009 does, however, show the lowest average concentrations to date across Scotland, and provides encouragement in that average roadside concentrations of NO_2 have now been below 40 μgm^{-3} for two consecutive years. This is despite accepted evidence of a levelling-off in the reduction in concentrations in recent years which UK experts (AQEG 2007) believe may be due to:

- An increase in the proportion of NO_2 emitted directly to the atmosphere. This, in turn, is due to the increased market penetration of diesel cars and the retrofitting of pollution control devices, such as catalytically regenerative traps to buses.
- Increasing background O_3 which promotes the oxidation of emitted NO to NO_2.

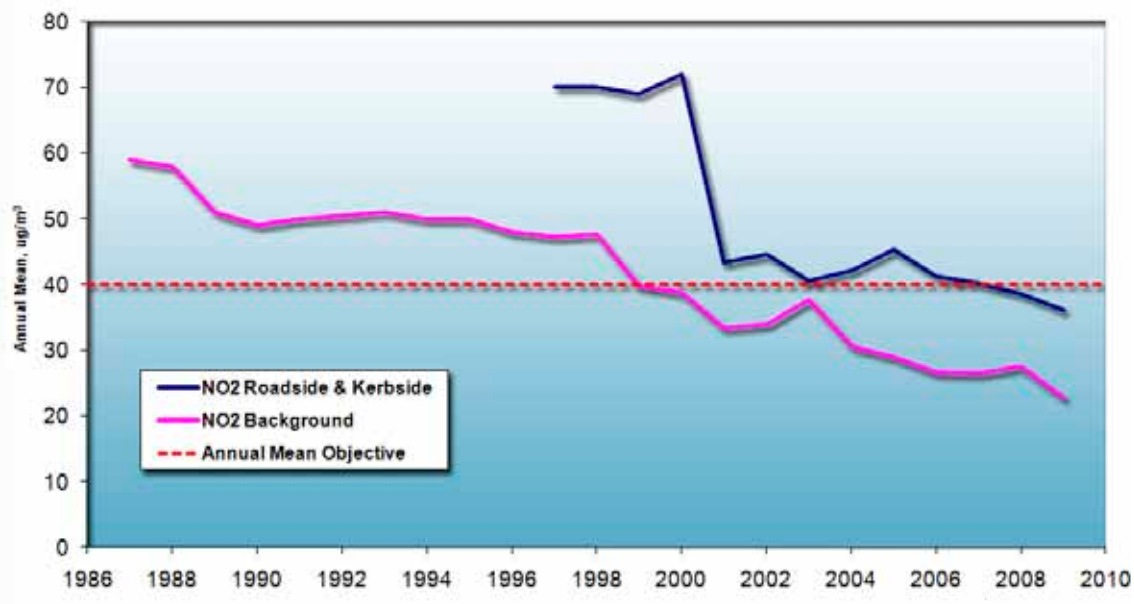


Figure 5 . Trends in NO_2 annual means at urban background and roadside sites in Scotland: 1987 - 2009.

5.2 Ozone

Figure 6 overleaf illustrates the increase in background ozone, which is small but detectable at rural and remote locations in Scotland. The trend clearly increased at urban background locations until 2004 but has, perhaps, levelled off in recent years.

5.3 Particulate Matter (PM_{10})

Finally, we examine the trends in PM_{10} particulate matter across Scotland in Figure 7 below. These are of great interest since:

- Scotland has adopted a more stringent annual mean PM_{10} objective than the rest of the UK for 2010, at 18 μgm^{-3}.
- Scientists do not believe that there is actually a safe level of this pollutant in terms of human health effects.

This figure demonstrates that there has been a general decline in urban background PM_{10} concentrations since 1992, but that - for the last few years - concentrations have hovered around the critical 18 μgm^{-3} annual mean objective level. Once again, however, there is encouragement in that the provisional 2009 figures show that- for last two consecutive years - average background PM_{10} concentrations across Scotland have been below the objective.

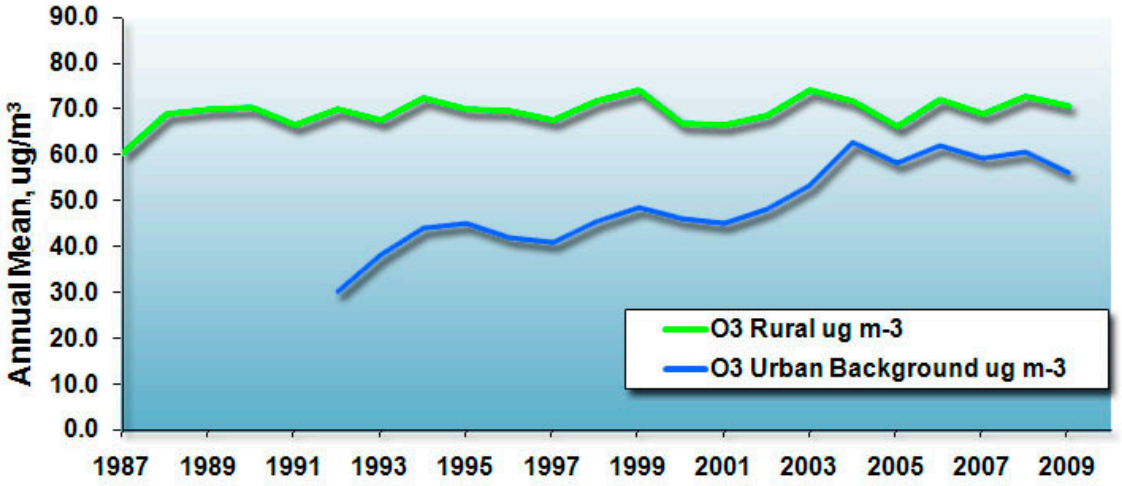


Figure 6. Trends in ground-level ozone at sites in Scotland: 1987 - 2009

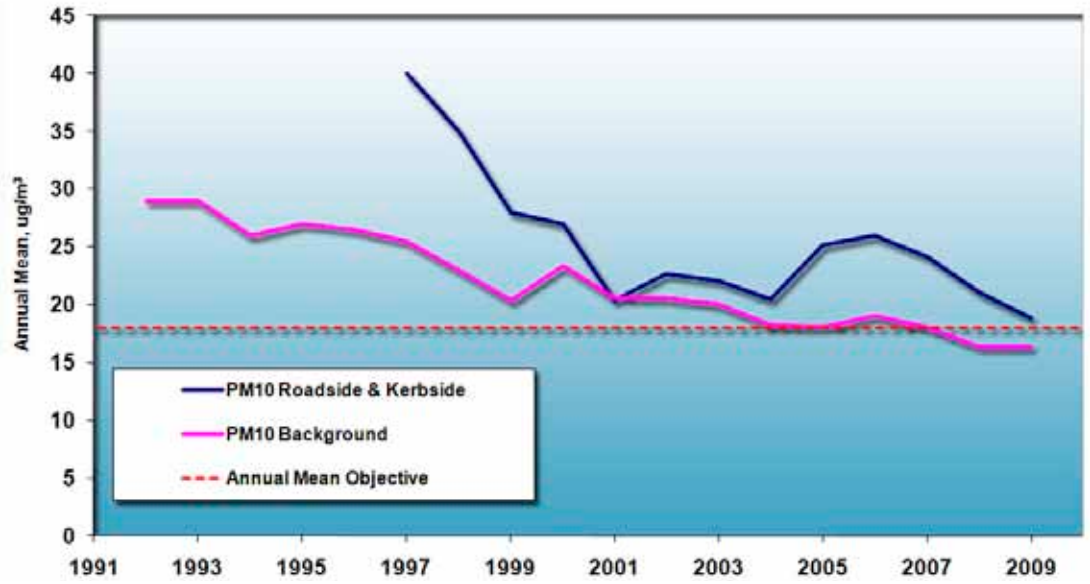


Figure 7. Trends in PM_{10} particulate matter annual means at urban background and roadside sites in Scotland: 1987 - 2009.

For roadside sites, the trend is similar but with more year-to-year variation than shown by the graph of background concentrations. There are two possible reasons for this:

1. Concentrations at roadside monitoring stations are more likely to be affected by localised and perhaps short-term pollution issues caused by road works, building construction or demolition, or temporary changes to traffic flow or intensity.
2. From 2004 onwards, there has been a dramatic increase in the number of roadside monitoring sites in Scotland in each consecutive year, as illustrated in Table 4 below. Current policy is to include all data in the analysis, but this may affect the robustness of the underlying trends.

Table 4: Increasing number of PM_{10} Kerbside/Roadside Monitoring Sites in Scotland: 2004 - 2009.

Year	2004	2005	2006	2007	2008	2009
Site numbers	5	13	18	27	41	49

6. Maps of air quality

As a component of the Scottish Air Quality Database project, AEA provides mapped concentrations of pollutants on a 1 x 1 km square grid basis. These maps combine measurement data with spatially disaggregated emissions information from the National Atmospheric Emissions Inventory (NAEI) to provide estimated pollutant concentrations for the whole of Scotland. The methodology for producing the Scottish pollutant maps is based on that used for producing air pollutant maps for the whole of the UK; this is described in the annual UK air quality modelling report. Further details can be found in www.airquality.co.uk/reports/cat09/0905061048_dd12007mapsrep_v8.pdf.

The focus of the work has been on:

- Calculating projected concentrations of PM_{10} NO_2 and NO_X for 2010, 2015 and 2020, based on a baseline year of 2008
- Determining the contribution from different source sectors to the modelled concentrations to assist Scottish Authorities with their Air Quality assessments.

The sampling equipment and procedures used for the additional Scottish Government measurements are identical to those used for measurements in the AURN. The modelled pollutant concentration maps are produced using a dispersion kernel derived with Scottish meteorological data obtained from RAF Leuchars, and are calibrated using Scottish pollutant monitoring data.

Provisional background and roadside maps are presented in Figure 8 and 9 for PM_{10} and NO_2 respectively.

For the purposes of the EU Air Quality Directive, Scotland has been split into two agglomerations (urban areas with population greater than 250,000) – Edinburgh Urban Area and Glasgow Urban Area and four zones – Scottish Borders, Central Scotland, North East Scotland and Highland. Whilst the concept of zones and agglomerations has no specific relevance in terms of the Air Quality Strategy and the Air Quality Objectives for Scotland, it does provide a useful geographical reference for discussing the results.

The model outputs have been compared against the Air Quality Objectives for Scotland to determine the extent of exposure to specific concentrations. At background locations the area and population exposed are assessed. At roadside locations, the number of road links and the length of road exposed are determined. Due to the provisional nature of the maps, exceedence statistics are not presented here.

The model can only determine annual mean concentrations. Hence, to compare the model output with Objectives based on numbers of exceedences of daily values, it is first necessary to calculate an annual average equivalent to the set number of exceedences. This is achieved by analysis of the available monitoring data. The calculated annual mean equivalent of the UK wide daily objective of 35 exceedences of 50 µg m^{-3} was found to be 31.5 µg m^{-3}. The corresponding calculated annual mean equivalent of the Scotland daily objective of 7 permissible exceedences of 50 µg m^{-3} was found to be 22 µg m^{-3}. This is based on the relationship between daily 98th percentile and annual mean concentrations across the whole of the UK from 1992 to 2007. Note that this relationship exhibits a lower correlation (0.72) than the 90th percentile (0.90) used to derive the annual mean equivalent for the UK daily objective.

Final maps showing modelled annual mean concentrations of PM_{10}, NO_2 and NO_X for 2008, and exceedence statistics by Scottish zone and agglomeration will be provided in the final report to the Scottish Government.

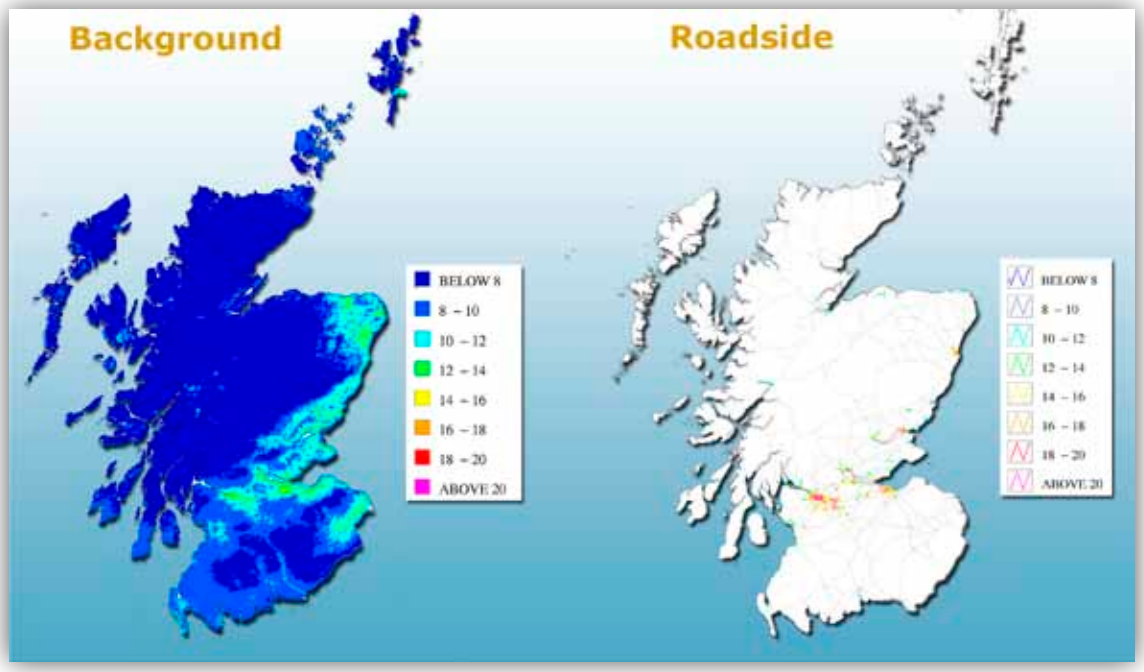


Figure 8. Provisional gravimetric PM_{10} maps for 2008, μgm^{-3} (Scotland-specific model)

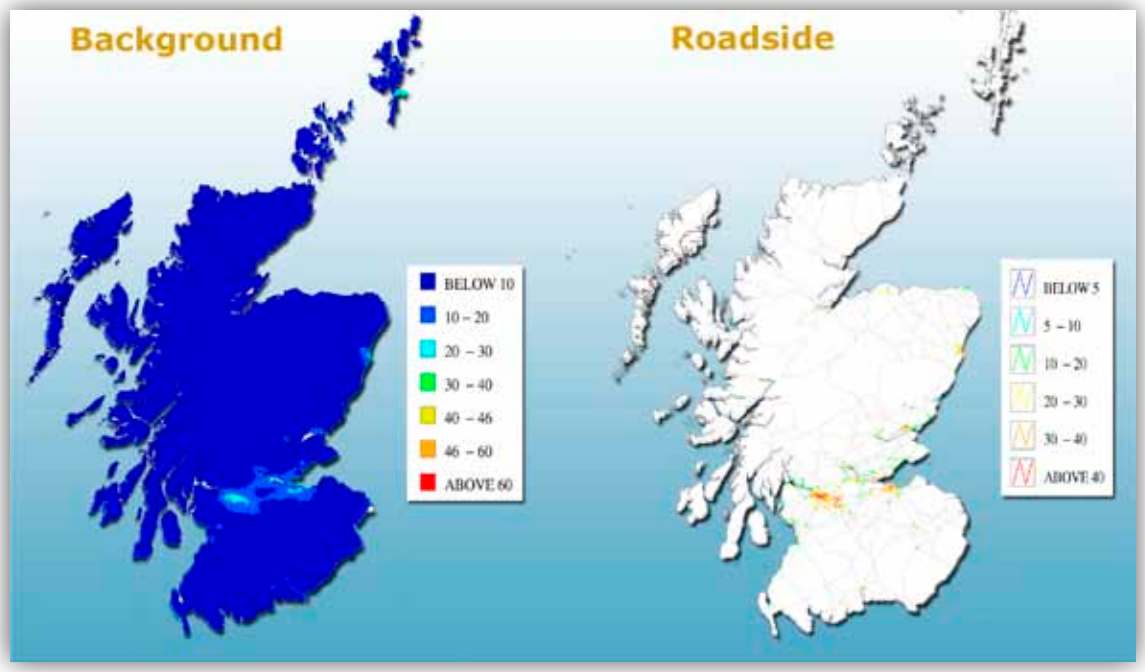


Figure 9. Provisional background and roadside NO_2 maps for 2008, μgm^{-3} (Scotland-specific model)

7. More information

1) The Air Quality Scotland Website

The national website, 'Air Quality Scotland' at www.scottishairquality.co.uk - has been created to provide a 'one stop shop' resource for information covering all aspects of air pollution in Scotland. This site is part of a family of air quality websites developed by AEA which cover the UK, Wales, Scotland and Northern Ireland.

The site is funded by the Scottish Government. It was designed from the outset to be:

- Accurate and reliable
- Comprehensive
- User-friendly
- Easily navigable
- Interactive
- Able to meet the needs of the general public as well as technical, local government and regulatory user communities.

The website provides information on:

- Latest up-to-date air quality levels across Scotland
- Reports and analysis of trends and historical data
- Information on both national air quality policy and the work of Scotland's Local Authorities
- Descriptions of what causes air pollution, how it is measured, and relevant health, amenity and ecosystem impacts

The home page provides a simple summary of latest up-to-date concentrations using an 'Air Pollution Index', and a map showing where Scotland's automatic monitoring stations are located.

By clicking on the map, users can interactively view details of each monitoring site, a photograph of its location, and a list of the pollutants monitored.

In a new web functionality, from the Home page users can now Register to receive daily or hourly e-mail updates of the latest air quality data.

2) Mobile Services - Air Quality in Scotland

The website has recently been upgraded to allow latest information to be displayed on your mobile phone or PDA whilst you are on the move. Just access www.scottishairquality.co.uk/mobile.

Later in 2010, a free subscription service will also be launched to allow you to receive text alerts when air pollution in Scotland is expected to reach levels where susceptible members of the public may wish to take preventative action to protect their health.

Details of this and any further new services will, of course, be provided on the Air Quality in Scotland website.

3) Current and forecast air quality (national and local)

In addition to the Air Quality Scotland website, this information is rapidly available from:

- Teletext page 156
- The Air Pollution Information Service on freephone 0800 556677
- The UK Air Quality Archive on www.airquality.co.uk

4) General information on Air Quality

- The Scottish Government's Air Quality Management Internet Pages at www.scottishairquality.co.uk/laqm.php
- The UK Air Quality Information Archive on www.airquality.co.uk
- The National Atmospheric Emissions Inventory on www.naei.org.uk
- The Defra air quality information web resource on http://www.defra.gov.uk/environment/quality/air/airquality/index.htm
- The Air Quality Scotland website at: www.scottishairquality.co.uk
- The Air Pollution Information System website at www.apis.ac.uk
- CEH Atmospheric Sciences pages at www.atmosci.ceh.ac.uk/Home.htm

5) Local Air Quality Issues

For further information on air quality issues in your area, please contact the Environmental Health Department at your Local Authority office. Further information on Local Air Quality Management may also be found at:

www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116

www.defra.gov.uk/environment/quality/air/airquality/local/index.htm

www.scottishairquality.co.uk/laqm.php

Rainbow over Grangemouth Refinery

The Air Pollution in Scotland Report for 2009 has been produced by AEA on behalf of the Scottish Government. Its principal authors this year are Ken Stevenson Paul Willis and Justin Lingard. We would also like to thank Heath Malcolm from CEH Edinburgh for providing Section 4 on the RoTAP report. Edit, layout, design and artwork by Jon Bower.