Scottish Air Quality Database Annual Report for 2009

A report to the Scottish Government

AEA

The Scottish Government

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	Date	01 September 2009

Executive summary

AEA was commissioned by The Scottish Government to undertake a 3-year project (Apr 2007 – Apr 2010) to develop an Air Quality Database and Website for Scotland. From April 2010, this contract was renewed for a further 2-years.

This report presents the activities undertaken during the third year of the project – April 2009 – April 2010. There has been considerable project activity during the year with major enhancements to the website, more new sites added to the database, inclusion of first routine $PM_{2.5}$ measurement data, links to emissions data both on the website and within this report, expansion of the pollution climate mapping work to produce maps, source apportionment and future year projection factors based solely on Scottish data and, support to the Scottish Government on the update of the Clean Air Act.

The database and website were launched on 2 April 2007. Continuous expansion and improvements have been undertaken since the launch and these will continue throughout the duration of the project. In particular, during 2009 there were new mobile web and low graphics versions of the web pages launched to make the database accessible to even more users. Development of a Know and Respond SMS Alert service and pages to forge closer links with the SEPA Scottish Pollutants Release Inventory are currently in progress.

All automatic data within the Scottish database are subject to the same QA/QC procedures as at the national network air quality monitoring stations within the UK Automatic Urban and Rural Network. This ensures that all data in the database are quality assured and are traceable to UK national calibration standards for the various pollutants.

At the end of 2009 the Scottish Air Quality Database contained data for a total of 79 automatic monitoring sites. In total, 22 new sites were incorporated into the database during 2009, but 5 of these replaced closed or relocated sites. Hence, the number of live sites in the database increased by 17 from 2008, which in turn was 15 more than in 2007.

A summary of ratified data for 2009 is provided. Where exceedences of the Scottish Air Quality Objectives occur then these are in areas where the relevant Local Authority has already declared, or is in the process of declaring, an Air Quality Management Area (AQMA). Where Air Quality Management Areas are declared then the Local Authority will produce an Air Quality Action Plan and undertake the necessary actions to move towards compliance with the Air Quality Objectives in the future. One additional AQMA was declared in Scotland during 2009.

$PM_{2.5}$ monitoring has now commenced throughout the UK following the requirements of the EU Directive. On-going monitoring of $PM_{2.5}$ is now undertaken at seven sites in Scotland and these data are included in the database and available on the website.

Also, this annual report contains a summary of data from a wider range of pollutants measured in Scotland as part of several national network monitoring programmes. As many of these monitoring networks rely on chemical analysis of samples collected, in some cases, the full dataset for 2009 is not yet available and data for 2008 are provided in this report.

This report also includes a summary of pollutant emissions data for Scotland. Data on emissions from all sources are available from the National Atmospheric Emissions Inventory and more detailed data on industrial emissions for Scotland are available from the Scottish Environmental Protection Agency Pollution Release Inventory.

As the number of monitoring sites in the database has increased it is now feasible to undertake pollution climate mapping of PM_{10} and NO_2 concentrations throughout Scotland, based on Scottish monitoring data and Scottish meteorological data. The pollution maps produced by this exercise are presented in this report.

In addition, a study last year showed that a key requirement for Scottish Local Authorities was the source apportionment and future year projection factors associated with the pollution map data.

Hence, for the first time, these have been calculated from the Scottish pollution maps using all available Scottish based data. Though these could not, unfortunately, be produced in time for use by the Scottish Local authorities for this year's Review and Assessment reports, now that the methodology has been developed, these data will be available for the reports next year.

Data within the database covering many years have been used to examine trends in air pollution throughout Scotland. Inevitably, the data from earlier years are based on only a few monitoring sites. However, as the number of monitoring sites within the database increases over time, then the reliability of the trend data will improve. For NOx, NO_2 and PM_{10} the plots show a continued reduction in concentrations averaged over all monitoring sites in Scotland. For NO_2, this is despite the accepted evidence of leveling-off in the reduction in concentration in recent years. However, this overall indicator may be affected by new sites joining the database and also, does not indicate that decreasing concentrations are seen at all sites.

As part of the SAQD contract during 2009, AEA has undertaken a review on behalf of Scottish Government to assess the Clean Air Act 1993. This review is prompted by the need to update the Clean Air Act so that it can become the effective legislative measure to ensure that the use of biomass combustion can be rolled out in a manner which takes full account of possible air quality issues associated with biomass burning. The report of this work has now been published.

The Scottish Air Quality website is available at www.scottishairquality.co.uk

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Appendices

1 Introduction

The Scottish Government undertakes considerable monitoring of a wide range of air pollutant species as part of joint national programmes run in conjunction with Defra, the Welsh Assembly Government and the Department of the Environment in Northern Ireland. In addition a large number of Local Authorities measure air quality as part of requirements of the Local Air Quality Review and Assessment process. Prior to 2006 air quality data in Scotland outside of the nationally operated sites were collected by a wide range of organisations for a number of purposes and were widely dispersed. Experience across the rest of the UK indicated that a comprehensive centralised resource providing air quality information for Scotland would serve to improve the quality of research and data analysis required to support and evaluate Scottish air quality policies. Hence, in 2006, The Scottish Government contracted AEA to undertake a pilot programme to develop an air quality database for Scotland.

The pilot study developed the initial database and website, undertook stakeholder feedback and assessed the air quality data available across Scotland. The results of this study are discussed in the Pilot Study Report[1]. The key recommendations that were developed from this initial study were based around the methodology for successful harmonisation of existing air quality monitoring data. It was suggested that a programme for Scotland should include:

- Independent audit of every site - to include checks on both the analysers and the site calibration cylinders
- Regular data checks
- Longer term data checking and adjustment where necessary.

Following this pilot study AEA were commissioned to undertake the next stage which was to further develop and extend the database and website incorporating all stakeholder comments and to bring selected Local Authority sites in line with the national QA/QC requirements.

The report of the first and second years[2,3] of the project, 2007 and 2008, are available on the website (www.scottishairquality.co.uk).

This is the third annual report of this project and summarises the progress made during 2009 in the on-going project tasks and also summarises the considerable new work undertaken during 2009. New activities in the project include:

- Improvements to the database and to website functionality including, mobile phone version, low graphics version and SMS text alert system (to be launched soon)
- Incorporation of routine $PM_{2.5}$ monitoring data
- Summarising of data from a wider range of pollutants within this report
- Links SEPA Pollution Release Inventory on the website
- Information on pollutant emissions in Scotland provided in this report
- Air quality mapping, source apportionment and forward year projection factors from Scottish data
- Advice on update of the Clean Air Act.

Chapter 2 provides information on significant enhancements to the website during 2009. These include the development of the low graphics website for users with dial up modem or slow broadband connections and a version of the website specifically tailored for access via mobile phones. A further development to provide SMS text alerts of forecast high pollution has been developed and will be launched shortly.

[1] Willis P. (2006). Pilot study for a Scottish air quality database – Final report. AEAT/ENV/R/2338/Issue 1
http://www.scottishairquality.co.uk/documents/reports/177070326_Pilot_Study_for_a_Scottish_Air_Quality_Database__Final.pdf

[2] Willis P et al. Scottish Air Quality Database Annual Report 2007. AEAT/ENV/R/2640 Issue 1
http://www.scottishairquality.co.uk/documents/reports2/207080626_Scottish_Air_Quality_2007_-_Final_Report_23-06-08.pdf

[3] Willis P et al Scottish Air Quality Database Annual Report 2008 AEAT/ENV/R/2812 Issue 1
http://www.scottishairquality.co.uk/documents/reports2/244090615_Scottish_Government_Annual_Air_Quality_Report_2008_Issue_1-1.pdf

The website also now contains links to the SEPA Scottish Pollution Release Inventory (SPRI) to provide information on industrial releases of pollutants in Scotland. This report also includes a new section on emissions in Scotland with data from both the National Atmospheric Emissions Inventory (NAEI) and the SEPA SPRI (**Chapter 9**).

The overall number of sites in the database has increased by a further 17 and the number of sites with data available for all or part of 2009 is now 79. The corresponding QA/QC programmes (**Chapter 5**) have expanded to encompass these additional sites. As in 2008, the PM_{10} data from TEOM analysers have been corrected using the Volatile Correction Model for all sites in Scotland. This has been undertaken on an hourly basis for 2009, compared to a daily basis in 2008. Summary statistics for all of the available data are provided in **Chapter 6**. This now includes data for $PM_{2.5}$ at seven monitoring sites in Scotland. In addition, this section has been expanded to include data on many additional pollutants monitored within Scotland as part of UK National Networks.

With the increased number of monitoring sites, pollution climate mapping of NOx, NO_2 and PM_{10} have, for the first time, been undertaken using solely Scottish measurement data. In addition, source apportionment and future year projection factors have been calculated specifically for Scotland. The Scottish pollution climate mapping work is described in **Chapter 7.**

Chapter 8 shows overall trends in pollutant concentrations throughout Scotland, based on all of the available data.

Finally, in **Chapter 10** we summarise an investigation undertaken in 2009, as part of the project, into how the Clean Air Act could be modified and updated to assist The Scottish Government and Local Authorities to further control air pollution and in particular to control emissions from proposed biomass boiler installations.

2 Database and Website

The national air quality 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.

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

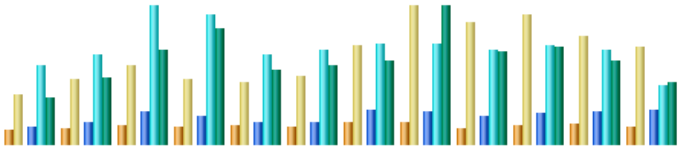
- Accurate and reliable
- Comprehensive
- User-friendly
- Easily navigable
- As interactive as possible
- Able to meet the needs of the general public as well as technical, local government and regulatory user communities.

Recent development work in 2009/10 has focussed on making the database more accessible through adding new or improved interfaces to the data. This has resulted from both user feedback and implementation of more up-to-date technologies.

General website and database activities for the past year will be described here, followed by some details of the upgrades which have been developed and launched.

2.1 Usage Statistics

Since its launch, usage of the website has been monitored through the on-line tracking tool awstats, the statistics can be accessed by clicking the following link - http://www.scottishairquality.co.uk/cgi-bin/awstats.pl. The software tool provides in-depth analysis of the time, date, location and access route of all those coming to the website (It does not store any personal information which would require declaring under the Data Protection Act). Figure 2.1 below illustrates how the number of hits varied during 2009.



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan	1066	3632	11450	51071	638.10 MB
Feb	1152	4789	14310	58665	893.70 MB
Mar	1395	5751	21210	90029	1.24 GB
Apr	1255	4771	18529	84086	1.53 GB
May	1370	4477	14086	58386	1013.30 MB
Jun	1293	4967	14038	61844	1.04 GB
Jul	1658	7167	22959	65622	1.10 GB
Aug	1661	10070	21342	65192	1.82 GB
Sep	1199	8883	18508	61481	1.23 GB
Oct	1451	9461	20585	64738	1.29 GB
Nov	1488	7942	21369	61815	1.10 GB
Dec	1248	7095	22584	38816	843.05 MB
Total	16236	79005	220970	761745	13.67 GB

Figure 2.1 Air Quality Scotland Website Hits 2009.

The hits will include some automated search engine visits which are required in order to keep the sites' rating on Google and Yahoo as high as possible. However, we have endeavoured as far as

possible to configure the site security and tracking software to exclude automated web crawlers which may be attempting to scan the site maliciously for personal information to be used in spamming.

Assuming that hits statistics are genuine, it can therefore be seen that the largest numbers of unique visitors to site were recorded in March, May, July, August, October and November 2009. The number of visitors per month varied between around 1000 and 1650, and it is not clear that the periods of maximum activity corresponded to any particular air quality events or publicity. Possible reasons for increased usage are:

- The annual cycle of local authority review and assessment activity in the spring each year.
- Release of website improvements in Autumn 2009.

The monthly activity is lower than the initial 3000 or more unique visitors just after the site launch, but is increasing year-on-year from the 500 visitors per month level recorded at the end of 2007. Usage is showing a reasonable level of activity similar in magnitude to usage statistics for the comparable air quality websites for Wales and Northern Ireland. We believe that this indicates the website is being used by an increasing core group who are active in using the full functionality of the pages.

Key users of the website include Local Authorities, The Scottish Government, SEPA, Universities, Health Professionals and the General Public.

2.2 Website Maintenance

On a daily basis the web pages are fully checked by the AEA web team, both manually and using a number of automated software systems, in order to ensure that the website is fully functional with no broken links

In addition to this a number of routine maintenance tasks are carried on a daily/weekly/monthly basis as required in order to keep the underlying database up-to-date and fully populated. These include:

- Updates to the national AURN sites are made as required (e.g. If new particulate monitoring instruments come on-line or other sites/instruments are changed.)
- New local authority monitoring sites are added to the database once agreement is reached with the operators.
- Site photos are added as soon as AEA carry out our QA/QC visits, or they are provided by the local authority.
- Ratified data (or any improved provisional data) load automatically to the website from AEA's data management software on a daily basis.
- Statistics are automatically recalculated every night:
    - Daily, Monthly & Annual Means etc.
    - All exceedence statistics
- The LAQM pages are automatically updated with any changes to the status of Local Authority Air Quality Management Areas.
- New technical guidance documents and reports (including local authority review and assessment reports) are added to the website when made available.
- The news section is updated with any relevant information provided by the Scottish Government or other website stakeholders.

We are pleased to report that thanks to the ongoing checks and maintenance the web pages were available for around 98% of the time during 2009 with no extended breakdowns or downtime reported.

2.3 Website Upgrades During 2009

A number of enhancements to the website were carried out in 2009, at the request of Scottish Government and the website users, in order to improve the appearance and functionality of the pages.

2.3.1 Introduction of a Low Graphics version of the Website

This was introduced in response to feedback that the website was becoming too graphics intensive, and therefore too slow to use for those with either dial-up or slow broadband access.

A review of the website content was therefore carried out and alternative displays for the most graphics intensive sections were introduced.

The low graphics version is accessed via a button in the top right-hand corner of the web pages, as illustrated in Figure 2.2 below. Figure 2.3 shows the alternative, low graphics version of the website home page.

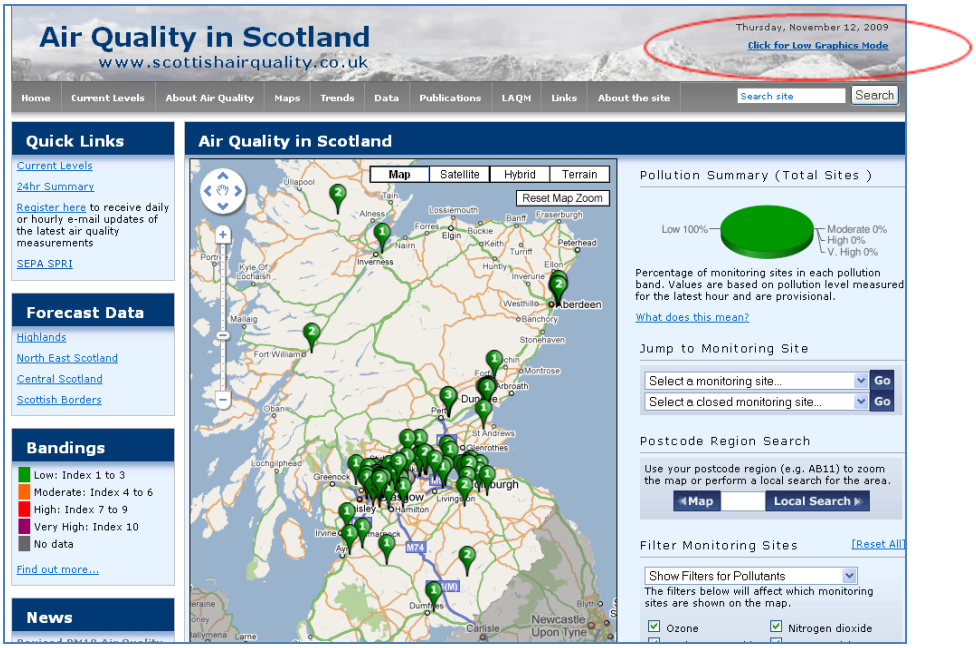


Figure 2.2 Link to low-graphics version of website.

Figure 2.3 Low-graphics version of home page.

2.3.2 Website for PDAs and Mobile Devices

In today's modern world people are constantly on the move and yet ever more demanding of information on the environment in which they are living. In order to meet this need Scottish Government commissioned a pilot study for mobile web services during 2009, and this was successfully introduced to the live website during the latter part of the year.

The specification was to provide the following:

- A simple graphical presentation of latest air pollution and the daily forecast for near you, searchable by postcode.
- Details of monitoring sites, including a Google Map and photo.
- Some general background information on air quality, health effects, local, regional and international sources of pollution.

Figure 2.4 shows the address of the mobile services and the introductory page on the main website

http://www.scottishairquality.co.uk/mobile-services.php

Figure 2.4 Introductory Page for Website Mobile Services..

The mobile pages were tested using a variety of real mobile phones and emulators during the pilot study period. There was no negative feedback so we can be reasonably confident that the pages will display correctly on any modern handset.

User statistics for the mobile pages are also tracked separately on the main Air Quality in Scotland website at:

- http://m.scottishairquality.co.uk/cgi-bin/awstats.pl

At the moment there seems to be a core group of around 200 – 300 users for this service per month. Hopefully as word spreads and with further publicity the usage of the mobile services aspect of the project will increase with time.

2.3.3 Know and Respond Air Quality Alerts

This is an SMS text alert service which will be launched shortly for the public and scientific community. It will enable people to register to be informed in near-real-time (free-of-charge in the UK) of any increases in pollutants above health alert threshold values.

During 2009 the information dissemination and sign-up systems were developed ready to be launched. Figure 2.5 below shows a draft of the sign up page which is currently being prepared for this service.

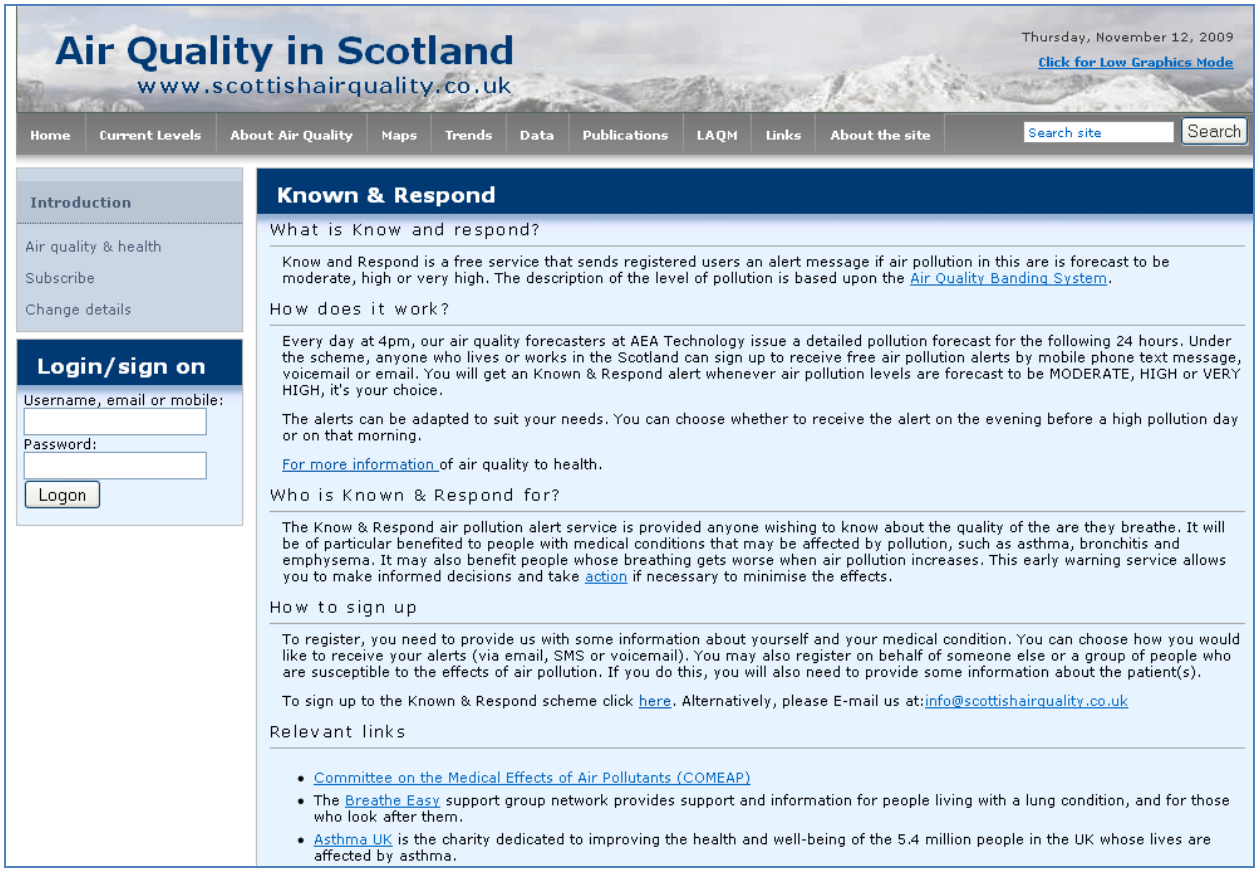


Figure 2.5 Initial Concept for Know and Respond Sign-Up page.

It is planned that the system will just hold peoples' contact details, not any confidential health-related information.

Plans for the roll-out of the service are currently being discussed with Health Protection Scotland for a mid-2010 launch.

2.4 Links to the Scottish Pollutants Release Inventory (SPRI)

Ambient air pollution measurements and industrial air pollutant emissions are often considered together when looking at the overall air pollution impact in a local area or region. Whilst there is often no direct link between the two it is helpful that the data from the two separate databases – SAQD and SPRI are closely linked so that the required data can be easily found if necessary.

During 2009 the first step in this process was to establish simple reciprocal links in highly visible areas of both websites – on the home page of Air Quality in Scotland.

In parallel, an interface to the air emissions data in the SPRI is being developed so that a simple summary of air emissions for each industrial installation will be available from the Air Quality Scotland website. If more detailed technical information is required then a link on the Air Quality Scotland website will take users directly into the records for the selected installation within the SPRI itself.

Figure 2.6 illustrates a draft design in progress for display of the SPRI air emissions data on the Air Quality Scotland website.

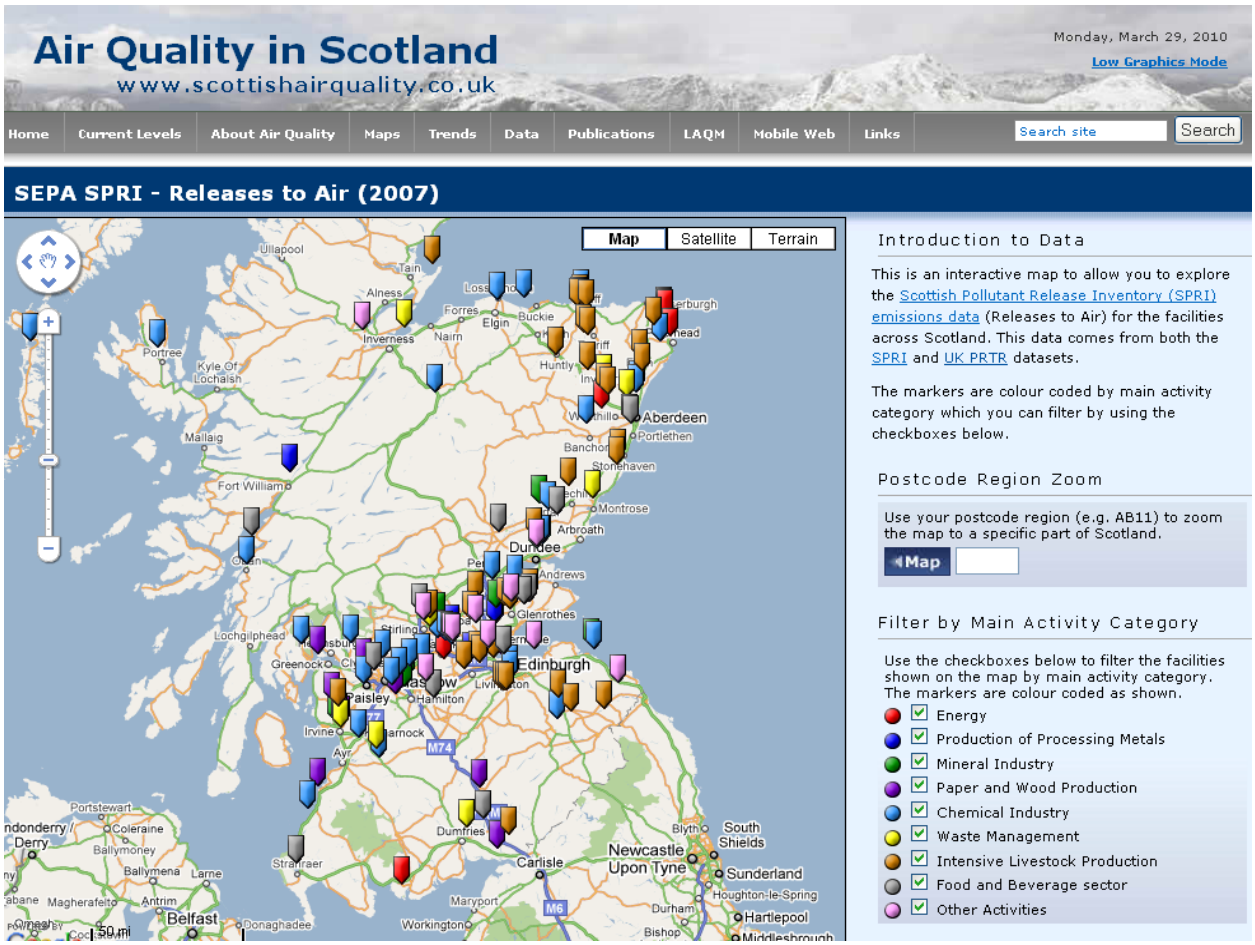


Figure 2.6 Draft interface to SPRI Air Emissions Data.

2.5 Website Developments Planned for 2010

For 2010 a number of further possible website developments are currently under consideration or in early stages of development. These include options to enhance both the statistical power of the database and the graphical user interface as follows:

- Additional automated e-mail alerts to cover exceedences of Air Quality Strategy Standards and Objectives, in addition to the existing alerts for High or Very High according to the Air Quality Bandings.
- Alerts to inform when new reports, news or website developments become available.
- Fun and informative pages on air quality and related issues suitable to be used for educational purposes.
- A technical discussion forum to enable local authorities and other organisations to communicate more effectively on queries relating to air pollution.

The specification and implementation of these options will be discussed and agreed with Scottish Government and the website stakeholders over the course of 2010.

3 Annual Air Quality Seminar and Newsletter

3.1 Scottish Air Quality Seminar

As part of the Scottish Air Quality Database project, AEA organise, on behalf of Scottish Government, an annual air quality seminar. The latest Scottish Government Annual Air Quality Seminar was held in Edinburgh on Tuesday 31 March 2010. The event was attended by over fifty air quality experts from a range of Local Authorities and other stakeholder groups in Scotland. The objective was to discuss the most recent work carried under the Scottish Air Quality Database and Website project, and to consider a number of other topical air quality issues for Scotland.

The latest progress on the QA/QC, website, mapping and trends elements of the project were presented by AEA. In addition, Alison Searl from IOM Edinburgh and Heath Malcolm from CEH Edinburgh provided presentations on health effects and ecological effects of air pollution respectively.

The agenda for the day is shown in Figure 3.1. All of the presentations from the seminar are available to download at http://www.scottishairquality.co.uk/reports.php?n_action=seminar .

3.2 Scottish Air Quality Newsletter

In addition to this report, a short annual newsletter (Air Pollution in Scotland[4]) is also produced as part of this project. The newsletter for 2009 was distributed at the Annual Seminar. This sets the legislative and policy background to air quality control in Scotland and briefly reviews available air quality monitoring and key results. Trends and mapping of air quality are also briefly presented and a list of website addresses for further information provided. For this years newsletter, CEH Edinburgh provided a short article on recently published consultation draft report – Review of Transboundary Air Pollution (RoTAP). Printed copies of the newsletter are available from Ken Stevenson ken.stevenson@aeat.co.uk (postal address is given at the start of this report). Electronic copies in pfd format are available at http://www.scottishairquality.co.uk/reports.php?n_action=report2 .

[4] Air Pollution in Scotland 2009
http://www.scottishairquality.co.uk/documents/reports2/281100426_Scottish_Newsletter_2009-vFF4_screenopt.pdf

The Scottish Government

AEA

Scottish Annual Air Quality Seminar 2010

Date Tuesday 30 March 2010

Time 10.30

Location Malmaison Hotel, Leith, Edinburgh

This seminar will provide an opportunity for local authorities and other stakeholders to discuss the latest air quality issues in Scotland and to find out about the progress of the Scottish Air Quality Database & Website project.

PROGRAMME

Chair – Ken Stevenson, AEA		
1. 10.30	Coffee and Registration	
2. 11.00 - 11.15	Welcome & Overview	Geeta Puri (SG)
3. 11.15 – 12.30	Scottish Air Quality Database Project: Overview and QA/QC AQ Mapping for Scotland AQ Trends and website update	 Ken Stevenson (AEA) Justin Lingard (AEA) Paul Willis (AEA)
LUNCH 12.30 – 13.30		
5. 13.30 – 14.00	The Effects of Air Pollution on the Environment: Conclusions of the Review of Transboundary Air Pollution (RoTAP)	Heath Malcolm (CEH - Edinburgh)
6. 14.00 – 14.30	Health benefits of LAQM	Alison Searl (IOM - Edinburgh)
TEA 14.30 – 14.45		
7. 14.45 – 15.05	Update on LAQM web based reporting	Paul Willis (AEA)
7. 15.05 – 15.25	Review of LAQM	Andrew Taylor (SG)
8. 15.25 – 15.45	Local Authority Feedback and Questions General Discussion	Chair
9. 15.45 – 16.00	Closing remarks	Geeta Puri (SG)

CLOSE 16.00

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AEA is a business name of AEA Technology plc

Figure 3.1 Agenda for the Scottish Air Quality Seminar on 31 March 2010

4 Data Availability in 2009

4.1 Hourly data for Nitrogen Dioxide, Carbon Monoxide, Sulphur Dioxide, Ozone, PM_{10} and $PM_{2.5}$

At the end of 2009 the Scottish Air Quality Database contained data for a total of 79 automatic monitoring sites. In total, 22 new sites were incorporated into the database during 2009, but 5 of these replaced closed or relocated sites. Hence, the number of live sites in the database increased by 17 from 2008, which in turn was 15 more than in 2007. This shows how the database has grown rapidly since its inception in 2006. Two of the new stations in 2009 are part of the AURN (Peebles and Grangemouth Moray) and the remaining 15 site are Local Authority sites adopted into the Scottish Database.

For the 17 National Network AURN monitoring stations in the Scottish Database the data are available from the commencement of these stations – which in some cases is as long ago as 1986. However, for Local Authority monitoring stations, data are only available from when the station joined the database project – though in many cases the stations commenced much earlier. These earlier data may be available from the relevant Local Authority.

Data availability for 2009, in terms of site, pollutants and months available, is summarised in Table 4.1. The full 12-figure OS grid reference and the site location classification are also provided for each site.

Table 4.1 also provides the start date for each site. However, not all pollutants are measured over the same period at all sites – measurements of some pollutants may commence or cease during the lifetime of monitoring at the particular site. The dates of availability of data for each pollutant measured at each site can be found by selecting the site on the Home page of www.scottishairquality.co.uk and then selecting the “site details” tab.

Also, some sites may join a network or change network during their lifetime and hence, earlier data from a site may be available elsewhere. At a small number of sites, different pollutants are in different networks. This is due to the differing requirements of specific networks.

The data from closed sites are available in the database for their period of operation.

Table 4.1 Scottish Air Quality Database Data Availability in 2009

Site Name	Type	East	North	Pollutants	Network	Start date#	Data in 2009
Aberdeen Anderson Drive	Roadside	392506	804186	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Aberdeen Errol Place	Urban Background	394416	807408	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	1999	Jan – Dec
Aberdeen King Street*	Roadside	394333	808770	NO_2 PM_{10}	SAQD	2008	Jan - Dec
Aberdeen Market Street 2*	Roadside	394535	805687	NO_2 PM_{10}	SAQD	2009	June – Dec
Aberdeen Union Street~	Roadside	393656	805967	NO_2	AURN	2008	Jan – Dec
				PM_{10}	SAQD	2005	
Aberdeen Wellington Road	Roadside	394395	804779	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Alloa*	Roadside	288750	693150	PM_{10}	SAQD	2006	Jan - Dec
Angus Forfar*	Roadside	345914	750613	PM_{10}	SAQD	2007	Jan - Dec
Auchencorth Moss	Rural	322050	656250	O_3 PM_{10} $PM_{2.5}$	AURN	2006	Jan – Dec
Bush Estate	Rural	324500	663500	NO_2 O_3	AURN	1986	Jan – Dec
Dumfries	Roadside	297012	576278	CO NO_2 PM_{10}	AURN	2001	Jan – Dec
Dundee Broughty Ferry Road	Roadside	341970	730997	PM10 SO_2	SAQD	2006	Jan – Dec
Dundee Lochee Road	Kerbside	338861	730773	NO_2	SAQD	2006	Jan – Dec
Dundee Mains Loan	Urban background	340972	731893	PM_{10}	SAQD	2006	Jan – Dec
Dundee Seagate	Kerbside	340487	730446	NO_2	SAQD	2006	Jan – Dec
Dundee Union Street	Kerbside	340236	730090	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Whitehall Street	Kerbside	340279	730155	NO_2	SAQD	2006	Jan – Dec
East Ayrshire Kilmarnock+	Urban Background	241810	638705	CO NO_2 PM_{10} SO_2	SAQD	2010	Jan - Jun
East Ayrshire New Cumnock*	Urban Background	261812	613503	NO_2 PM_{10}	SAQD	2009	Jan – Dec
East Dunbartonshire Bearsden	Kerbside	254269	672067	NO_2 PM_{10}	SAQD	2005	Jan – Dec
East Dunbartonshire Bishopbriggs	Roadside	260995	670130	NO_2 PM_{10}	SAQD	2003	Jan – Dec
East Dunbartonshire Kirkintilloch*	Roadside	265700,	673500	NO_2 PM_{10}	SAQD	2007	Jan – Dec
East Lothian Musselburgh N High St*	Roadside	333941	672836	PM_{10}	SAQD	2008	Jan - Dec
East Renfrewshire Sheddens*	Roadside	257455	657113	PM_{10}	SAQD	2008	Jan - Dec
Edinburgh Gorgie Rd*	Roadside	323121	672314	NO_2	SAQD	2005	Jan - Dec
Edinburgh Queen St*	Roadside	324890	674100	NO_2 PM_{10}	SAQD	2007	Jan - Dec
Edinburgh Roseburn	Roadside	322939	673233	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Edinburgh Salamander St*	Roadside	327605	676344	NO_2 PM_{10}	SAQD	2009	Sept - Dec
Edinburgh St John's Road	Kerbside	320100	672890	NO_2	SAQD	2007	Jan – Dec
Edinburgh St Leonards~	Urban background	326200	673200	CO NO_2 O_3 $PM_{2.5}$ SO_2	AURN	2003	Jan – Dec
				PM_{10}	SAQD	2003	
Eskdalemuir	Rural	323500	602800	NO_2 O_3	AURN	1986	Jan – Dec
Falkirk Grangemouth MC	Urban background	292816	682009	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Dec
Falkirk Haggs*	Roadside	278977	679271	NO_2	SAQD	2009	Jan - Dec
Falkirk Hope Street	Roadside	288688	680218	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Dec
Falkirk Park Street	Roadside	288892	680070	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Dec
Falkirk West Bridge St*	Roadside	288457	680064	NO_2 PM_{10}	SAQD	2007	NO_2 Jan – Dec PM_{10} Sep - Dec
Fife Cupar	Kerbside	337401	714572	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Fife Dunfermline	Roadside	309910	687745	NO_2	SAQD	2007	Jan – Dec
Fife Rosyth	Roadside	311752	683515	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Fort William	Suburban	210849	774421	NO_2 O_3	AURN	2006	Jan – Dec
Glasgow Abercromby Street	Roadside	260420	664175	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Anderston	Urban background	257925	665487	CO NO_2 PM_{10} SO_2	SAQD	2005	Jan – Dec
Glasgow Battlefield Road	Roadside	258417	661385	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Broomhill	Roadside	255030	667195	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Byres Road	Roadside	256553	665487	CO NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Centre	Urban centre	258902	665028	CO NO_2 O_3 PM_{10} $PM_{2.5}$ SO_2	AURN	1996	Jan – Dec
Glasgow City Chambers	Urban background	259528	665308	CO NO_2	AURN	1987	Jan – Dec
Glasgow Kerbside	Kerbside	258708	665200	CO NO_2 PM_{10} $PM_{2.5}$	AURN	1997	Jan – Dec
Glasgow Nithsdale Road	Roadside	257883	662673	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Waulkmillglen Reservoir	Rural	252520	658095	NO_2 O_3 PM_{10}	SAQD	2005	Jan – Dec

Site Name	Type	East	North	Pollutants	Network	Start date#	Data in 2009
Grangemouth	Urban industrial	293840	681032	CO NO_2 PM_{10} $PM_{2.5}$ SO_2	AURN	2001	Jan – Dec
Grangemouth Moray*~	Urban Background	296436	681344	NO_2 PM_{10}	AURN	2009	NO_2 June – Dec PM_{10},SO_2 Jan – Dec
				SO_2	SAQD	2007	
Inverness	Roadside	265720	845680	CO NO_2 PM_{10} $PM_{2.5}$	AURN	2001	Jan – Dec
Lerwick	Rural	445337	1139683	O_3	AURN	2005	Jan – Dec
Lerwick Staney Hill*	Urban Background	446562	1142361	NO_2 SO_2	SAQD	2008	Jan - Dec
Midlothian Dalkeith	Kerbside	333159	667305	NO_2 SO_2 PM_{10}	SAQD	2008	Jan – Dec
Midlothian Pathhead	Kerbside	339558	664230	SO_2 PM_{10}	SAQD	2008	Jan – Dec
N Lanarkshire Chapelhall	Roadside	278174	663124	NO_2 PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Coatbridge Whifflet	Urban background	273668	663938	NO_2 PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Croy	Roadside	272775	675738	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Dec
N. Lanarkshire Harthill West*	Urban background	287480	663810	CO NO_2 PM_{10} SO_2	SAQD	2009	Apr – Dec
N. Lanarkshire Moodiesburn*	Roadside	269929	670386	NO_2 PM_{10}	SAQD	2008	Jan - Dec
N. Lanarkshire Motherwell*	Roadside	275460	656785	PM_{10}	SAQD	2007	Jan - Dec
N. Lanarkshire Shawhead Coatbridge*	Roadside	273411	662997	NO_2 PM_{10}	SAQD	2009	June - Dec
North Ayrshire Irvine High St*	Kerbside	232142	638892	NO_2 PM_{10}	SAQD	2009	Feb - Dec
Paisley Central Road	Roadside	248445	664191	NO_2	SAQD	2004	Jan – Dec
Paisley Glasgow Airport	Airport	248294	666533	NO_2	SAQD	2004	Jan – Dec
Paisley Gordon Street	Roadside	248316	663615	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Peebles*	Suburban	324812	641083	NO_2,O_3	AURN	2009	Nov - Dec
Perth Atholl Street	Roadside	311688	723625	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Perth High Street	Roadside	311582	723931	NO_2 PM_{10}	SAQD	2003	Jan – Dec
South Ayrshire Ayr High St	Roadside	233725	622120	NO_2 PM_{10}	SAQD	2007	Jan _ Dec
South Ayrshire Tarbolton*	Roadside	243096	626948	NO_2 PM_{10}	SAQD	2007	Jan - Dec
South Lanarkshire East Kilbride	Roadside	264390	655658	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Stirling Craig's Roundabout*	Roadside	279955	693012	NO_2 PM_{10}	SAQD	2009	Jan - Dec
Strath Vaich	Remote	234829	874785	O_3	AURN	1987	Jan – Dec
West Dunbartonshire Clydebank	Roadside	249724	672042	NO_2 PM_{10}	SAQD	2007	Jan - Dec
West Dunbartonshire Glasgow Road	Roadside	240236	675195	NO_2	SAQD	2007	Jan - Dec
West Lothian Broxburn	Roadside	308364	672248	NO_2 PM_{10}	SAQD	2008	Jan – Dec
West Lothian Linlithgow	Roadside	299926	677087	NO_2 PM_{10}	SAQD	2008	Jan – Dec
West Lothian Uphall+	Roadside	306219	670160	NO_2 PM_{10}	SAQD	2008	Jan - Nov

* Sites added to database in 2009
+ Sites closed during 2009
# This is the date of the site joining the network. Data for some pollutants may not be available from this date. Also, data for some pollutants may be available from earlier dates from the Local Authority other networks. The period of availability for data for each pollutant measured at each site can be seen on www.scottishairquality.co.uk by selecting the site and the "site details" tab.
~ At these sites, some pollutants are in the AURN network and some pollutants are in the SAQD Network.

Note also that the monitoring site at Edinburgh Haymarket closed in Jan 2009 and hence is not included in this report.

Data summaries for all of these monitoring sites are provided on a pollutant-by-pollutant basis in Section 6.1

4.2 Volatile Correction Model for PM_{10}

4.2.1 Background

The EU Directive on Ambient Air Quality[5] and the UK Air Quality Strategy[6] set targets and limit values for PM_{10} concentrations in terms of gravimetric measurements referenced to the EU reference method

[5] *Directive 2008/50/EC Of The European Parliament and of The Council 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

of measurement (EN 12341). It has long been recognized that PM_{10} measurements made with many automatic PM_{10} monitors are not equivalent to the EU reference method. However, these analysers are widely used since they provide hourly resolved data and have many operational advantages over the manual reference method. Hence, correction factors, most noticeably the 1.3 correction factor for the TEOM analyser, have been widely used for many years. In setting the value of 1.3 as a correction factor, it was recognized that this was a conservative factor and that TEOMx1.3 data were likely to overestimate PM_{10} concentrations. In Scotland, a lower correction factor of 1.14, which was based on intercomparison data obtained in Edinburgh, has also been widely used.

The results of the formal UK PM_{10} Equivalence Study[7] carried out in 2006, showed that data from the TEOM could not be considered as equivalent to the EU reference method, whether or not a correction factor was used. The reason for this is that the TEOM heats the filter used to collect PM_{10} to 50°C in order to eliminate the possible interference from water vapour – this heating also removes some of the more volatile components of the particulate matter.

In the new modification to the TEOM – the FDMS TEOM, the volatile fraction of PM_{10} is measured separately and used to correct the data in order to obtain results that are equivalent to the EU reference method. The equivalence of the FDMS TEOM analyzer to the EU reference method was confirmed in the UK Equivalence study. Note that this study also showed that a number of other PM_{10} analysers could also provide data equivalent to the EU reference method - Partisol 2025, FDMS Model B, Opsis SM200 Beta Attenuation Monitor (BAM), Opsis SM200 sampler (with slope and intercept correction) and the Met One BAM (with slope correction).

King's College London (KCL) have developed a relationship utilising FDMS purge (volatile PM_{10}) measurements to correct data from nearby TEOM analysers. These corrected data were tested for equivalence with the EU reference method and shown to pass the appropriate criteria. Since then, as additional FDMS data have become available throughout the UK, the geographic range of the model has been extended and on-going tests have shown that any TEOM located within 130km of an FDMS TEOM can be corrected with data from that analyzer.

KCL have now developed a user-friendly web portal http://www.volatile-correction-model.info/Default.aspx), to enable the model to be applied in a straightforward step-by-step approach. The model enables the user to input daily or hourly-average pressure, temperature measurements and purge measurements (volatile measurements) from Filter Dynamics Measurement System (FDMS) analysers. The measured volatile fraction is then added to the TEOM measurements giving the corrected data.

4.2.2 Use of the VCM in Scotland

The VCM correction of Scottish PM_{10} data was first undertaken for the 2008 dataset. As the VCM method was relatively new and, hourly meteorological data for pressure were not readily available, the corrections were undertaken on a daily, rather than hourly basis. These corrected data were provided to the Local Authorities and made available on the Scottish Air Quality website as a separate data spreadsheet.

However, additional refinement of the VCM model has been undertaken and hourly meteorological data for all parameters has been sourced and hence, VCM correction of the 2009 dataset has been undertaken on an hourly basis. This also brings into line the processing of the Scottish Local Authority data with that of the AURN.

The TEOM measurements are recorded with an inbuilt correction factors of 1.03x+3 (where x is the raw TEOM measurement) as mandated by the US Environmental Protection Agency, This is first removed and the data are then corrected to ambient pressure and temperature (as required by the EU Directive) using meteorological data from met monitoring sites within 260 km of the TEOM.

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[6] *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007. CM 7169* http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/6116

[7] *UK Equivalence Programme for Monitoring of Particulate Matter. David Harrison Bureau Veritas UK Ltd. June 2006 (BV/AQ/AD202209/DH/2396)* http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf

Data from FDMS analysers within 130km of the TEOM are then used to provide an estimate of the volatile particle concentration at the TEOM location. This estimated volatile fraction is then added back onto the TEOM measurements to give Gravimetric Equivalent mass concentrations.

The following data were used as inputs to the VCM:

- Hourly average temperatures (°C)
- Hourly average pressures (mbar)
- Hourly average TEOM concentrations ($\mu g\ m^{-3}$)
- Hourly average FDMS purge concentrations ($\mu g\ m^{-3}$)

Hourly average temperatures from Edinburgh Airport and pressures measurements from Edinburgh Gogarbank meteorological monitoring stations were used in the model. These sites were selected as a good representation of the weather in the central belt of Scotland and are also located approximately 150 km from Aberdeen, which is within the specified 260 km limit.

Hourly average purge measurements from all Scottish FDMS monitoring sites within the Scottish Government network (SAQD) and the national network (AURN) were used for the correction. Table 4.2 lists the sites used for correcting hourly TEOM data from Central Scotland and Aberdeen. A total of 4 FDMS sites were used for correcting Aberdeen TEOM data and 24 FDMS sites used for correcting data from TEOM sites located in the central belt of Scotland.

Any outliers in the FDMS purge measurements were identified using Grubbs' Test[8] on daily average data. All hourly data within a day identified as an outlier were then removed from the data set and the average of each hourly purge measurement from the FDMS sites was calculated and used in the VCM calculations.

Table 4.2 FDMS Monitoring Sites used in VCM Correcting TEOM Data from Aberdeen and Central Scotland Monitoring Sites

TEOM Locations	FDMS Sites used in VCM	Monitoring Network
Aberdeen	Aberdeen PM_{10}	AURN
	Aberdeen $PM_{2.5}$	AURN
	Angus Forfar	SAQD
	Fife Cupar	SAQD
Central Scotland	Angus Forfar	SAQD
	Auchencorth Moss PM_{10}	AURN
	Auchencorth Moss $PM_{2.5}$	AURN
	East Dunbartonshire Kirkintilloch	SAQD
	East Renfrewshire Sheddens	SAQD
	Edinburgh PM_{10}	AURN
	Edinburgh $PM_{2.5}$	AURN
	Fife Cupar	SAQD
	Fife Rosyth	SAQD
	Glasgow Abercromby	SAQD
	Glasgow Broomhill	SAQD
	Glasgow Centre PM_{10}	AURN
	Glasgow Centre $PM_{2.5}$	AURN
	Glasgow Kerbside PM_{10}	AURN
	Glasgow Kerbside $PM_{2.5}$	AURN
	Glasgow Nithsdale Road	SAQD
	Grangemouth PM_{10}	AURN
	Grangemouth $PM_{2.5}$	AURN
	Paisley Gordon St	SAQD
	S. Lanarkshire East Kilbride	SAQD
	W. Dunbartonshire Clydebank	SAQD
	W. Lothian Broxburn	SAQD
	W. Lothian Linlithgow	SAQD
	W. Lothian Uphall	SAQD

[8] Grubbs' Test is a statistical method for identifying outliers within a dataset. For more information visit the Engineering Statistics Handbook at: http://www.itl.nist.gov/div898/handbook/eda/section3/eda35h.htm

The corrected data for 2009 and calculated summary statistics have been provided to the local authorities. If a PM_{10} analyser was upgraded to an FDMS from a TEOM during 2009, the statistics quoted are calculated using the combination of VCM corrected data and FDMS data. AEA are in the process of modifying the website database so that all VCM corrected data are available on the SAQD website via an additional selection option in the data download pages.

A flow chart showing the overall process employed for VCM correction of 2009 SAQD TEOM data is shown in Figure 4.1. The monitoring sites where VCM correction of PM_{10} data have been undertaken for all or part of the year are indicated in Table 6.2.

However, note that it is not possible to correct historical data with the VCM as measurements of volatile particle concentrations are not available prior to 2008.

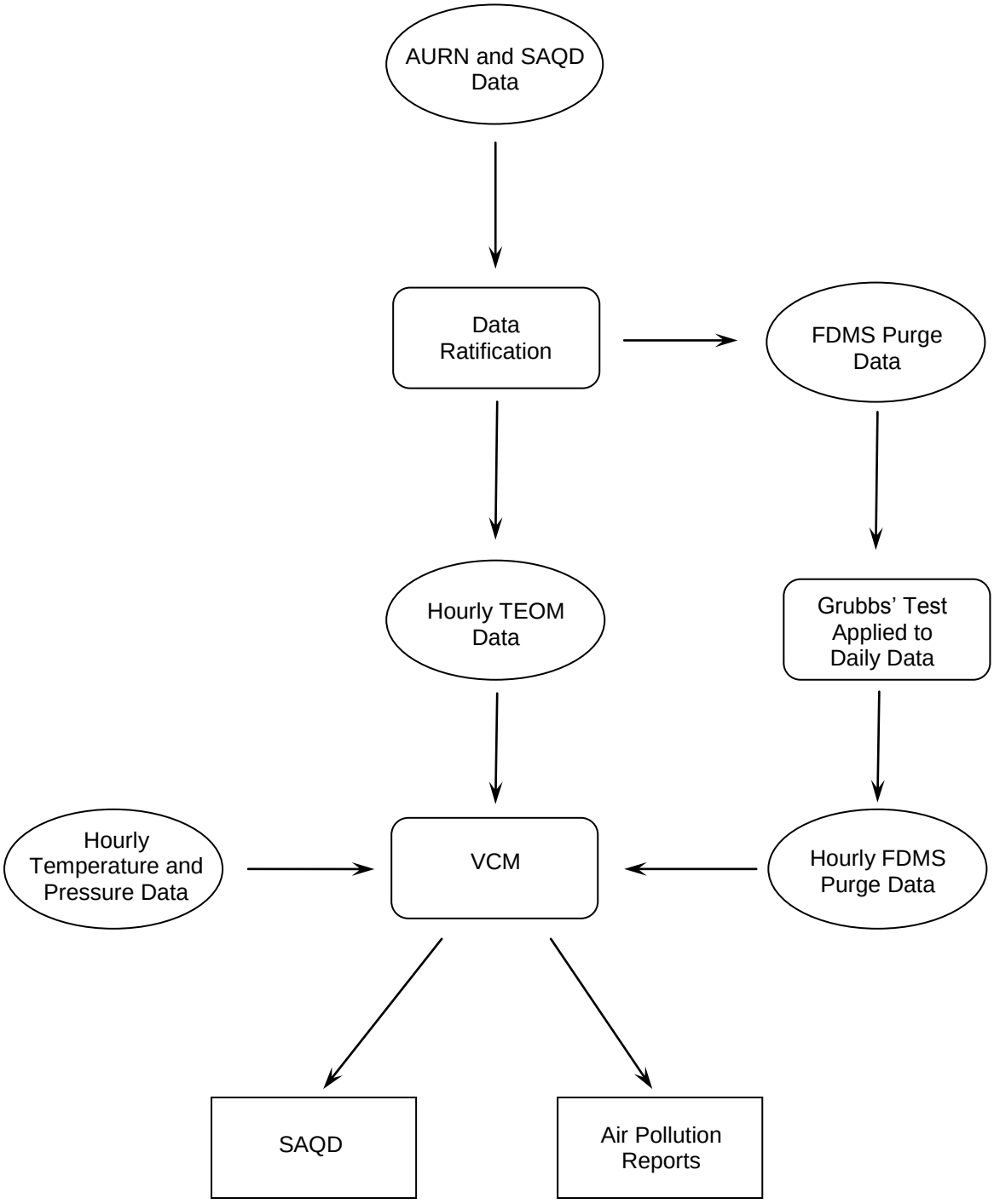


Figure 4.1 Process used for VCM Correction of SAQD TEOM Data

4.3 National Network Monitoring for other pollutants in Scotland

In addition to the 17 UK National Network AURN monitoring sites in Scotland, a number of other pollutants are monitored within other national networks:

- UK Automatic Hydrocarbon Monitoring Networks – 2 sites
- PAH Monitoring Network – 4 sites
- Heavy Metals Monitoring Networks – 4 sites
- Acid Deposition Network – 11 sites
- Ammonia and Nitric Acid Monitoring Network – 28 sites

Details of these sites are presented in Appendix 1. It has not been possible to load all of these data onto the Scottish database, but as the database develops, these data will be loaded, or links provided to other locations and hence, the database will become a consolidation of air quality data from a wide variety of sources. Data will then be available from one easily accessible web portal. In this report, we summarise the data available for Air Quality Strategy pollutants from these networks. For non- Air Quality Strategy pollutants, we highlight what species are monitored and where the data can be obtained.

4.4 NO_2 Monitoring with Diffusion tube samplers

Monitoring of nitrogen dioxide (NO_2) with diffusion tube samplers is undertaken widely throughout Scotland.

Nitrogen Dioxide (NO_2) diffusion tube samplers measure periodic (typically monthly) concentrations of nitrogen dioxide. 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 are generally used to complement detailed measurements made at automatic monitoring sites or, in circumstances where hourly measurements from automatic analysers are not required. Many Local Authorities have large networks of diffusion tubes samplers to assist with identifying any areas where the Objective for NO_2 is exceeded for the purpose of Local Air Quality Management (LAQM). Although there is no longer a national monitoring network based upon NO_2 diffusion tubes, the Scottish Government continues to provide a central web-based NO_2 diffusion tube data collation facility, together with QA/QC support for this monitoring[9], [10].

Available data from these networks are summarised in Section 6.3.1

In addition, CEH Edinburgh operate a network of rural NO_2 diffusion tube sampler sites and data for these sites are summarised in Section 6.3.7.

[9] Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance
http://www.airquality.co.uk/reports/cat05/0802141004_NO2_WG_PracticalGuidance_Issue1a.pdf
[10] NO_2 Diffusion Tubes for LAQM: Guidance Note
for Local Authorities
http://www.airquality.co.uk/reports/cat13/0604061218_Diffusion_Tube_GN_approved.pdf

5 QA/QC of the Scottish Database

In order that all data within the Scottish Air Quality Database are harmonised to the same quality standard, the QA/QC procedures adopted within the UK Automatic and Rural Network (AURN) are provided for all Local Authority sites within the database.

The main elements of the QA/QC programme are on-site analyser and calibration gas intercalibrations every 6-months, daily automatic data collection and validation and data ratification in 6-monthly blocks.

5.1 On-site analyser and calibrations gas audits

The automatic air quality monitoring stations located throughout Scotland employ a wide variety of different analyser types and site infrastructure. Intercalibration of the stations provides essential input to the data management process, to ensure that data across Scotland are harmonised, consistent in quality and traceable to a recognised gas calibration standard.

Monitoring station audits evaluate analysers to obtain an assessment of their performance level on the date of test. This information, in conjunction with the full analyser data set and additional calibration and service records, helps ensure data quality specifications have been met during the preceding data period.

The assessment of the on-site calibration cylinder concentrations against accredited and traceable AEA gas standard cylinders provides the essential final link in the measurement traceability chain (Fig 5.1). This process ensures that all monitoring stations in Scotland are traceable to reference gas standards held at AEA. These in turn are traceable to UK national reference standard gases held by the National Physical Laboratory who, in turn regularly intercompare these standards internationally. AEA also participate in EU level intercomparisons at the EU Joint Research Centre at Ispra, Italy. Hence, there is an unbroken traceability chain from each monitoring site in Scotland to internationally agreed gas calibration standards. This check also identifies any unstable gas cylinders which may need to be recertified or discarded.

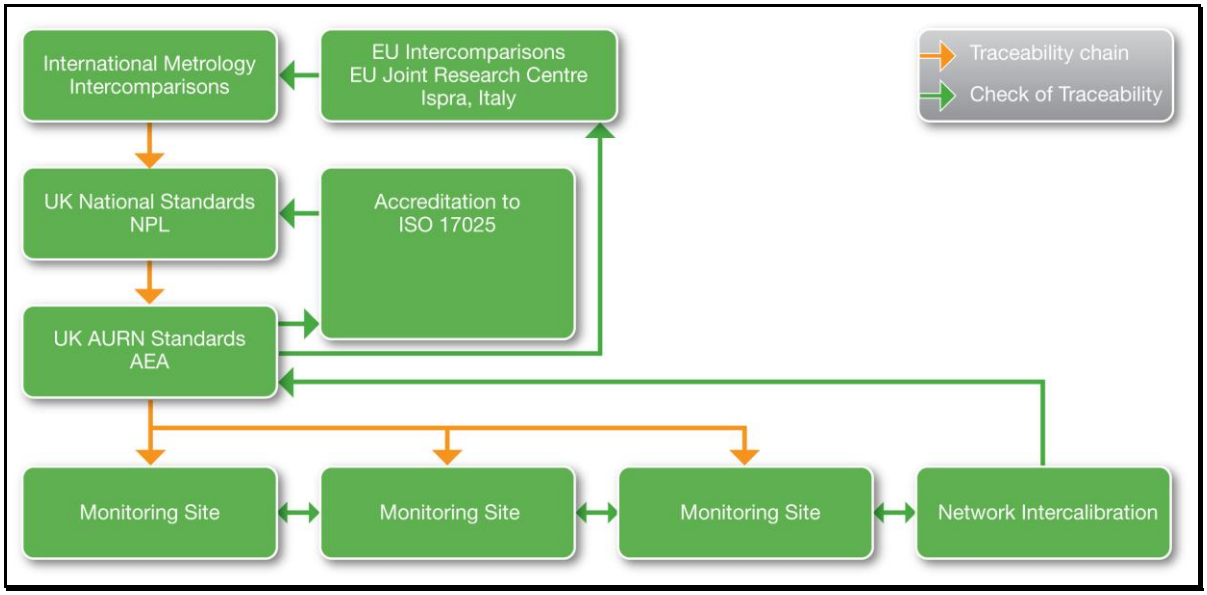


Figure 5.1 Traceability chain for the SAQD monitoring stations

The aims and objectives of the audit and intercalibration exercise can be summarised as follows:

- Ensure the correct operation of analysers at each monitoring station
- Ensure harmonisation of data throughout the network (i.e. that a NO_X analyser at one station measuring 40μgm^{-3} of NO_2 would also measure 40μgm^{-3} of NO_2 at any other site)

- Ensure traceability of all stations in the network to national and international standards
- Provide information on any necessary adjustments to data into the ratification process
- Report any faults found to the site operator.

Detailed audit procedures are provided in Appendix 2.

5.2 Data Management

The following sections describe the data management package applied to the data from the Scottish Local Authority monitoring stations. This is the same data management package, using the same data ratification procedures, that is applied to the AURN network stations across the UK.

The process includes the following tasks:
- Data acquisition
- Data validation
- Ratification

The data acquisition and management system consists of a central computer and telemetry facility that has been developed by AEA specifically for the UK's air quality monitoring programmes. The database used in this system is backed-up on a 24-hour basis to independent network servers to ensure data security.

A wide range of data management activities are routinely performed and these are integrated into the streamlined automatic data management system. Data are retrieved automatically from the Scottish air quality monitoring stations (*data acquisition*). The data are then rapidly processed by applying the latest available calibration factors (*data scaling*) and carefully screened using specifically developed computer algorithms to identify suspect data or equipment faults (*data validation*). These validated data are then appended to the site database and uploaded to the Scottish Database and Website. These operations are carried out automatically by computer systems, with all output manually checked by data management experts.

The validated data are then updated to the Scottish Air Quality Database – and accessible via the web - as provisional data. These data are therefore available to all users on a day-to-day basis. This gives the Local Authority the opportunity to easily view both their own data and data from other stations throughout Scotland. This will assist in dealing with day-to-day requests for information on specific data or the overall pollution situation either locally or throughout Scotland. In particular the automatic data summary bulletin, available by email from the website, and the plotting package incorporated into this, will be useful to authorities to rapidly evaluate their data against that from other stations.

5.3 Data Ratification

The validated data, which have been screened and scaled, are fit for day-to-day use and provide a good indication of pollution levels. However, the final stage of data management is a comprehensive and detailed critical review of the data and is generally termed 'ratification'. Note that ratification necessarily includes the results from the site audits and intercalibrations – ratified data must be shown to be traceable to national gas standards.

The aim of data ratification is to make use of all of the available information to identify and remove any faulty data, ensuring that remaining measurement data meet the accuracy and precision specifications of the Scottish Government for Detailed Review and Assessment (LAQM.TG(09)).

The policy on data rejection opted by AEA is that all data are assumed to be correct unless there is good evidence to suggest otherwise. This prevents the ratification process from erroneously removing any important air pollution episode data.

The ratification process is comprehensive and is outlined step-by-step in Appendix 2.

Data ratification of the Scottish Local Authority station data is undertaken on a 6-monthly basis, based on calendar year timetables (January through to December). The process of ratification can take up to six weeks - we therefore aim to have the finalised datasets from all network sites ready by 31 March of

the following year. This fits well with the timetable for Local Authority reporting under the Review and Assessment process.

The ratified data are uploaded to the Scottish Database and overwrite the provisional data. Summary statistics of these ratified data are available from the website to assist Local Authorities complete their Air Quality Review and Assessment reports.

5.4 QA/QC during 2009

5.4.1 Site intercalibrations and audits

As discussed above, site intercalibrations and audit visits are undertaken at 6-monthly intervals. However, where a site joins the database part way through a year then it is possible that only one audit will be conducted during the year. Table 5.2 shows the full list of intercalibrations and audits undertaken on air quality sites in the Scottish Database during 2009.

The majority of analysers and sites were found to be operating satisfactorily during the audits. However, inevitably some problems were identified at some sites, these are summarised in Table 5.1.

Table 5.1 Monitoring Site faults Identified during the 2009 Audits

Fault	Number of Monitoring Sites
FDMS* pump vacuum <21”Hg	3
TEOM** and TEOM FDMS k_0 out by > 2.5%	10 (mostly marginal)
TEOM and TEOM FDMS flow out by >10%	14
NO cylinder out by >10%	8
NO_x analyser converter <95% efficiency	1
SO_2 cylinder out by >10%	1

* Filter Dynamics Measurement System
** Tapered Element Oscillating Microbalance

These are all typical faults that are found during audit and intercalibration exercises. In general, the encouraging trend for fewer faults to be found continues. The likely reason for more TEOM FDMS faults identified this year is that there has been numerous new or upgraded units installed during the year and these results represent the first audits of these analysers. At some sites where there have been on-going problems with contamination of cylinders permanently connected to auto calibration systems, we have recommended that the Teflon tubing used for the auto-calibration plumbing is replaced with stainless steel.

One site fault was identified during data ratification. Examination of the daily pollution profile showed that the site logger clock was set 12 hours out. This has now been corrected and the correct time allocated to data already collected.

In many cases, the results from the audit and intercalibration visits provide the information necessary to correct for these issues at the data ratification stage so that the data can be corrected and retained, rather than being deleted as erroneous data.

Table 5.2 summarises the site intercalibrations and audits undertaken during 2009.

Table 5.2 Air Quality Site Intercalibration and Audits Conducted During 2009

Site	Summer 09	Winter 09/10		Site	Summer 09	Winter 09/10
Aberdeen Anderson Dr	✓	✓		Glasgow Abercromby	✓	✓
Aberdeen Errol Place	✓	✓		Glasgow Anderston	✓	✓
Aberdeen Kings Road	Site Started Feb 09	✓		Glasgow Battlefield Road	✓	✓
Aberdeen Market St 2	Site Started Jun 09	✓		Glasgow Broomhill	✓	✓
Aberdeen Union St	✓	✓		Glasgow Byres Road	✓	✓
Aberdeen Wellington Road	✓	✓		Glasgow Centre	✓	✓
Alloa	Site in SAQD Oct 09			Glasgow City Chambers	✓	✓
Angus Forfar	✓	✓		Glasgow Kerbside	✓	✓
Auchencorth Moss	✓	✓		Glasgow Nithsdale Dr	✓	✓
Bush Estate	✓	✓		Glasgow Waulkmillglen Reservoir	✓	✓
Dumfries	✓	✓		Grangemouth	✓	✓
Dundee Broughty Ferry Road	✓	✓		Grangemouth Moray	✓	✓
Dundee Lochee Road	✓	✓		Inverness	✓	✓
Dundee Mains Loan	✓	✓		Lerwick	✓	✓
Dundee Seagate	✓	✓		Lerwick Staney Hill	Site Started Dec 08	✓
Dundee Union Street	✓	✓		Midlothian Dalkieth	✓	✓
Dundee Whitehall Street	✓	✓		Midlothian Pathhead	✓	✓
East Ayrshire New Cumnock	Site Started Feb 09	✓		North Lanarkshire Chapelhall	✓	✓
East Dunbartonshire Bearsden Cross	✓	✓		North Lanarkshire Coatbridge Whifflet	✓	✓
East Dunbartonshire Bishopbriggs Cross	✓	✓		North Lanarkshire Croy	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓		North Lanarkshire Harthill West	Site Started Jun 09	✓
East Lothian Musselburgh	✓	✓		North Lanarkshire Moodiesburn	Site Started Oct 08	✓
East Renfrewshire Sheddons	✓	✓		North Lanarkshire Motherwell	✓	✓
Edinburgh Gorgie Road	✓	✓		North Lanarkshire Shawhead Coatbridge	Site Started May 09	✓
Edinburgh Haymarket	Site Closed Jan 09			North Ayrshire Irvine	Site Started Feb 09	✓
Edinburgh Queen St	✓	✓		Paisley Central Road	✓	Site suspended Oct 09
Edinburgh Roseburn	✓	✓		Paisley Glasgow Airport	✓	✓
Edinburgh Salamander St	Site Started Oct 09			Paisley Gordon Street	✓	✓
Edinburgh St Johns Road	✓	✓		Peebles	Site started Nov 09	
Edinburgh St Leonards	✓	✓		Perth 2 (Atholl St)	✓	✓
Eskdalemuir	✓	✓		Perth (High St)	✓	✓
Falkirk Grangemouth Municipal Centre	✓	✓		South Ayrshire Ayr High Street	✓	✓
Falkirk Haggs	Site Started Jan 09	✓		South Ayrshire Tarbolton	Site Started Jan 09	✓
Falkirk Hope St	✓	✓		South Lanarkshire East Kilbride	✓	✓
Falkirk Park St	✓	✓		Stirling Craig's Roundabout		Site in SAQD Oct 09
Falkirk West Bridge Street	Site Started Jan 09	✓		Strath Vaich	✓	✓
Fife Cupar	✓	✓		West Dunbartonshire Clydebank	✓	✓
Fife Dunfermline	✓	✓		West Dunbartonshire Glasgow Road	✓	✓
Fife Rosyth	✓	✓		West Lothian Broxburn	✓	✓
Fort William	✓	✓		West Lothian Linlithgow	✓	✓
				West Lothian Uphall	✓	Site relocated to Whitburn Nov 09

5.4.2 Data ratification

Data ratification is undertaken on 6-month data blocks at 6-monthly intervals. Hence, as with the intercalibrations and audits, if the site joins the database part way through a year then data can only be ratified from the date of the site joining the database.

All ratified data for 2009 have now been uploaded to the Scottish Air Quality website.

Table 5.3 summarises the ratification undertaken during 2009.

Table 5.3 Data Ratification undertaken during 2009

Site	Jan - June 2009	July - Dec 2009		Site	Jan - June 2009	July - Dec 2009
Aberdeen Anderson Dr	✓	✓		Glasgow Abercromby	✓	✓
Aberdeen Errol Place	✓	✓		Glasgow Anderston	✓	✓
Aberdeen Kings Road	Site Started Feb 09	✓		Glasgow Battlefield Road	✓	✓
Aberdeen Market St 2	Site Started Jun 09	✓		Glasgow Broomhill	✓	✓
Aberdeen Union St	✓	✓		Glasgow Byres Road	✓	✓
Aberdeen Wellington Road	✓	✓		Glasgow Centre	✓	✓
Alloa	Site in SAQD Oct 09			Glasgow City Chambers	✓	✓
Angus Forfar	✓	✓		Glasgow Kerbside	✓	✓
Auchencorth Moss	✓	✓		Glasgow Nithsdale Dr	✓	✓
Bush Estate	✓	✓		Glasgow Waulkmillglen Reservoir	✓	✓
Dumfries	✓	✓		Grangemouth	✓	✓
Dundee Broughty Ferry Road	✓	✓		Grangemouth Moray	✓	✓
Dundee Lochee Road	✓	✓		Inverness	✓	✓
Dundee Mains Loan	✓	✓		Lerwick	✓	✓
Dundee Seagate	✓	✓		Lerwick Staney Hill	Site Started Dec 08	✓
Dundee Union Street	✓	✓		Midlothian Dalkieth	✓	✓
Dundee Whitehall Street	✓	✓		Midlothian Pathhead	✓	✓
East Ayrshire New Cumnock	Site Started Feb 09	✓		North Lanarkshire Chapelhall	✓	✓
East Dunbartonshire Bearsden Cross	✓	✓		North Lanarkshire Coatbridge Whifflet	✓	✓
East Dunbartonshire Bishopbriggs Cross	✓	✓		North Lanarkshire Croy	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓		North Lanarkshire Harthill West	Site Started Jun 09	✓
East Lothian Musselburgh	✓	✓		North Lanarkshire Moodiesburn	Site Started Oct 08	✓
East Renfrewshire Sheddons	✓	✓		North Lanarkshire Motherwell	✓	✓
Edinburgh Gorgie Road	✓	✓		North Lanarkshire Shawhead Coatbridge	Site Started May 09	✓
Edinburgh Haymarket	Site Closed Jan 09			North Ayrshire Irvine	Site Started Feb 09	✓
Edinburgh Queen St	✓	✓		Paisley Central Road	✓	Site suspended Oct 09
Edinburgh Roseburn	✓	✓		Paisley Glasgow Airport	✓	✓
Edinburgh Salamander St	Site Started Oct 09			Paisley Gordon Street	✓	✓
Edinburgh St Johns Road	✓	✓		Peebles	Site started Nov 09	
Edinburgh St Leonards	✓	✓		Perth 2 (Atholl St)	✓	✓
Eskdalemuir	✓	✓		Perth (High St)	✓	✓
Falkirk Grangemouth Municipal Centre	✓	✓		South Ayrshire Ayr High Street	✓	✓
Falkirk Haggs	Site Started Jan 09	✓		South Ayrshire Tarbolton	Site Started Jan 09	✓
Falkirk Hope St	✓	✓		South Lanarkshire East Kilbride	✓	✓
Falkirk Park St	✓	✓		Stirling Craig's Roundabout		Site in SAQD Oct 09
Falkirk West Bridge Street	Site Started Jan 09	✓		Strath Vaich	✓	✓
Fife Cupar	✓	✓		West Dunbartonshire Clydebank	✓	✓
Fife Dunfermline	✓	✓		West Dunbartonshire Glasgow Road	✓	✓
Fife Rosyth	✓	✓		West Lothian Broxburn	✓	✓
Fort William	✓	✓		West Lothian Linlithgow	✓	✓
				West Lothian Uphall	✓	Site relocated to Whitburn Nov 09

6 Air Pollution in Scotland 2009

In this section we present a statistical summary of the available air quality data for Scotland as follows:

- Section 6.1 - Automatic monitoring of the pollutants NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and $O_{3,}$- summary data for 2009.

- Section 6.2 - Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and lead - summary statistics for 2008 or 2009 depending on the availability of data.

- Section 6.3 - Other pollutants and/or other methods of monitoring:
    1. NO_2 diffusion tube samplers
    2. Non- methane Volatile Organic Compounds (NMVOC)
    3. Poly aromatic hydrocarbons (PAH)
    4. Toxic Organic Micropollutants (TOMPS)
    5. Metals (Urban network)
    6. Metals (Rural and deposition network)
    7. United Kingdom Eutrophying & Acidifying Pollutants Network
        1. The Precipitation Network
        2. NO_2 rural diffusion tube Network
        3. Acid Gases and Aerosol Network (AGANET)
        4. National Ammonia Monitoring Network

6.1 Automatic monitoring of the pollutants NO_2, PM_{10}, $PM_{2.5}$, CO, SO_2 and Ozone

Tables 6.1.1 – 6.1.7 show the 2009 annual average data statistics for NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and O_3 respectively, for the ratified automatic data from monitoring sites included in the Scottish Air Quality Database. These are shown along with the corresponding data capture for the year.

These data will have been used by Local Authorities to assess air quality within their area as part of the Local Air Quality Review and Assessment process. Where any of the Air Quality Objectives for Scotland have been exceeded – at locations where there is relevant exposure of the general public – then the Authority will need to proceed to a Detailed Assessment to confirm the exceedence and estimate its extent. Where the exceedence is confirmed then the Authority will declare an Air Quality Management Area (AQMA). At present, 12 Local Authorities in Scotland have declared AQMAs (see http://www.scottishairquality.co.uk/laqm.php) and a number of other authorities are proceeding through the process of declaration.

Based on the data in the database, a brief summary of the air quality situation throughout Scotland, along the lines of that already provided in the Newsletter, is given under each table.

6.1.1 Nitrogen Dioxide

Table 6.1.1 Ratified data annual average concentration and data capture for NO_2 in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2009 (μgm^{-3})	No. hours > 200μgm^{-3}	Data capture NO_2 2009 (%)
Aberdeen Anderson Drive	Roadside	24	0	95
Aberdeen Errol Place	Urban Background	26	0	96
Aberdeen King St	Roadside	32	0	89
Aberdeen Market Street 2	Roadside	40	2	36
Aberdeen Union Street	Roadside	52	10	70
Aberdeen Wellington Road	Roadside	43	0	97
Bush Estate	Rural	7.2	0	85
Dumfries	Roadside	35	0	82
Dundee Lochee Road	Kerbside	54	23	88
Dundee Seagate	Kerbside	51	1	74
Dundee Union Street	Kerbside	45	2	99
Dundee Whitehall Street	Kerbside	38	0	93
East Ayrshire Kilmarnock	Urban Background	17	0	36
East Ayrshire New Cumnock	Urban Background	7	0	80
East Dunbartonshire Bearsden	Kerbside	43	19	99
East Dunbartonshire Bishopbriggs	Roadside	33	1	90
East Dunbartonshire Kirkintilloch	Roadside	42	0	94
Edinburgh Gorgie Road	Roadside	38	0	85
Edinburgh Queen Street	Roadside	33	0	98
Edinburgh Roseburn	Roadside	26	0	99
Edinburgh Salamander St	Roadside	39	0	28
Edinburgh St John's Road	Kerbside	70	114	97
Edinburgh St Leonards	Urban background	24	0	98
Eskdalemuir	Rural	4.3	0	94
Falkirk Grangemouth MC	Urban background	23	0	99
Falkirk Haggs	Roadside	38	1	86
Falkirk Hope Street	Roadside	24	0	96
Falkirk Park St	Roadside	29	0	99
Falkirk West Bridge St	Roadside	38	0	91
Fife Cupar	Kerbside	34	0	57
Fife Dunfermline	Roadside	30	0	99
Fife Rosyth	Roadside	29	2	99
Fort William	Suburban	9	0	88
Glasgow Anderston	Urban background	36	4	92
Glasgow Battlefield Road	Roadside	34	1	99
Glasgow Byres Road	Roadside	40	0	99
Glasgow Centre	Urban centre	42	48	91
Glasgow City Chambers	Urban background	46	12	97
Glasgow Kerbside	Kerbside	78	57	97

Site Name	Type	Annual Average NO_2 2009 (μgm^{-3})	No. hours > 200μgm^{-3}	Data capture NO_2 2009 (%)
Glasgow Waulkmillglen Reservoir	Rural	12	0	94
Grangemouth	Urban industrial	18	0	90
Grangemouth Moray	Urban Background	19	0	58
Inverness	Roadside	21	0	96
Lerwick Staney Hill	Urban Background	8	0	77
Midlothian Dalkeith	Kerbside	20	0	99
N Lanarkshire Chapelhall	Roadside	40	1	88
N Lanarkshire Coatbridge Whifflet	Urban background	24	0	93
N Lanarkshire Croy	Roadside	24	0	74
N Lanarkshire Harthill West	Urban Background	17	0	54
N Lanarkshire Moodiesburn	Roadside	37	0	93
N Lanarkshire Shawhead Coatbridge	Roadside	35	0	65
North Ayrshire Irvine High St	Kerbside	26	0	51
Paisley Central Road	Roadside	88	760	82
Paisley Glasgow Airport	Airport	25	0	99
Paisley Gordon Street	Roadside	34	1	89
Peebles	Suburban	12	0	15
Perth Atholl Street	Roadside	56	3	98
Perth High Street	Roadside	25	0	97
South Ayrshire Ayr High St	Roadside	20	0	99
South Ayrshire Tarbolton	Roadside	8	0	97
South Lanarkshire East Kilbride	Roadside	37	4	99
Stirling Craig's Roundabout	Roadside	26	0	94
West Dunbartonshire Clydebank	Roadside	26	0	99
West Dunbartonshire Glasgow Rd	Roadside	23	0	98
West Lothian Broxburn	Roadside	39	1	99
West Lothian Linlithgow High St	Roadside	21	0	99
West Lothian Uphall	Roadside	17	0	62

Shaded sites indicate data only available for part year (data capture <75%)
Highlighted figures indicate exceedence of Scottish Air Quality Objectives

Table 6.1.1 shows nitrogen dioxide data for the 67 sites utilising automatic monitoring in 2009, although data for 13 of these are only available for part of the year and the overall data capture is less than 75%. These include sites which opened or closed during the year, sites which were closed for part of the year due to roadworks etc and sites with instrument problems.

Of the remaining 54 sites with more than 75% data capture, 11 of these (9 kerbside or roadside and 2 urban sites, both in Glasgow) exceeded the AQS Objective for the NO_2 annual mean (40μgm^{-3}). At 6 of these sites, the AQS Objective of not more than 18 exceedences of 200μgm^{-3} for the hourly mean was also exceeded.

Two sites equaled the annual average objective, but did not exceed. Of the sites with less that 75% data capture, 2 of these exceeded (both had 70% or more data capture) and one equaled the annual average objective, but only had a data capture of 36%.

Highest concentrations were measured at Paisley Central Road, Glasgow Kerbside and Edinburgh St John's Road. The Glasgow Kerbside and Edinburgh St John's sites both sit 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 arrangement at this location is currently being remodeled.

Eight Local Authorities have declared one or more Air Quality Management Areas for exceedences of the AQS for NO_2. All of these, with the exception of Fife, have sites which exceeded the NO_2 objective in 2009. At Fife, the monitor at Bonnygate, Cupar was unable to operate for almost half of the year due to road realigning in the immediate vicinity of the site location.

6.1.2 Particulate Matter – PM_{10}

Table 6.1.2 Ratified data annual average concentration and data capture for PM_{10} in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2009 (μgm^{-3} gravimetric equivalent)*	Annual Average PM_{10} 2009 (μgm^{-3} gravimetric equivalent VCM)	No. days > 50μgm^{-3} (**)	Data capture PM_{10} 2009 (%)
Aberdeen Anderson Dr	Roadside	TEOM (VCM)		15	1	96
Aberdeen Errol Place	Urban Background	FDMS/TEOM(VCM)		15**	2	97
Aberdeen King St		BAM (Un-heated Inlet)	17		2	92
Aberdeen Market St 2	Roadside	TEOM (VCM)		24	3	22
Aberdeen Union St	Roadside	TEOM (VCM)		18	1	99
Aberdeen Wellington Road	Roadside	TEOM (VCM)		23	5	93
Alloa	Roadside	TEOM (VCM)		17	3	86
Angus Forfar	Roadside	FDMS	17		2	97
Auchencorth Moss	Rural	FDMS	7		0	54
Dundee Broughty Ferry Road	Roadside	TEOM (VCM)		15	2	99
Dundee Mains Loan	Urban Background	TEOM (VCM)		13	0	84
Dundee Union Street	Kerbside	TEOM (VCM)		17	1	99
East Ayrshire Kilmarnock	Urban Background	BAM (Un-heated Inlet)	23		5	22
East Ayrshire New Cumnock	Urban Background	BAM (Un-heated Inlet)	12		0	76
East Dunbartonshire Bearsden	Kerbside	BAM (Heated Inlet)	19		3	70
East Dunbartonshire Bishopbriggs	Roadside	BAM (Heated Inlet)	19		4	79
East Dunbartonshire Kirkintilloch	Roadside	FDMS	23		14	93
East Lothian Musselburgh N High St	Roadside	BAM (Un-heated Inlet)	15		1	68
East Renfrewshire Sheddens	Roadside	FDMS	16		4	96
Edinburgh Queen Street	Roadside	TEOM (VCM)		17	1	96
Edinburgh Roseburn	Roadside	TEOM (VCM)		14	0	99
Edinburgh Salamander St	Roadside	TEOM (VCM)		22	2	27
Edinburgh St Leonards	Urban Background	FDMS	18		2	53
Falkirk Grangemouth MC	Urban Background	TEOM (VCM)		14	0	97
Falkirk Hope St	Roadside	TEOM (VCM)		15	1	96
Falkirk Park St	Roadside	TEOM (VCM)		15	2	98
Falkirk West Bridge St	Roadside	TEOM (VCM)		19	0	28
Fife Cupar	Kerbside	FDMS/TEOM(VCM)		16**	0	56
Fife Rosyth	Roadside	FDMS	16		2	98
Glasgow Abercromby	Roadside	FDMS	18		7	93
Glasgow Anderston	Urban Background	TEOM (VCM)		15	1	88
Glasgow Battlefield Road	Roadside	TEOM (VCM)		16	2	89
Glasgow Broomhill	Roadside	FDMS	18		7	92
Glasgow Byres Road	Roadside	TEOM (VCM)		19	2	98
Glasgow Centre	Urban centre	FDMS	25		21	76
Glasgow Kerbside	Kerbside	FDMS/TEOM(VCM)		24**	10	94

Site Name	Site Classification	PM_{10} Analyser Type*	Annual Average PM_{10} 2009 (μgm^{-3} gravimetric equivalent)*	Annual Average PM_{10} 2009 (μgm^{-3} gravimetric equivalent VCM)	No. days > 50μgm^{-3} (**)	Data capture PM_{10} 2009 (%)
Glasgow Nithsdale Road	Roadside	FDMS	17		6	90
Glasgow Waulkmillglen Reservoir	Rural	TEOM (VCM)		11	0	97
Grangemouth	Urban industrial	FDMS/TEOM(VCM)		13**	0	90
Grangemouth Moray	Urban Background	TEOM (VCM)		14	0	99
Inverness	Roadside	Partisol	12		0	94
Midlothian Dalkeith	Roadside	TEOM (VCM)		14	1	92
Midlothian Pathead	Kerbside	TEOM (VCM)		17	1	95
N Lanarkshire Chapelhall	Roadside	TEOM (VCM)		19	4	89
N Lanarkshire Coatbridge Whifflet	Urban Background	TEOM (VCM)		14	0	93
N Lanarkshire Croy	Roadside	TEOM (VCM)		19	15	75
N Lanarkshire Harthill West	Urban Background	TEOM (VCM)		12	0	53
N Lanarkshire Moodiesburn	Roadside	BAM (Un-heated Inlet)	18		2	59
N Lanarkshire Motherwell	Roadside	TEOM (VCM)		17	2	97
N Lanarkshire Shawhead Coatbridge	Roadside	BAM (Un-heated Inlet)	16		0	51
North Ayrshire Irvine High St	Kerbside	BAM (Un-heated Inlet)	18		1	84
Paisley Gordon Street	Roadside	FDMS	18		5	78
Perth Atholl Street	Roadside	TEOM (VCM)		21	3	91
Perth High Street	Roadside	TEOM (VCM)		16	2	96
South Ayrshire Ayr High St	Roadside	FDMS	17		4	99
South Ayrshire Tarbolton	Roadside	FDMS	12		0	87
South Lanarkshire East Kilbride	Roadside	FDMS	15		5	98
Stirling Craig's Roundabout	Roadside	TEOM (VCM)		19	4	98
West Dunbartonshire Clydebank	Roadside	FDMS	17		3	72
West Lothian Broxburn	Kerbside	FDMS	19		5	99
West Lothian Linlithgow High Street	Roadside	FDMS	17		2	86
West Lothian Uphall	Urban Background	FDMS/TEOM(VCM)		13**	1	80

* FDMS data are equivalent to gravimetric and hence are not adjusted
BAM (heated inlet) data are adjusted using gravimetric equivalent factor of 1.3
BAM (un-heated inlet) data are adjusted using gravimetric equivalent factor of 0.8333
** Weighted average of FDMS and VCM corrected TEOM data
Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures indicate exceedence of Scottish Air Quality Objectives

Table 6.1.2 shows the 2009 gravimetric equivalent particulate matter – PM_{10} - data from 61 sites utilising automatic monitoring and the Partisol daily sampler at Inverness. Of these sites, 13 have less than 75% data capture. As discussed in Section 4.2.2, all TEOM data have been adjusted using VCM. Five sites changed from TEOM analysers part way through the year. In these cases, the VCM corrected TEOM data have been merged with data from the replacement monitor to produce an overall summary from all available

Of the 49 sites with more that 75% data capture, 11 sites exceeded the Annual Average PM_{10} Objective of 18μgm^{-3} and a further 5 equaled this Objective. Four of these sites also exceeded the Daily Objective of 50μgm^{-3} not to be exceeded more than 7 times a year. In addition, 2 sites exceeded a daily mean of 50μgm^{-3} on 7 occasions.

No site exceeded the UK AQS Objective of 40μgm^{-3} for the annual mean PM_{10} or the daily objective of 35 exceedences of 50μgm^{-3}.

Eight Local Authorities in Scotland (Aberdeen, Glasgow, East Dunbartonshire, Fife, Midlothian, North Lanarkshire, Perth and South Lanarkshire) have declared Air Quality Management Areas for exceedences of the PM_{10} Air Quality Objective.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for PM_{10} (and $PM_{2.5}$). The results shown in Table 6.1.2 are from the FDMS analyser. The results from the Partisol analyser are almost identical, with both analysers recording an annual average of 7μgm^{-3} and no exceedences of the daily Objective. Note however that the data capture was 95% for the Partisol and 54% for the FDMS.

Figure 6.1.1 shows the 2009 Annual Average PM_{10} and $PM_{2.5}$ concentrations for all SAQD monitoring sites with more than 75% data capture.

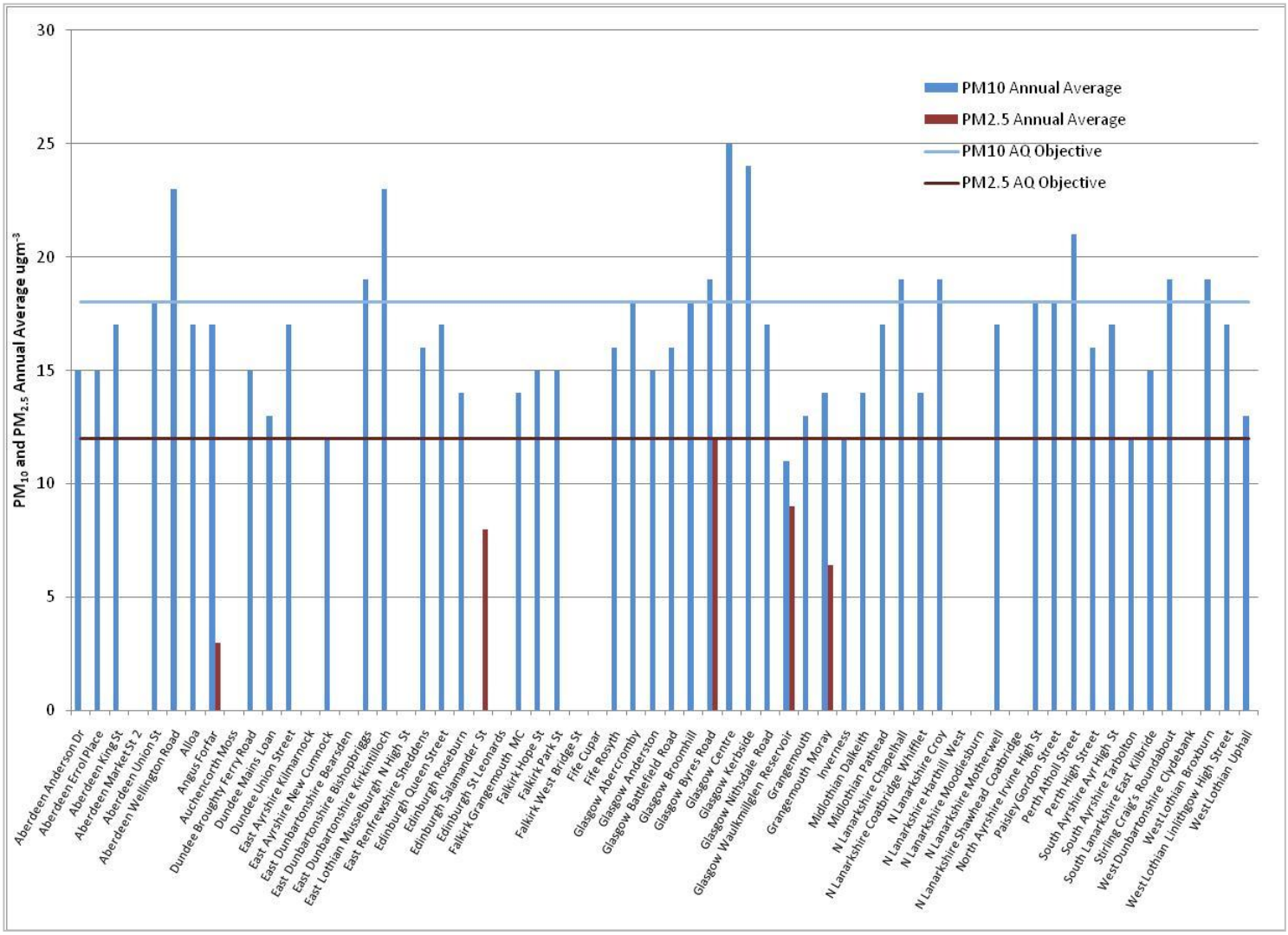


Figure 6.1.1 Annual Average PM_{10} and $PM_{2.5}$ concentrations (μgm^{-3}) for all SAQD sites with more than 75% data capture in 2009.

6.1.3 Particulate Matter – $PM_{2.5}$

Table 6.1.3 Ratified data annual average concentration and data capture for $PM_{2.5}$ in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	$PM_{2.5}$ Analyser Type	Start date	Annual Average $PM_{2.5}$ 2009 (μgm^{-3} gravimetric equivalent)	Data capture $PM_{2.5}$ 2009 (%)
Aberdeen Errol Place	Urban Background	FDMS	20/02/2009	7	61
Auchencorth Moss	Rural	FDMS	01/01/2006	3	98
Edinburgh St Leonards	Urban Background	FDMS	01/10/2008	8	95
Glasgow Centre	Urban Background	FDMS	16/12/2008	12	98
Glasgow Kerbside	Kerbside	FDMS	28/05/2009	20	47
Grangemouth	Urban Industrial	FDMS	03/12/2008	9	95
Inverness	Roadside	Partisol	01/06/2008	6.4	95

Shaded sites indicate data only available for part year and/or <75% data capture

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

Two of these sites had less than 75% data capture. At the remaining 5 sites, the Scottish AQS Objective of $12\mu gm^{-3}$ was met at these sites, although at Glasgow Centre, the annual average equalled the objective value of $12\mu gm^{-3}$, but did not exceed it. The objective was exceeded at Glasgow Kerbside, though the data capture at this site was only 47%.

Figure 6.1.1 shows the 2009 Annual Average $PM_{2.5}$ (and PM_{10}) concentrations for all SAQD monitoring sites with more than 75% data capture.

Over the whole of the UK, the provisional $PM_{2.5}$ Average Exposure Indicator (AEI) for 2009 was $12.7\mu gm^{-3}$- borderline between a required reduction of 10 or 15% by 2020 according to the requirements of the EU Directive. The final AEI will to be calculated as an average over 2009, 2010 and 2011.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for $PM_{2.5}$ (and PM_{10}). The results shown in Table 6.1.3 are from the FDMS analyser. The results from the Partisol analyser are similar, with the FDMS recording an annual average of $3\mu gm^{-3}$ and the Partisol an annual average of $4.5\mu gm^{-3}$.

The $PM_{2.5}/PM_{10}$ ratios found in for 2009 are shown in Table 6.1.4. These ratios are similar, but slightly lower than those found the Scottish PM_{10} and $PM_{2.5}$ study in 2007. Due to the wider range of site types, the spread of $PM_{2.5}/PM_{10}$ ratios found is greater in 2009 measurements. The particularly high value of 0.81 found at the Glasgow kerbside site presumably reflects the unusual nature of this site very close to a busy road.

Table 6.1.4 $PM_{2.5}/PM_{10}$ ratios for 2009 annual average concentrations

Site Name	Annual Average PM_{10} 2009 (μgm^{-3} gravimetric equivalent)	Annual Average $PM_{2.5}$ 2009 (μgm^{-3} gravimetric equivalent)	Ratio
Aberdeen Errol Place	14.8	6.9	0.47
Auchencorth Moss (FDMS)	6.6	3.4	0.51
Auchencorth Moss (Partisol)	7.0	4.5	0.64
Edinburgh St Leonards	16.8	8.5	0.50
Glasgow Centre	25.1	11.7	0.46
Glasgow Kerbside VCM	24.3	19.7	0.81
Grangemouth VCM	12.5	8.6	0.68
Inverness	11.7	6.4	0.55

Shaded sites indicate data only available for part year and/or <75% data capture

6.1.4 Carbon Monoxide

Table 6.1.5 Ratified data annual average concentration and data capture for CO in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2009 (mgm^{-3})	Max. Running 8hr Mean CO 2009 (mgm^{-3})	Data capture CO 2009 (%)
East Ayrshire Kilmarnock	Urban background	0.2	0.8	40
Edinburgh St Leonards	Urban background	0.2	3.2	96
Glasgow Anderston	Urban background	0.1	1.6	93
Glasgow Byres Road	Roadside	0.3	1.8	98
Glasgow Centre	Urban centre	0.2	1.9	96
N Lanarkshire Harthill West	Roadside	0.1	0.5	55

Shaded sites indicate data only available for part year

Table 6.1.5 shows carbon monoxide was monitored using automatic techniques at 6 sites in 2009 – 1 less than in 2008. The sites at N. Lanarkshire Harthill West and East Ayrshire Kilmarnock only operated for part of the year. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

No Air Quality Management Areas have been declared for carbon monoxide.

6.1.5 Sulphur Dioxide

Table 6.1.6 Ratified data annual average concentration and data capture for SO_2 in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average SO_2 2009 (μgm^{-3})	No. Exceed 15min SO_2 2009 (μgm^{-3})	No. Exceed 1hr SO_2 2009 (μgm^{-3})	NO. Exceed 24hr SO_2 2009 (μgm^{-3})	Data capture SO_2 2009 (%)
Dundee Broughty Ferry Road	Roadside	5	0	0	0	93
East Ayrshire Kilmarnock	Urban background	2	0	0	0	39
Edinburgh St Leonards	Urban Background	3	0	0	0	95
Falkirk Grangemouth MC	Urban Background	7	17	0	0	99
Falkirk Hope St	Roadside	4	0	0	0	95
Falkirk Park St	Roadside	4	0	0	0	99
Glasgow Anderson	Urban Background	2	0	0	0	88
Glasgow Centre	Urban Centre	4	0	0	0	97
Grangemouth		8	21	0	0	94
Grangemouth Moray		11	65	1	2	99
Lerwick Staney Hill		4	0	0	0	95
Midlothian Dalkieth	Kerbside	2	0	0	0	96
Midlothian Pathhead	kerbside	7	0	0	0	95
N Lanarkshire Croy	Roadside	2	0	0	0	80
N Lanarkshire Harthill West	Roadside	2	0	0	0	48

Shaded sites indicate data only available for part year
Highlighted figures indicate exceedence of Scottish Air Quality Objectives

Table 6.1.6 shows sulphur dioxide data from the 15 sites utilising automatic monitoring for 2009. Sites Kilmarnock and N. Lanarkshire Harthill West only operated for part of the year. All sites in Scotland met the requirements of the Air Quality Strategy for 1-hour and 24-hour mean SO_2 in 2009. All except one site (Grangemouth Moray) met the requirements of the Air Quality Strategy for 15-minute mean. At this site there were 65 exceedeces of the Air Quality Strategy 15min Objective whereas only 35 are permitted. Falkirk has already declared an Air Quality Management Area for sulphur dioxide, based on data from previous years.

6.1.6 Ozone

Table 6.1.7 Ratified data annual average concentration and data capture for O_3 in 2009 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average O_3 2008 (μgm^{-3})	No of days with running 8-hr mean >100ugm^{-3}	Data capture O_3 2008 (%)
Aberdeen Errol place	Urban Background	42	1	94
Auchencorth Moss	Rural	56	5	98
Bush Estate	Rural	56	4	98
Edinburgh St Leonards	Urban background	52	3	95
Eskdalemuir	Rural	56	20	99
Fort William	Suburban	53	10	88
Glasgow Centre	Urban centre	32	1	98
Glasgow Waulkmillglen Reservoir	Rural	52	5	94
Lerwick	Rural	70	28	91
Peebles	Suburban	45	0	15
Strath Vaich	Remote	67	4	95

Shaded sites indicate data only available for part year
Highlighted figures indicate exceedence of Scottish Air Quality Objectives

Table 6.1.7 shows ozone data from 11 sites utilising automatic monitoring for 2009. Ozone (O_3) is a secondary pollutant formed by reactions involving other pollutant gases, in the presence of sunlight, and over several hours; it 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. In 2009, the air quality objective of not more than 10 days with a maximum 8hr running mean greater than 100μgm^{-3} was exceeded at Eskdalemuir and Lerwick. At Fort William the daily target was exceeded on 10 days.

6.2 Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1.3-butadiene and lead

In this section, we present a summary of data from a range of national monitoring networks. Summaries are provided for pollutants covered by the Air Quality Strategy. As some of these networks are based on sampler measurement techniques and subsequent chemical analysis there is often a considerable delay in the availability of data. Hence, in some cases, the latest data available at the time of preparing this report is for 2008. Where other pollutants are also monitored in these networks, these pollutants are listed, but the data are not provided in this report.

6.2.1 PAH Monitoring Network[11]

The UK Monitoring and Analysis Network monitors some 39 Poly Aromatic Hydrocarbon (PAH) species at about 30 sites.

PAH monitoring of the compound benzo[a]pyrene is undertaken to provide data in compliance with the EU Air Quality Directive (Directive 2004/107/EC). An air quality Objective for this compound is also set in the Air Quality Strategy. A wide range of other PAH species are also monitored in the particulate phase and in the gaseous phase at some sites, for research purposes. The monthly summary results for all species monitored in the PAH network can be downloaded as spreadsheet summary data from www.airquality.co.uk .

The airborne PAH monitoring is undertaken using Digitel DHA-80 Air Sampling System with PM_{10} inlet. Particulate collection is undertaken on a filter and, at some sites, vapour phase collection is also undertaken using polyurethane foam in addition to filter. At two sites, deposition samplers are also used to determine deposited PAH material.

The PAH monitoring sites in Scotland are shown in Table 6.2.1. The sites at Edinburgh and Glasgow are co-located with the Edinburgh St Leonards and Glasgow Centre AURN sites respectively. The site at Kinlochleven is located close to the closed Aluminium works and the site at Auchencorth Moss is a rural EMEP site as discussed in the automatic hydrocarbon section.

Table 6.2.1. PAH monitoring sites in Scotland

Site	Address	Grid Reference
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow	St Enoch Square Glasgow G2 8BX	258964, 665018
Kinlochleven 2	Electrical Substation Kinlochleven	219305,761905
Auchencorth Moss	Rural site in Scotland, south of Edinburgh	322050,656250

Annual average concentrations for Benzo(a)pyrene (B(a)P) for 2008 are shown in Table 6.2.2. This table shows that the Air Quality Objective for B(a)P of 0.25ngm^{-3} annual average was exceeded at Glasgow Centre and Kinlochleven 2. However, the EU Directive target value of 1ngm^{-3} annual average was not exceeded at any monitoring site in Scotland.

Table 6.2.2. Annual Average Benzo(a)Pyrene concentrations for 2008 at 4 sites in Scotland

Site	2008 Annual Mean B(a)P concentration (ngm^{-3})
Auchencorth Moss A	0.038
Edinburgh St Leonards	0.12
Glasgow Centre	0.31
Kinlochleven 2	0.27

6.2.2 Benzene

Non- automatic hydrocarbon monitoring[12]

[11] Conolly C. et al Annual Report for 2008 on the UK PAH Monitoring and Analysis Network
http://www.airquality.co.uk/reports/cat05/1003151640_AEA_PAH_Network_2008_Report_final_issue_4.pdf
[12] Butterfield D. et al UK Non-Automatic Hydrocarbon Network: Annual Report for 2008
http://publications.npl.co.uk/npl_web/pdf/as44.pdf

Monitoring of benzene is undertaken on a two weekly basis with pumped tube samplers at 37 sites throughout the UK – The UK Non-automatic Hydrocarbon Network. One of these sites is in Grangemouth and is co-located with the Grangemouth AURN site (grid reference 293840,681032).. The non-automatic monitoring network provides benzene data for compliance with the EU air quality Directive.

The benzene monitoring method used in this network involves pumping ambient air at a rate of 10ml/min through nominally duplicate tubes containing the sorbent Carbopack X, with subsequent laboratory analysis of the benzene content of the tubes.

Results for this site for 2008 are provided in Table 6.2.3.

Table 6.2.3. Annual Mean Benzene concentrations at Grangemouth in 2008

Site Name	Annual Mean benzene for 2008 μgm^{-3}
Grangemouth	1.2

6.2.3 Automatic Hydrocarbon Monitoring

Table 6.2.4 gives the site details for the 2 automatic hydrocarbon monitoring stations in Scotland - Glasgow Kerbside and Auchencorth Moss. Benzene and a limited range of other hydrocarbon species are measured at the Glasgow Kerbside Site. Auchencoth Moss is a rural site south of Edinburgh. The data from this site are used both to provide data for ozone precursor hydrocarbon species, in compliance with the EU Air Quality Directive (2008/50/EC). In addition, this site is one of the 2 European Monitoring and Evaluation Programme (EMEP) level II sites (EMEP "supersites") in the UK. The other EMEP supersite is located a Harwell in Oxfordshire. A much wider range of hydrocarbon species is monitored at Auchencorth Moss. However, the rural nature of this site means that often the concentrations are below the detection limit and hence, the data capture is low. Data for the full range of hydrocarbon species monitored at Glasgow Kerbside and Auchencorth Moss can be downloaded from www.scottischairquality.co.uk .The data for 2008 are summarised in the 2008 Annual Report[13] .

Table 6.2.4. Location of Automatic Hydrocarbon monitoring sites in Scotland

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322000,656200
Glasgow Kerbside	KERBSIDE	Benzene and 1,3-butadiene	258708,665200

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

Table 6.2.5. Annual Average Benzene concentration at Glasgow Kerbside and Auchencorth Moss sites in the UK Automatic Hydrocarbon Network, for 2008 and 2009

Site	2008 Benzene Annual mean concentration (μgm^{-3})	2008 Benzene Maximum running annual concentration (μgm^{-3})	2008 % Data capture	2009 Benzene Annual mean concentration (μgm^{-3}) (Provisional)	2009 % Data Capture (provisional)
Glasgow Kerbside	1.04	1.08	96.3	1.11	93
Auchencorth Moss	0.21	N/A (low data capture)	27	0.38	50

Table 6.2.3 and 6.2.5 show that the EU limit value for benzene of 5μgm^{-3} was not exceeded at any site in Scotland and that the Scottish Objective of 3.25μgm^{-3} for the annual running mean concentration is unlikely to be exceeded.

[13] Annual summary of data produced by the UK Ambient Automatic Hydrocarbon Air Quality Network, 2008 http://www.airquality.co.uk/reports/cat05/1004131217_2008_annual_rep_issue1_v2.pdf

6.2.4 1,3-butadiene

The species 1,3-butadiene is also measured as part of the UK Automatic Hydrocarbon Network at the same sites as for Benzene. Measurements of 1,3-butadiene within the non-automatic hydrocarbon network stopped during 2007.

Table 6.2.6. Annual Average 1,3-butadiene concentration at Glasgow Kerbside and Auchencorth Moss sites in the UK Automatic Hydrocarbon Network, for 2008 and 2009

Site	2008 1,3-butadiene Annual mean concentration (μgm^{-3})	2008 1,3-butadiene Maximum running annual concentration (μgm^{-3})	2008 % Data capture	2009 1,3-butadiene Annual mean concentration (μgm^{-3}) (Provisional)	2009 % Data Capture (provisional)
Glasgow Kerbside	0.15	0.16	96	0.13	93
Auchencorth Moss	0.04	N/A (low data capture)	29	0.05	58

Table 6.2.6 shows that the Air Quality Objective for 1,3-butadiene of 2.25μgm^{-3} is unlikely to be exceeded in Scotland. There is no EU Directive covering 1,3-butadiene.

6.2.5 Lead

Lead, and a wide range of other metals, are monitored in two UK networks – the UK Heavy Metals Monitoring Network (mainly urban sites) and the National Monitoring Network for Heavy Metals (mostly rural sites). The urban network determines airborne particulate concentrations of 13 metals, including the metals lead, nickel, arsenic, cadmium and mercury which are covered by the EU Directive (Directives 2008/50/EC for lead and Directive 2004/107/EC for other metals). The rural network determines the concentration of more than 20 metals both as airborne particulate matter and as deposited material in rainwater samples. Results for all metals monitored in the UK Heavy Metals Monitoring Network and for a selection of metals monitored in the National Monitoring Network for Heavy Metals are available from annual average spreadsheet summaries at www.airquality.co.uk .

Urban Heavy metals[14]

Monitoring of metals in urban areas is undertaken in compliance with EU Directive 2004/107/EC to determine compliance with the Directive limit values for lead, nickel, arsenic, cadmium and mercury and the Air Quality Objective for lead. Particulate samples are collected using Partisol 2000 instruments fitted with PM_{10} heads and operating at a flow rate of $1m^3h^{-1}$. Analysis of the samples is undertaken using ICP-MS.

Table 6.2.7 gives details of the monitoring sites in Scotland and Table 6.2.8 provides a summary of the results for the measurement of lead and other metals for 2008.

Table 6.2.7. Heavy Metals Monitoring Network Sites in Scotland 2008

Site	Site type and grid ref	Address	Metals measured
Eskdalemuir	Rural 323500,602800	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn
Motherwell	Urban Background 275764,656282	Civic centre, Motherwell	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn

[14] Brown R et al Annual Report for 2008 of the UK Heavy Metals Monitoring Network
http://www.airquality.co.uk/reports/cat13/0904081100_Defra_UK_Heavy_Metals_Network_Annual_Report_2008_FINALsm.pdf

Table 6.2.8. Annual mean metal concentrations 2008 (ngm^{-3}) (Urban Network)

Site	Annual Mean Lead concentration (ngm^{-3})	Annual Mean Nickel concentration (ngm^{-3})	Annual Mean Arsenic concentration (ngm^{-3})	Annual Mean Cadmium concentration (ngm^{-3})	Annual Mean Mercury(p)* concentration (ngm^{-3})	Annual Mean Mercury(v)+ concentration (ngm^{-3})
Eskdalemuir	1.2	0.34	0.06	0.04	0.02	1.61
Motherwell	6.6	0.35	0.33	0.12	0.02	2.23

* mercury in particulate phase
\+ total gaseous mercury

Rural Heavy Metals[15]

In the National Monitoring Network for Heavy Metals, particles are collected using either single sample or multiple sample FH95 samplers which draw air through a PM_{10} head at a flow rate of $1m^3$ per hour. Particulate metals are collected on a filter paper for subsequent analysis. The sampling period is normally one week. Rainwater collectors are used to collect samples for rainwater analysis of metals to determine metal deposition.

Details of the 2 sites in Scotland are provided in Table 6.2.9 and data for the measurement of lead are provided in Table 6.2.10.

Table 6.2.9. Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322000,656200
Banchory	Rural site, NE Scotland	NO676985

Table 6.2.10 Annual Mean metal concentrations 2008 (ngm^{-3}) (Rural Network)

Site	Annual Mean Lead concentration (ngm^{-3})	Annual Mean Nickel concentration (ngm^{-3})	Annual Mean Arsenic concentration (ngm^{-3})	Annual Mean Cadmium concentration (ngm^{-3})	Annual Mean Mercury concentration (ngm^{-3})
Auchencorth Moss	1.85	0.28	0.23	0.05	1.23
Banchory	1.35	0.19	0.21	0.04	1.11

The results from these networks show that the EU limit value for Lead, and the target values for Nickel, Arsenic and Cadmium are not exceeded at any site in Scotland. The Air Quality Objectives for lead ($500ngm^{-3}$ for 2004 and $250ngm^{-3}$ for 2008) were not exceeded at any site in Scotland.

6.3 Discussion of additional pollutants monitored and/or other methods of monitoring

This section discusses other air pollution measurements made in Scotland. Detailed results are not provided, but are available in the annual reports of the various networks. The following additional pollutants or additional monitoring methods are discussed:

1. NO_2 diffusion tube samplers
2. Non- methane Volatile Organic Compounds (NMVOC)
3. Poly aromatic hydrocarbons (PAH)
4. Toxic Organic Micropollutants (TOMPS)
5. Metals (Urban network)
6. Metals (Rural and deposition network)

[15] Fowler D. Et al UK Heavy Metal Monitoring Network
http://www.uk-pollutantdeposition.ceh.ac.uk/sites/uk-pollutantdeposition.ceh.ac.uk/files/UK_HeavyMetals_Final_report_2006_final_version.pdf

7. United Kingdom Eutrophying & Acidifying Pollutants Network
    1. The Precipitation Network
    2. NO_2 rural diffusion tube Network
    3. Acid Gases and Aerosol Network (AGANET)
    4. National Ammonia Monitoring Network

6.3.1 NO_2 Diffusion tube results

There is no specific requirement for Local Authorities to provide their NO_2 diffusion tube data to a central storage facility. However, through the Local Authority Air Quality Support contract, a mechanism has been provided for authorities to provide these data (http://www.laqmsupport.org.uk/). Where these data are provided by the authorities, they are then available for download from both the UK air quality website (www.airquality.co.uk) and the Scottish air quality website (www.scottishairquality.co.uk)

The NO_2 diffusion tube data, for 2008, available in the Scottish Database are summarised in Table 6.3.1

Table 6.3.1. Number of monitoring sites with valid annual mean for 2008 by local authority and site type

Local Authority	Urban Background	Intermediate	Roadside	Kerbside	Total
Abeerdeenshire	6		7		13
Clackmannanshire	2		2		4
Dundee	2		2		4
East Dunbartonshire	4		19		23
East Renfrewshire	1	1	3		5
Edinburgh	2		2		4
Falkirk	4		2		6
Fife	3		6	11	20
Highland	2		2		4
Midlothian	2	1	1		4
North Ayrshire	2		2		4
North Lanarkshire	20		17		37
Scottish Borders	5		7		12
South Ayrshire	2		2		4
South Lanarkshire	2		1		3
Stirling	2		2		4
West Dunbartonshire	3		4		7
West Lothian	1		2		3
Total	65	2	83	11	161

It can be seen that many authorities continue to provide the data for the 3 or 4 tube sites that were part of the previous National NO_2 Diffusion Tube Network, whereas other authorities provide data for many more of their monitoring sites. Clearly, much more data are available, but are not provided to the database. The Pilot study identified that there were over 800 NO_2 diffusion tube monitoring sites in Scotland in 2006.

A clear limitation in undertaking analysis of these data is that all the diffusion tube data provided are **not bias corrected**. Bias correction of diffusion tube data is required as the tubes may over, or underestimate concentrations and Authorities will have calculated a local bias correction factor, or used an appropriate national factor, prior to using the diffusion tube data in their LAQM review and assessment reports.

Hence, to avoid confusion, detailed analysis of these data will not be undertaken. However, an overview of all the data is provided in Figure 6.3.1 to give an indication of NO_2 concentrations throughout Scotland.

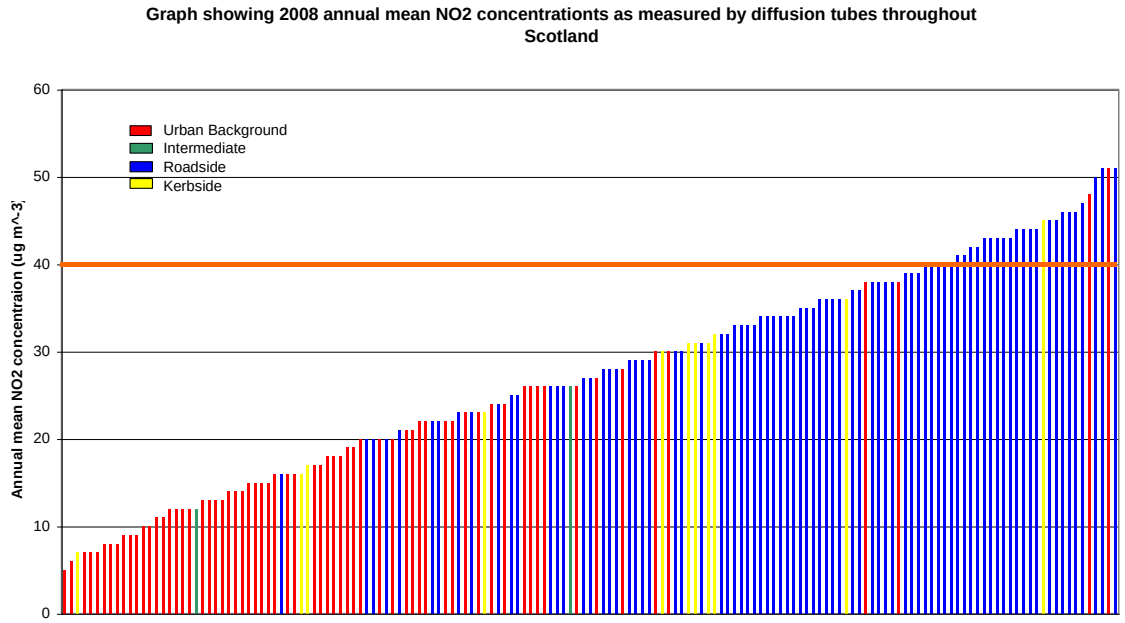


Figure 6.3.1. Summary of NO_2 diffusion tube results for Scotland 2008
Note – These data are NOT bias corrected

A further limitation on undertaking spatial analysis of these data is that many of the grid references supplied for the location of the monitoring site have insufficient precision. To assist with this problem, AEA has added an additional site location tool to the Members Area of the Scottish air quality website to allow authorities to position their diffusion tube sites directly on a detailed Google map. The grid references are then automatically uploaded into the database. This system worked extremely well in obtaining more exact locations for the automatic monitoring locations, and we encourage authorities to use the new tool to locate all their diffusion tube sites accurately.

6.3.2 Non- methane Volatile Organic Compounds (NMVOC)

As discussed in Section 6.2.3 and 6.2.4 the UK Automatic Hydrocarbon Network monitors a wide range of non-methane volatile organic compounds (NMVOC) in addition to the Air Quality Strategy pollutants of Benzene and 1,3-butadiene. At Glasgow kerbside the following pollutants are monitored.

1,3-Butadiene
Benzene
Toluene
Ethylbenzene
(m+p)-Xylene *
o-Xylene

At Auchencorth Moss a much wider range of NMVOCs are monitored to provide ozone precursor pollutant concentrations in compliance with the EU Directive (2008/50/EC). The following compounds are monitored:

Ethane
Ethene
Propane
Propene
Ethyne
2-Methylpropane
n-Butane
trans-2-Butene
1-Butene
cis-2-Butene
2-Methylbutane
n-Pentane
1,3-Butadiene
trans-2-Pentene
1-Pentene
2-Methylpentane
n-Hexane
Isoprene
Benzene
2,2,4-trimethylpentane
n-Heptane
n-Octane
Toluene
Ethylbenzene
(m+p)-Xylene
o-Xylene
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
1,2,3-Trimethylbenzene

Hourly data for all these species are available on the Scottish Air Quality website

6.3.3 Poly aromatic hydrocarbons (PAH)

As discussed in Section 6.2.1, a wide range of particulate and gaseous PAH compounds are monitored within the UK PAH network. The following PAH species are sampled on a daily basis (but bulked into monthly results after analysis) at the 4 PAH sites in Scotland

Benzo(c)phenanthrene
Benzo(a)anthracene
Chrysene
Cyclopenta(c,d)pyrene

Benzo(b)naph(2,1-d)thiophene
5-Methyl Chrysene
Benzo(b+j)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenzo(ah.ac)anthracene
Benzo(ghi)perylene
Anthanthrene
Dibenzo(al)pyrene
Dibenzo (ae)pyrene
Dibenzo(ai)pyrene
Dibenzo(ah)pyrene
Coronene
Cholanthrene

6.3.4 Toxic Organic Micropollutants

Toxic Organic Micropollutants (TOMPs) include Polychlorinated Dibenzo-p-Dioxins, Polychlorinated Dibenzofurans (PCDD/Fs), PAHs , and Polychlorinated Biphenyls (PCBs). PCDD/Fs and PAHs are formed as unwanted by-products during various industrial, chemical and combustion processes. PCBs were formerly manufactured for use in a wide range of electrical and other products until 1986. These highly toxic and persistent species are ubiquitous in the environment, but are normally present at extremely low concentrations, the atmosphere being the principal route for their redistribution in the environment. The TOMPs network provides data on concentrations of these species in the air throughout the UK.

There were six sites in the TOMPs network during 2007 – one in Scotland at Auchencorth Moss, a remote background site in Southern Scotland.

The TOMPs network samples are analysed for PCDD/Fs and PCBs. Portions from the extracts of samples are also analysed for PAHs as part of the PAH network. The sampling method is based around the use of a modified Andersen GPS-1 sampler with subsequent chemical analysis requiring the use of a range of sophisticated chemical analysis techniques. These include gas chromatography coupled with high-resolution mass spectrometry for the PCDD/Fs and for those PCBs with dioxin-like effects and low-resolution mass spectrometry for the other PCBs.

Annual average concentrations for Auchencorth Moss can be downloaded in spreadsheet format from www.airquality.co.uk .

6.3.5 Metals (Urban network)

As discussed in Section 6.2.5 a wide range of metals are monitored in the Heavy Metals Monitoring Network. At the two sites in Scotland, Eskdalemuir and Motherwell, the following metals are measured:

Arsenic, Cadmium, Chromium, Copper, Iron, Mangananese, Nickel, Lead, Platinum, Vanadium, Zinc, Mercury (particulate) and Mercury (Vapour).

6.3.6 Metals (Rural and deposition network)

As discussed in Section 6.2.5 a wide rage of metals are monitored in both air and rainwater within the National Monitoring Network for Heavy Metals. At the two sites in Scotland, Auchencorth Moss and Banchory, the following metals are monitored:

Aluminium (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb), Manganese (Mn), Molybdenum (Mo), Rubidium (Rb), Scandium (Sc), Selenium (Se), Strontium (Sr), Tin (Sn), Titanium (Ti), Tungsten (W), Vanadium (V) and Zinc (Zn).

6.3.7 United Kingdom Eutrophying & Acidifying Pollutants Network[16] (UKEAP)

This network focuses on the measurement of Eutrophying & Acidifying Pollutants in rural areas. The number of sites in Scotland is different for the various species measured. Final data for this network for 2008 are not yet available at the time of preparing this report. Data for 2007 are provided in the annual report[17]. In addition, a major review of Acidification, Eutophication, Ground Level Ozone and Heavy Metals in the EK has recently been published as a consultation draft (Review of Transboundary Air Pollution (RoTAP) Consultation Draft[18]).

The UKEAP has 4 component networks:

- The Precipitation Network,
- NO_2 network,
- Acid Gas and Aerosol Network (AGANET)
- National Ammonia Monitoring Network (NAMN).

Each network functions on a national scale, however with differing spatial and temporal resolution which reflects the spatial and temporal heterogeneiety of the atmospheric pollutant concerned

The Precipitation Network
There are 38 sites in PrecipNet at which the chemical composition of precipitation (i.e. rainwater) is measured. Six of the sites, Lochnagar, Llyn Llagi, Scoat Tarn, Loch Chon/Tinker, River Etherow, Beaghs Burn and Crai Reservoir (Head of the Valleys) were specifically located within sensitive ecosystems. The network allows estimates of wet deposition of sulphur and nitrogen chemicals

Fortnightly precipitation samples are collected at 38 sites throughout the UK, of which, 11 are in Scotland (see Appendix 1). Sampling is undertaken with using a bulk rainwater collector. The collected rainwater samples are analysed for sulphate, nitrate, chloride, phosphate, sodium, magnesium, calcium, potassium, pH and conductivity.

NO_2 network
The nitrogen dioxide measurements are made at 24 of the 38 PrecipNet composition sites. Diffusion tubes are used to measure nitrogen dioxide. The tubes are mounted on the upright of the rain collector stand and exposed for four or five week periods throughout each year.

Triplicate nitrogen dioxide diffusion tube measurements are run at three AURN sites with co-located automatic instruments (Yarner Wood, Harwell and Eskdalemuir).

Nitrogen dioxide is measured with diffusion tube samplers at 11 sites in Scotland. The annual average concentrations measured in 2007 are provided in Table 6.3.1

[16] For information on this network see http://www.uk-pollutantdeposition.ceh.ac.uk/ukeap
[17] Lawrence et al UK Acid Deposition Monitoring Network: Data Summary 2007
http://www.airquality.co.uk/reports/cat04/0812231140_Acid_dep_2007_Issue_1.pdf
[18] Review of Transboundary Air Pollution (RoTAP)
http://www.rotap.ceh.ac.uk/documents

Table 6.3.1. NO_2 annual average concentration 2007 at rural monitoring sites

Site	NO_2 ugm^{-3}
Loch Dee	3.3
Eskdalemuir	4.2
Whiteadder	-
Loch Chon	-
Balquhidder 2	2.7
Polloch	2.2
Lochnagar	-
Glensaugh	3.9
Allt a' Mharcaidh	2.0
Strathvaich Dam	1.8
Forsinain	2.6

Acid Gas and Aerosol Network (AGANET)

The UK Acid Gases and Aerosols Monitoring Network has been in operation since September 1999, providing monthly measurement data of acid gases and aerosols.

An extension of the CEH DEnuder for Long Term Atmospheric sampling (DELTA) system at the network sites is used to additionally sample gaseous HNO_3, SO_2, HCl and particulate NO^{3-}, SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+}. The new expanded network includes measurements of gaseous SO_2 and particulate SO_4^{2-} .

The RoTaP Consultation Draft Report (reference 18) states that “concentrations of sulphur dioxide in UK surface air have declined to values which no longer pose a direct threat to sensitive plant species” whereas, “within a 10-year period of measured [SO_4] aerosol concentrations in the UK there are no clear trends”. The report also states that “concentrations of oxidized nitrogen in surface air (as NO_2) have declined approximately in line with emission reductions”.

The 28 sites in this network located in Scotland are listed in Appendix 1

National Ammonia Monitoring Network (NAMN)

Established in 1996, the objectives of the network are to quantify temporal and spatial changes in air concentrations and deposition in NH3 and NH4+ (included since 1999) on a long term basis. The monitoring provides a baseline in the reduced nitrogen species (NH_3 + NH_4^+), which is necessary for examining responses to changes in the agricultural sector and to verify compliance with targets set by international agreements.

The RoTaP Consultation Draft Report (reference 18) states that “concentrations of reduced nitrogen (of NH_3) have changed little since 1990”.

The 28 sites in this network located in Scotland are listed in Appendix 1

7 Air Quality Mapping for Scotland

As part of the Scottish Air Quality Database project, AEA provide mapped concentrations of pollutants on a 1x1km square grid basis. These pollution maps combine measurement data with the 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 maps is based on that used for producing air pollution maps for the whole of the UK.

The are now sufficient monitoring sites in the SAQD for mapping to be undertaken for NOx, NO_2 and PM_{10} for Scotland using only the Scottish data. Hence the Pollution Climate Mapping methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2008 using measurements exclusively from Scottish air quality monitoring sites and Scottish meteorology. The maps provide spatial representation of the annual mean concentrations of:

- gravimetric equivalent PM_{10} concentration (PM_{10}), and
- NO_X and NO_2.

The pollutant data used in the mapping work presented here uses appropriately scaled PM_{10} monitoring data (FDMS, Partisol and VCM corrected TEOM data) and automatic monitoring data for NO_X and NO_2 in 2008, in conjunction with Scottish meteorology data (from RAF Leuchars) to create the Scotland-specific model. The model results have been compared with the measured concentrations in Scotland and with the UK model outputs.

In addition, following the short study described in Section 7.1, it was clear that source apportionment and forward year projection factors were also required for the Scottish pollution maps. Hence, for the first time, these have now been calculated, using data specific for Scotland. Whilst it was not possible, this year, to provide these data in time for use by Scottish Authorities for their Local Air Quality Management Review and Assessment reports, now that the methodology has been established we propose to provide these data in good time in future years.

7.1 LA study into use of maps

As part of the Scottish Air Quality Database contract, AEA undertook additional investigation of air quality mapping throughout Scotland[19]. In 2008, this work focussed on using the additional PM_{10} and $PM_{2.5}$ data from the Scottish Partisol monitoring programme to produce Scotland specific maps for these pollutants.

These Scotland specific maps showed generally good agreement with the corresponding UK maps. However, there were some differences and AEA were requested to liaise with four Scottish Local Authorities to investigate the possible effect of these differences on the Local Air Quality Management (LAQM) process in Scotland. The four Local Authorities were two with long term exceedences and declared Air Quality Management Areas (AQMA) for PM_{10} (Glasgow and N. Lanarkshire) and two with borderline concentrations compared to the Scottish Air Quality Objectives for PM_{10} (Edinburgh and East Renfrewshire).

The study showed that:

- The main use of the background PM_{10} maps by Local Authorities has been to roll forward 2008 measured concentrations to estimated 2010 concentrations for comparison with the Scottish Air Quality Objective
- To undertake this calculation, the source apportionment and forward projection factors are required for each square in addition to the mapped total PM_{10} concentration. This breakdown of the total mapped PM_{10} concentration has not been undertaken previously on a Scotland specific basis.

[19] Investigation of the possible effect of the use of Scottish Specific Air Quality Maps in the LAQM process in four selected Local Authorities
http://www.scottishairquality.co.uk/documents/reports2/258100203_LA_mapping_Report_Issue_1_FINAL.PDF

- However, use of the Scotland specific maps for forward projection in the 4 example authorities showed only very small differences compared to the use of the UK map data. These differences were generally smaller than rounding errors introduced when monitored concentrations are reduced to integer values.

- For comparison of the Scottish and UK mapping methodology alone, the 2007 Scottish maps have been compared with UK maps for 2007. These correlations show very little difference between the two techniques (generally less that 1μgm^{-3}, with the Scottish map generally showing lower results)

- However, the UK map data available to Local Authorities on www.airquality.co.uk are based on 2006 maps projected forward to future years. These are the only data available to Local Authorities at present and hence, in assessing the overall difference to Authorities in using Scottish map data for their 2007 Updating and Screening assessment, the comparison between the UK map data available on www.airquality.co.uk and the Scottish map data have also been plotted. This shows slightly larger differences than between the mapping methodology alone (see above). The difference is more in the range 1-2μgm^{-3}, again with the Scottish maps giving lower results.

The results of this investigation provided useful information to inform the discussion on the requirements for pollution mapping in Scotland in future years. As a result of these discussions, Scotland specific source apportionment and forward projection factors based on the Scottish maps for 2008 will be calculated as part of the current project

7.2 Air Quality Maps for Scotland 2008

The details of the methodology and full results of the mapping study are provided in a separate report[20]. In this report, we summarise the main findings of this work.

7.2.1 PM_{10} maps for 2008

Annual mean concentrations of PM_{10} have been modelled for Scotland for 2008 at background and roadside locations. The modelling methodology used to calculate the annual mean PM_{10} concentration is broadly similar to that used in the previous year and used a mixture of appropriately scaled PM_{10} monitoring (FDMS, Partisol and VCM corrected TEOM) data. Many of the chemical components of the PM_{10} model are not affected by the Scotland-specific changes to the UK Pollution Climate Mapping (PCM) model. This includes the contribution to the total PM_{10} mass from the following components:

- secondary inorganic aerosols (e.g., sulphate, nitrate, ammonium)
- secondary organic aerosols
- long range transport primary component
- sea salt contributions, and
- iron and calcium associated dusts.

Maps of modeled PM_{10} concentrations throughout Scotland for background and roadside locations respectively are shown in Figures 7.1 and 7.2.

[20] Lingard, J. Scottish air quality modelling for 2008 and projected concentrations for 2010, 2015 and 2010: annual mean PM_{10}, NOx and NO_2. AEAT/ENV/R3030 Issue 1 – To be published

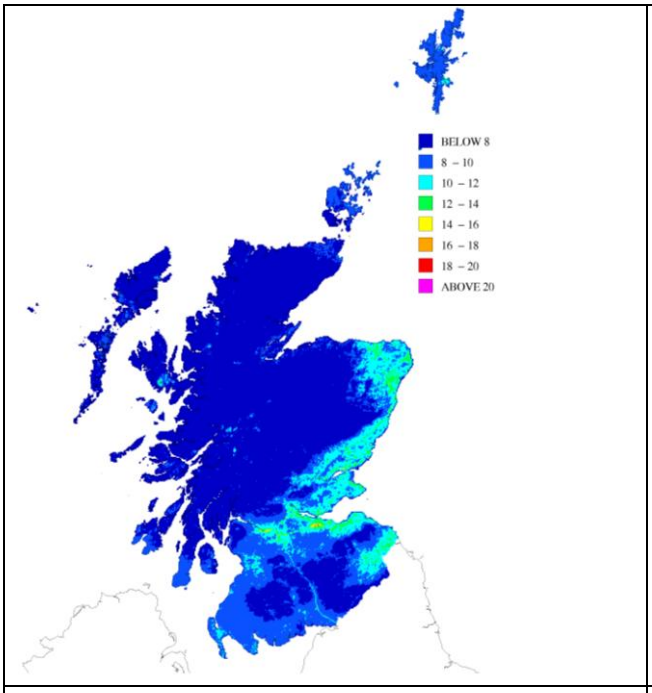


Figure 7.1 Background PM_{10} map for 2008, μgm^{-3} (Scotland-specific model).

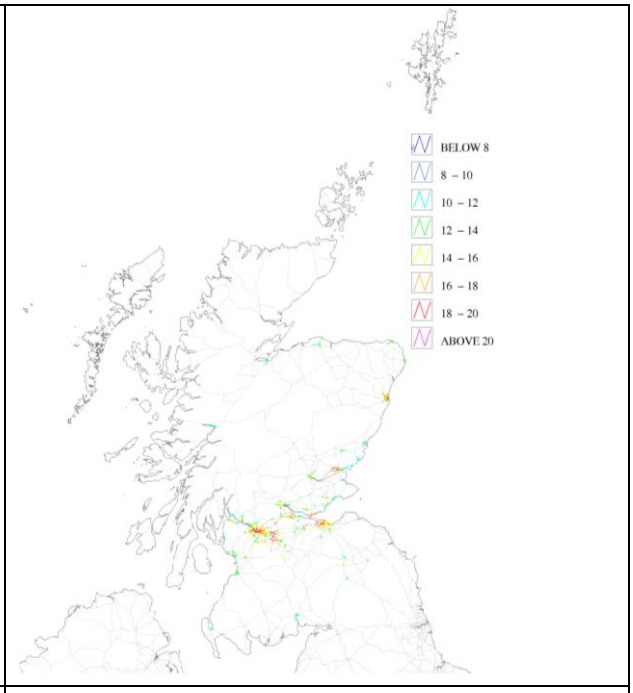


Figure 7.2 Roadside PM_{10} map for 2008, μgm^{3} (Scotland-specific model).

7.2.2 NO_2 maps for 2008

The annual mean NO_2 concentration for Scotland for 2008 was modelled at background and roadside locations. Figure 7.3 and Figure 7.4 present maps of annual mean NO_2 concentrations for these locations in 2008.

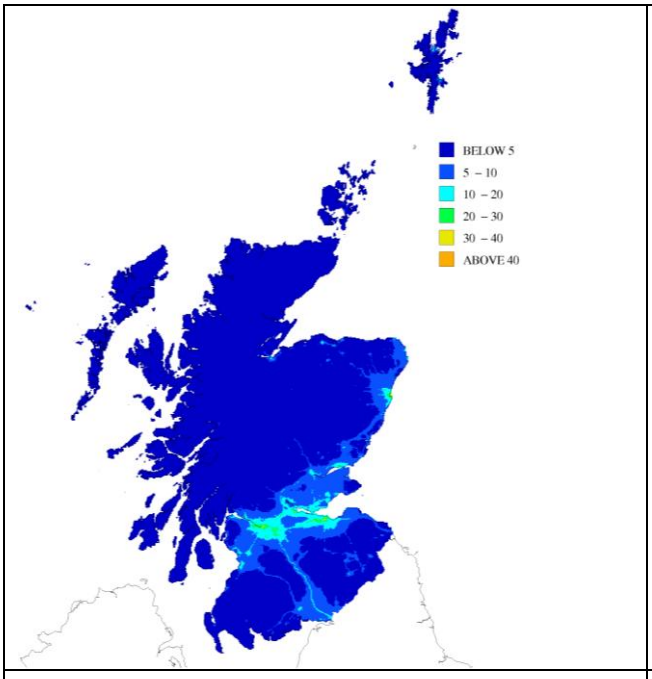


Figure 7.3 Background NO_2 map for 2008, μgm^{-3} (Scotland-specific model).

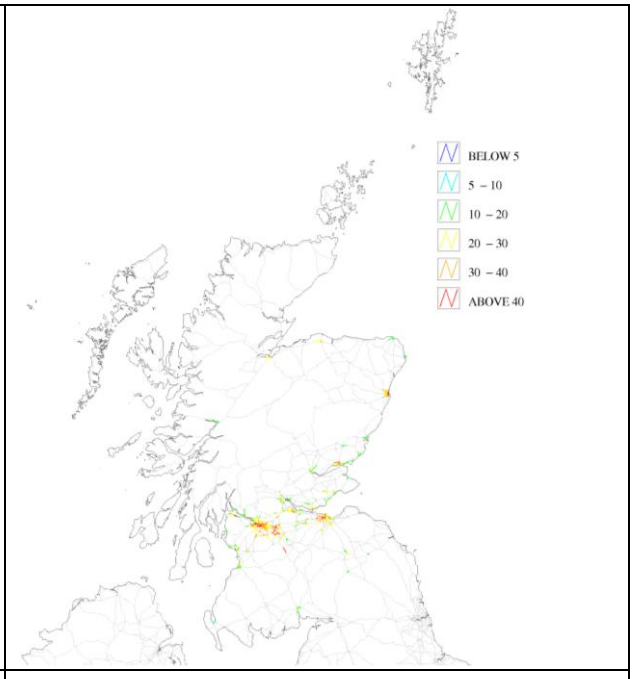


Figure 7.4 Roadside NO_2 map for 2008, μgm^{-3} (Scotland-specific model).

7.2.3 PM_{10} Scotland-specific pollutant projections for 2010, 2015 and 2020

Projected annual mean concentrations of PM_{10} for 2010, 2015 and 2020, from a base year of 2008, are presented for the purpose of forward projection assessment. The projected background annual mean concentrations were produced using the UK methodology, but as with the modelled Scottish annual mean concentrations for 2008, these were prepared using Scotland-specific data

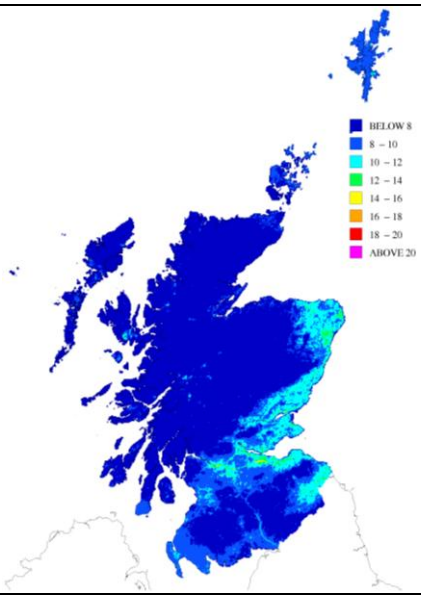


Figure 7.5 Background PM_{10} map for 2010, μgm^{-3} (Scotland-specific model).

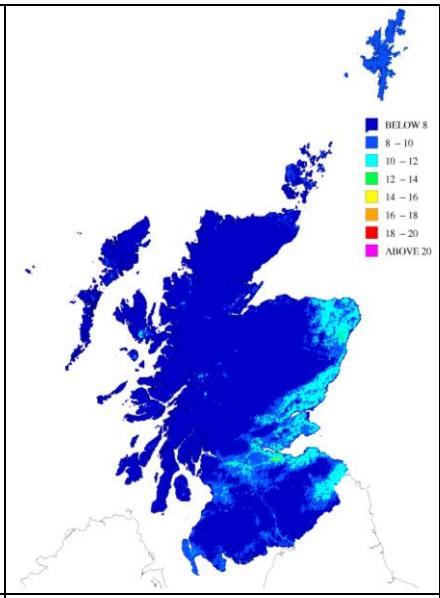


Figure 7.6 Background PM_{10} map for 2015, μgm^{-3} (Scotland-specific model).

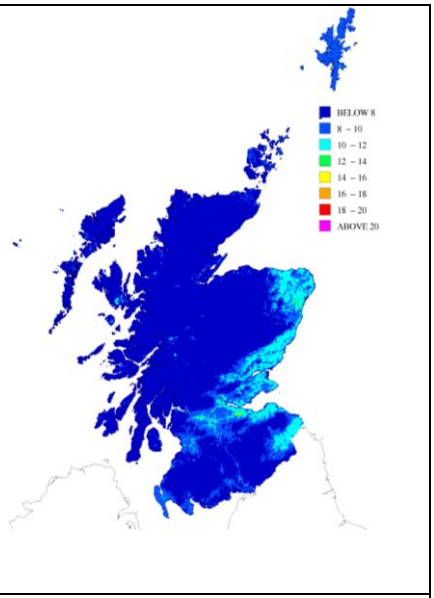


Figure 7.7 Background PM_{10} map for 2020, μgm^{-3} (Scotland-specific model).

Figure 7.5, Figure 7.6 and Figure 7.7 provide background maps of projected annual mean PM_{10} concentrations for 2010, 2015 and 2020 based on the 2008 Scotland-specific model. The projected background maps show a progressive decrease in the background annual mean PM_{10} concentration to below 8 μgm^{-3} between 2008 and 2020 for the majority of Scotland which is expected due to the predicted reduction in primary PM_{10} emissions, and consequentially secondary PM_{10} formation, over the next 12 years. High (10-14 μgm^{-3}) PM_{10} concentrations were projected to persist for the eastern coast of Scotland. This is believed to be due to enhancements in the annual mean background PM_{10} concentrations due to contributions from wind-blown soil dusts.

However, the accuracy of the forward projection maps presented here is closely dependent on the future emission projections used to prepare the background pollutant maps (see main report of the mapping work, reference 20, for more details).

7.2.4 NO_2 Scotland-specific pollutant projections for 2010, 2015 and 2020

As for PM_{10}, projected annual mean concentrations of NO_X and NO_2 for 2010, 2015 and 2020, from a base year of 2008, are presented for the purpose of forward projection assessment. The projected background annual mean concentrations were produced using the UK methodology, but as with the modelled Scottish annual mean concentrations for 2008, these were prepared using Scotland-specific data.

Figure 7.8, Figure 7.9 and Figure 7.10 provide background maps of projected annual mean NO_2 concentrations for 2010, 2015 and 2020 based on the 2008 Scotland-specific model. As with PM_{10}, the projected background maps for NO_2 show a progressive decrease in the background annual mean concentration between 2008 and 2020 due to the predicted reduction in primary NO_X and oxidant emissions, which contribute to the formation of NO_2

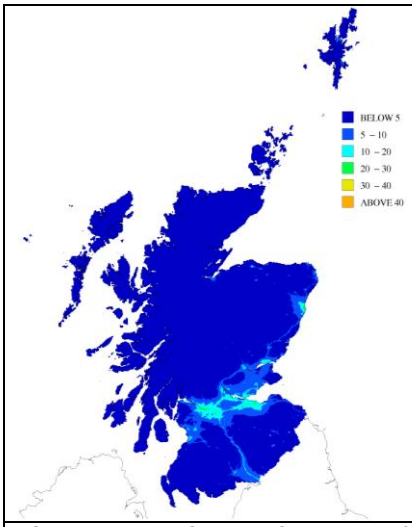


Figure 7.8 Background NO_2 map for 2010, μgm^{-3} (Scotland-specific model).

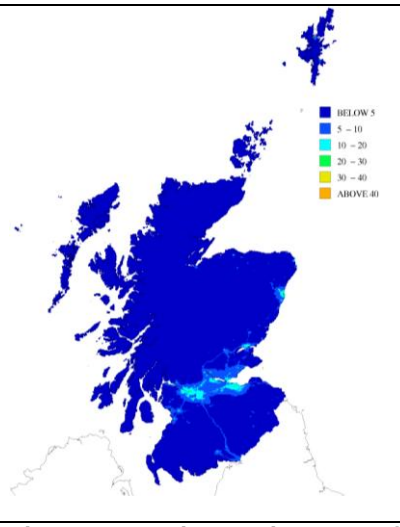


Figure 7.9 Background NO_2 map for 2015, μgm^{-3} (Scotland-specific model).

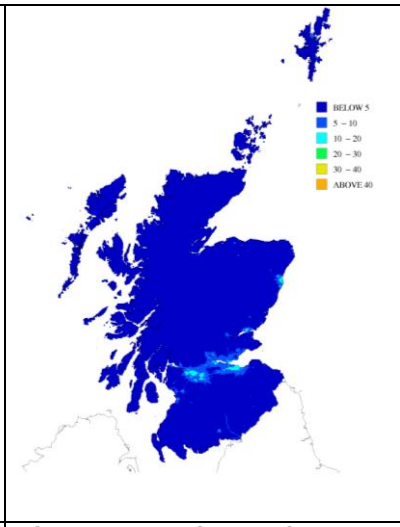


Figure 7.10 Background NO_2 map for 2020, μgm^{-3} (Scotland-specific model)

However, the accuracy of the forward projection maps presented here is closely dependent on the future emission projections used to prepare the background pollutant maps (see main report of the mapping work, reference 20, for more details).

8 Air Quality Trends for Scotland

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 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.

8.1 Nitrogen Dioxide (and Oxides of Nitrogen)

Within Scotland (and elsewhere across the UK) the largest number of AQMA's 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 earlier in Section 6 of this report). 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 to NO_2 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 8.1 below presents the annual mean variation in measured NO_x 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 NO_x concentrations thanks to the reductions in emissions from combustion sources which UK and EC policies have delivered.

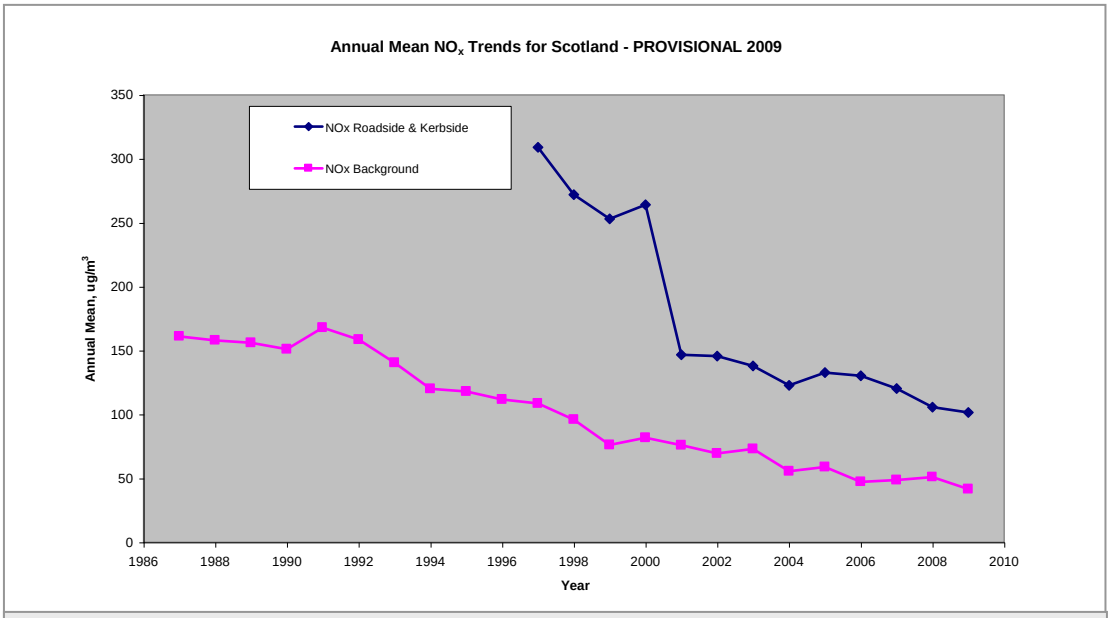


Figure 8.1 – Trends in NO_x annual means at urban background and roadside sites in Scotland: 1987 - 2009.

Figure 8.2 below shows the corresponding trends for NO_2, and also indicates a long-term decline in concentrations of this pollutant. In this case 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. 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 $\mu g/m^{-3}$ 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:

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

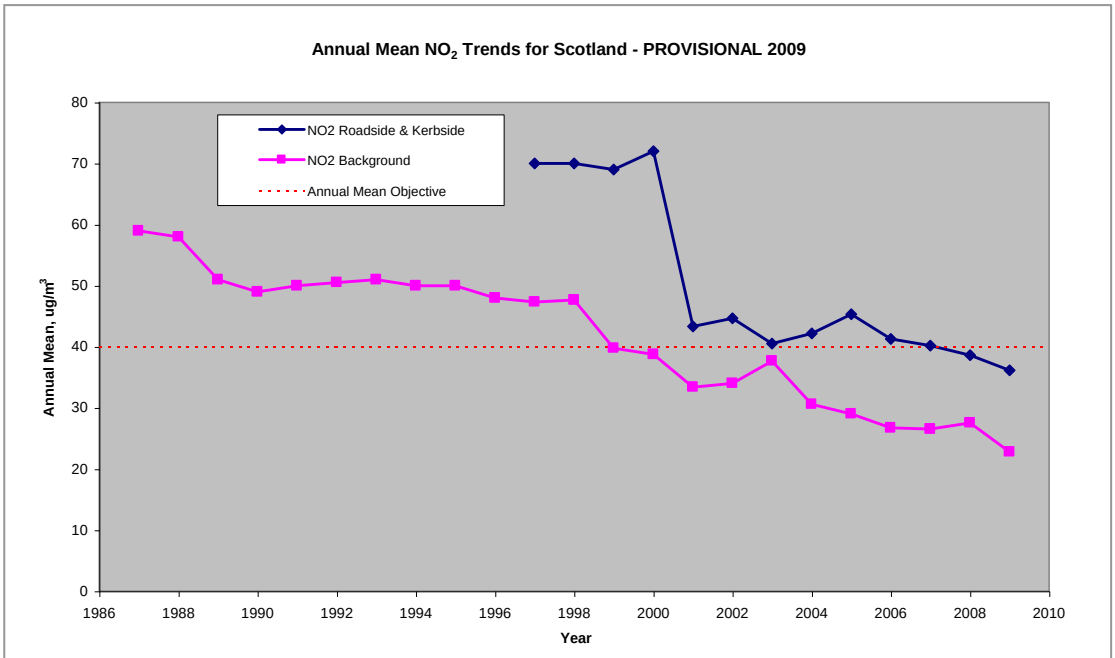


Figure 8.2: Trends in NO_2 annual means at urban background and roadside sites in Scotland: 1987 - 2009.

8.2 Particulate Matter (PM_{10})

Trends in PM_{10} particulate matter across Scotland are illustrated in Figure 8.3. These are of great interest since:

a) Scotland has adopted a more stringent annual mean PM_{10} objective than the rest of the UK for 2010, at 18μgm^{-3}
b) 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 reduction in urban background PM_{10} concentrations since 1992, but that for the last few years concentrations have hovered around the 18μgm^{-3} annual mean objective level. Once again there is encouragement in that the 2009 figures show that average background PM_{10} concentrations across Scotland are below the 18μgm^{-3} objective.

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:

a) 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.

b) 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 8.1 below. Current policy is to include all data in the analysis, but this may affect the robustness of the underlying trend.

Table 8.1: Increasing number of PM_{10} Kerbside/Roadside Monitoring Sites in Scotland: 2004 - 2009.

Year	2004	2005	2006	2007	2008	2009
Number of Sites	5	13	18	27	41	49

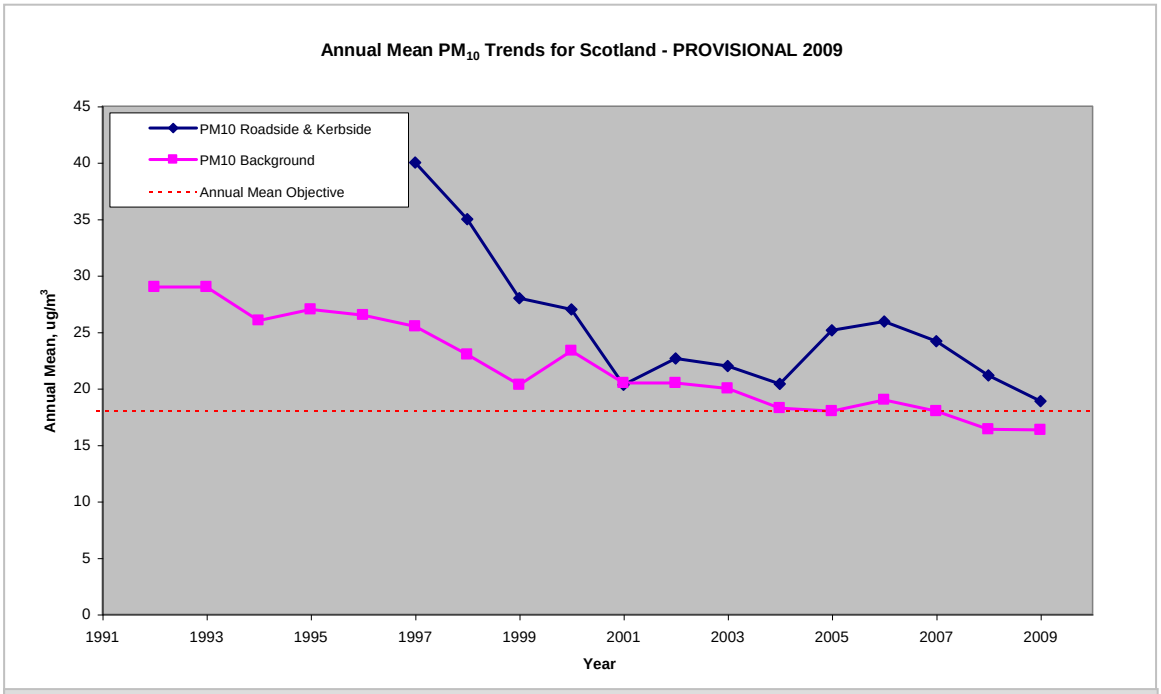


Figure 8.3 Annual Mean PM_{10} Concentrations in Scotland at urban background and roadside/kerbside locations from 1992 to 2009.

8.3 Ozone

Finally, Figure 8.4 below illustrates the increase in background ozone which is small but detectable at rural and remote locations, but dramatic and clear at urban background locations in Scotland. This is largely due to the reduction in NO_x concentrations in urban areas.

Whilst the reduction of ozone concentrations is outside the control of local authorities, and even Scottish Government to a certain extent, it is an extremely important pollutant in terms of health impacts, and the increasing concentrations, in urban areas in particular, are of concern.

8.4 Air Quality Management Areas

The number of Air Quality Management Areas (AQMAs) in Scotland continues to increase – 14 in 2007, 20 in 2008 and 21 in 2009. As the vast majority of these are for exceedences of the NO_2 and PM_{10} objectives, this may initially seem to conflict with the overall downward trend in the concentration of these pollutants averaged across all monitoring sites in Scotland (Sections 8.1 and 8.2 respectively). However, the increase in management areas reflects the continuing diligence of Local Authorities in undertaking Local Air Quality Management duties and continuing to investigate in more detail pollutant concentrations within their areas. As this work continues, additional excedence areas,

sometimes quite small in extent, are being identified and these are leading to additional AQMAs. Note that though there is a UK wide Air Quality Objective for Ozone, this has not been prescribed in the regulations for Local Air Quality Management and hence, Local Authorities are not required to assess or set AQMA's for this pollutant.

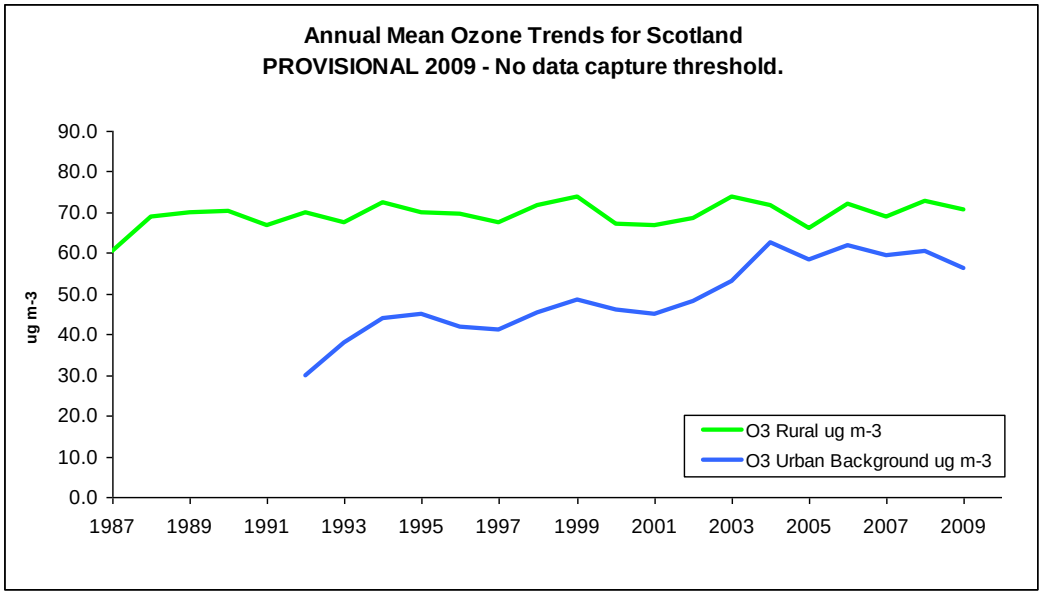


Figure 8.4: Trends in Ozone at Rural and Urban Background Sites in Scotland: 1987 - 2009.

9 Emissions of Pollutant Species

In this chapter we provide information on emissions of pollutants into the atmosphere in Scotland. The UK National Atmospheric Emissions Inventory (NAEI) calculates total emissions for the UK from a comprehensive range of sources including industry, domestic, transport etc. The UK inventory is now dissagregated into the UK constituent countries[21]. The inventory covers a wide range of pollutants, but in this report we provide information on NO_2 and PM_{10} only. Information on other pollutants can be found at www.naei.org.uk .

Within Scotland, SEPA collate the detailed information on emissions from industrial sources – this includes emissions to water and soil as well as to air – into the Scottish Pollution Release Inventory (SPRI). A summary of the SPRI air releases is available in the SEPA National Air Quality Report 2008[22] and full details are available on the SEPA SPRI database http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx . There is also a link to the SEPA SPRI website on the home page of www.scottishairquality.co.uk . The data from the SPRI form the basis of the industrial emission data for Scotland which are incorporated into the NAEI.

Information provided in Section 9.2 of this report on the main industrial emissions of NOx and PM in Scotland are reproduced from the SEPA National Air Quality Report, with permission from SEPA.

Note that emissions data are only available for 2007, whereas monitoring data are available for 2009. This reflects the inherent time lag in assimilation and reporting of emissions data.

9.1 NAEI data for Scotland

The National Atmospheric Emissions Inventory (NAEI) data for Scotland are reported using the Nomenclature for Reporting (NFR) format. The Nomenclature for Reporting is a reporting structure that was introduced in 2001 and is used for submitting data to international organisations such as the United Nations Economic Commission for Europe (UNECE) and the European Monitoring and Evaluation Programme *(*EMEP).

9.1.1 Scotland NO_X Inventory by NFR Sector, 1990-2007

The table and graph below provide a summary of the NO_X emissions in Scotland by broad NFR sector categories. The detailed data are available in the report and website cited in the introduction to this Chapter.

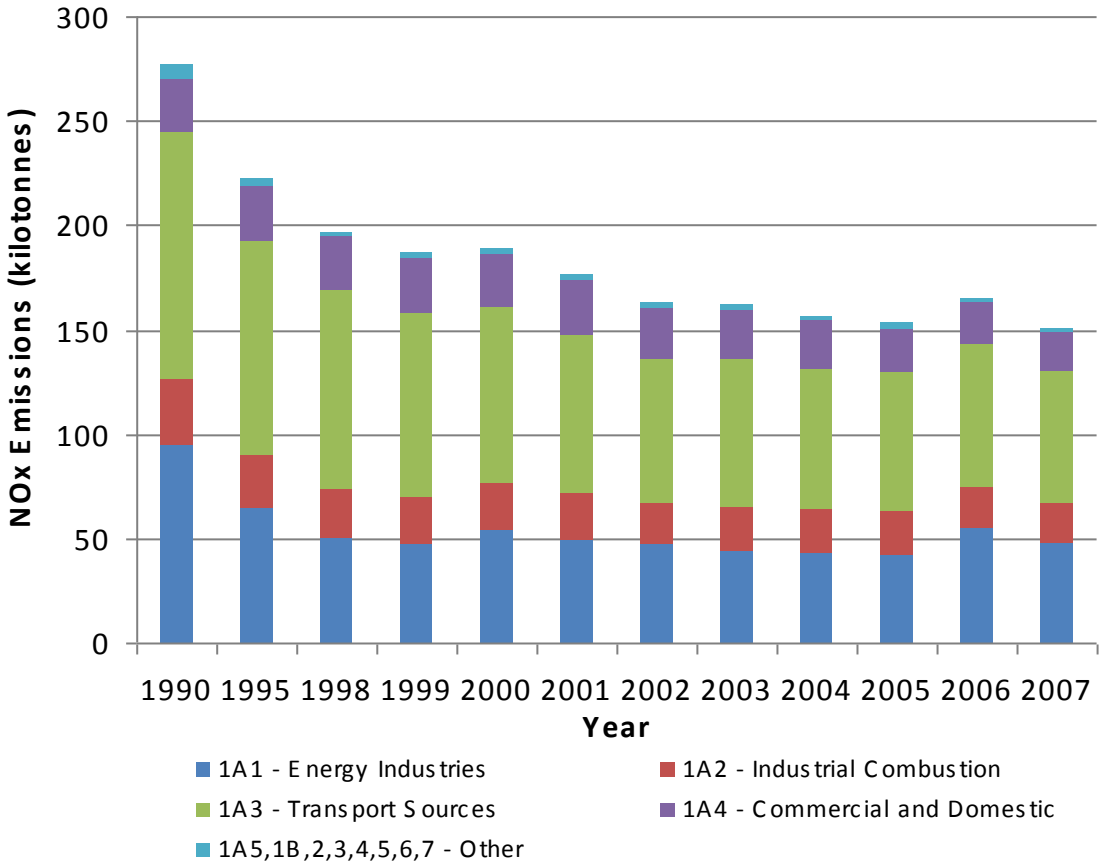
Table 9.1.1 - Scotland emissions of NO_x by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	95	64	50	47	54	49	47	44	43	43	55	48	32%
1A2 - Industrial Combustion	31	26	24	23	23	23	21	21	21	21	20	19	13%
1A3 - Transport Sources	119	103	94	88	84	76	69	71	68	66	68	63	42%
1A4 - Commercial and Domestic	26	26	26	26	25	25	24	23	22	21	20	18	12%
1A5,1B,2,4,5,6 – Other	6	4	3	3	3	3	3	2	3	3	3	2	2%
Total	277	222	197	187	189	177	163	162	157	154	165	151	100%

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007

[21] Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007
http://www.airquality.co.uk/reports/cat07/0910211141_DA_AQ_Inventory_Report_2007_maintext_Issue1.pdf

[22] SEPA's National air quality report 2008
http://www.sepa.org.uk/air/air_publications.aspx



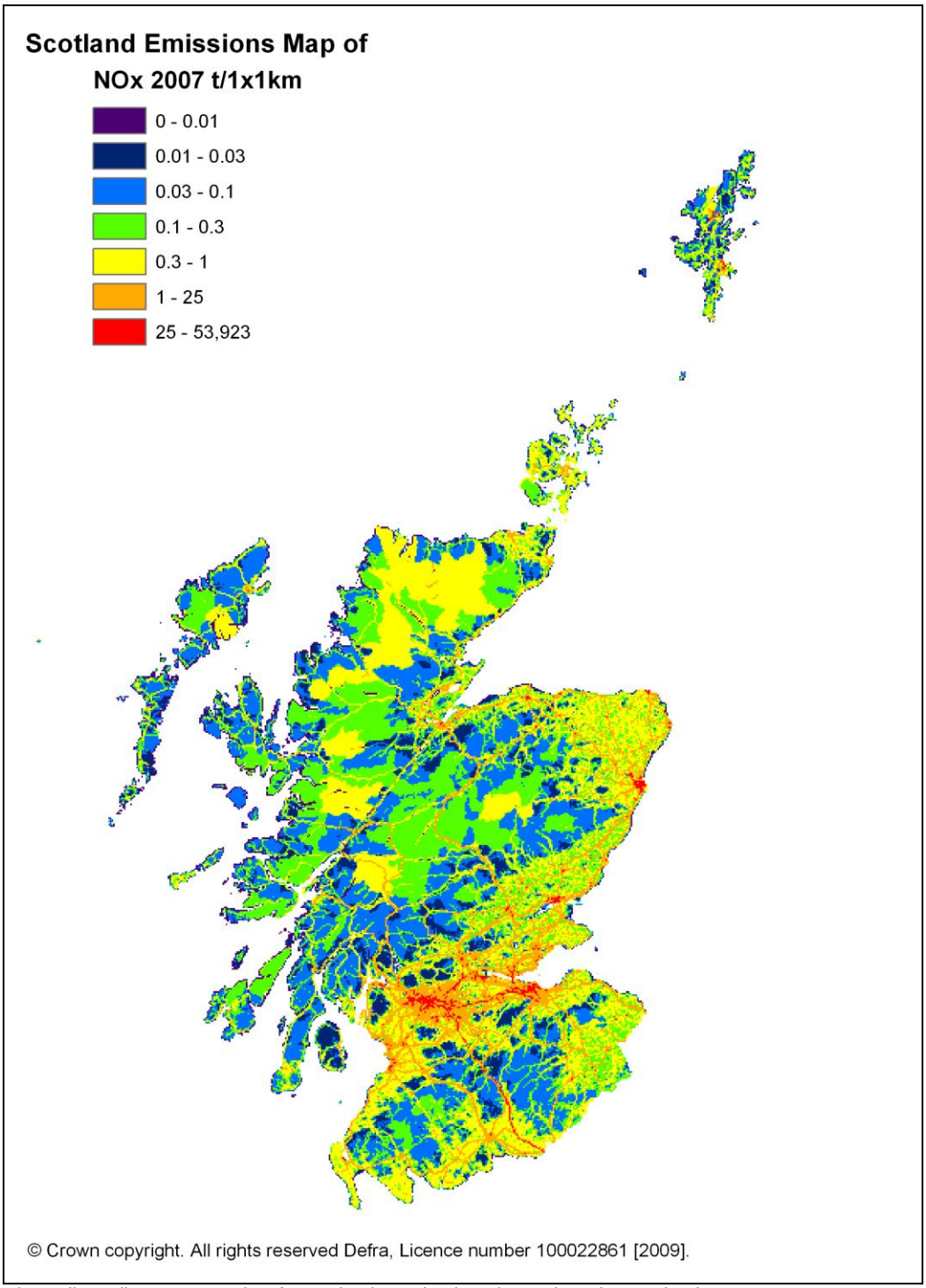
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007

Figure 9.1.1- Time series of Scotland NO_x emissions 1990-2007

Scotland's NO_X emissions have declined by 45% since 1990 and currently account for 10% of the UK total. Power generation is a very significant source, accounting for 28% of the Scotland total in 2007; emissions from this source have reduced by 51% since 1990. Recent trends in electricity generation have had a noticeable impact on the inventory; In Scotland, coal-fired generation increased by over 40% between 2005 and 2006 (12,092 GWh to 17,488 GWh), and then reduced by over 20% between 2006 and 2007 (to 13,802 GWh). The impact of the changes in contributions from coal-powered generation is reflected in the increased emissions of NO_X from Scotland in 2006 with a subsequent decline in emissions in 2007 (Figure 9.1.1).

A further 26% of NO_X emissions in Scotland arise from road transport combustion sources (1A3bi-iv: down by 59% since 1990), 13% stem from industrial combustion (1A2: down 39% since 1990) and 6% is from residential combustion sources (1A4bi: down 3% since 1990).

Increases in emissions are only apparent in relatively minor source sectors such as domestic and international aviation landing and take off (LTO) (1A3ai(i): up by 210% since 1990 and 1A3aii(i): up by 74% since 1990 in 2007). Combined, these sources account for less than 1% of the emissions in Scotland in 2007.



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007

Figure 9.1.2 Map of NOx Emissions in Scotland, 2007

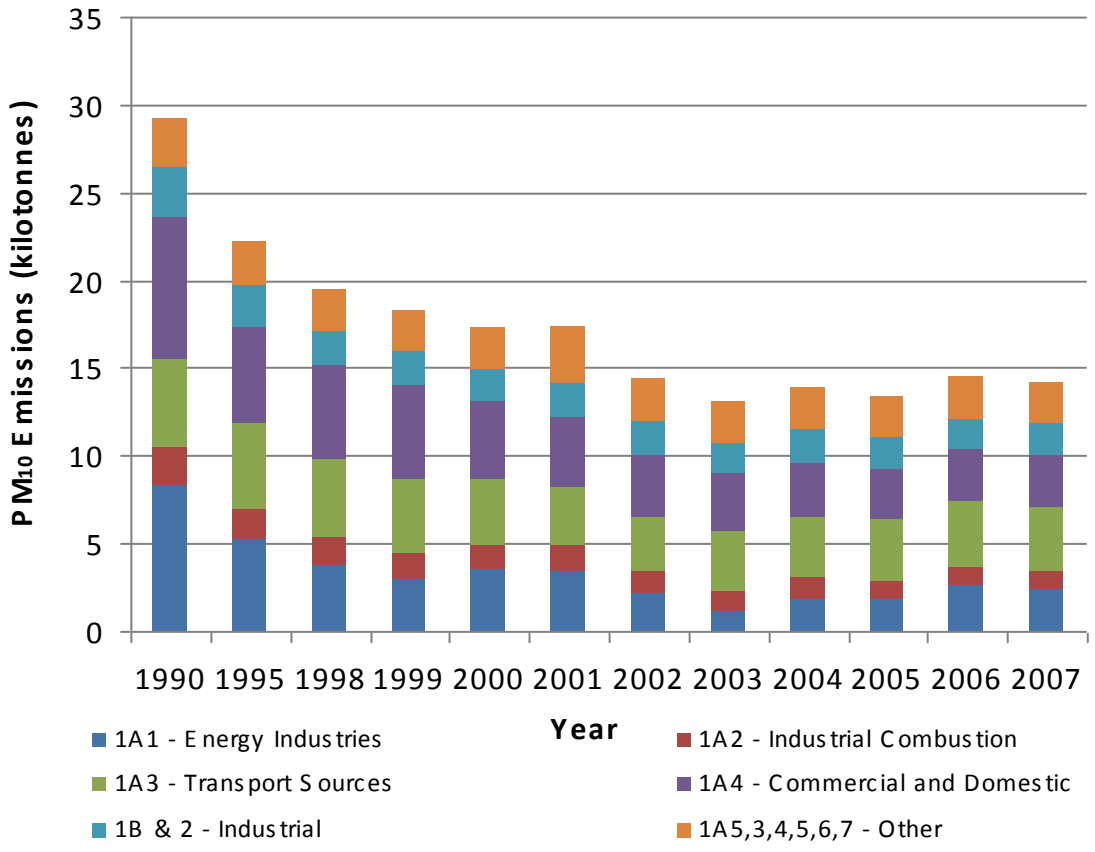
9.1.2 Scotland PM_{10} Inventory by NFR Sector, 1990-2007

The table and graph below give a summary of the PM_{10} emissions in Scotland by broad NFR sector categories. The detailed data are available in report and website cited in the introduction to this Chapter.

Table 9.1.2 - Scotland emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007 (%)
1A1 - Energy Industries	8.3	5.2	3.8	3.0	3.6	3.5	2.2	1.1	1.8	1.8	2.6	2.4	17%
1A2 - Industrial Combustion	2.2	1.7	1.5	1.4	1.4	1.4	1.2	1.2	1.2	1.1	1.1	1.1	8%
1A3 - Transport Sources	5.0	5.0	4.4	4.2	3.7	3.4	3.1	3.4	3.4	3.5	3.7	3.6	26%
1A4 - Commercial and Domestic	8.2	5.4	5.4	5.4	4.5	4.0	3.5	3.3	3.1	2.9	2.9	3.0	21%
1B & 2 – Industrial	2.8	2.4	1.9	1.9	1.8	1.9	1.9	1.8	1.9	1.8	1.8	1.7	12%
1A5,3,4,6,7 – Other	2.7	2.5	2.4	2.3	2.5	3.2	2.4	2.4	2.5	2.4	2.3	2.3	16%
Total	29	22	20	18	17	17	14	13	14	13	14	14	100 %

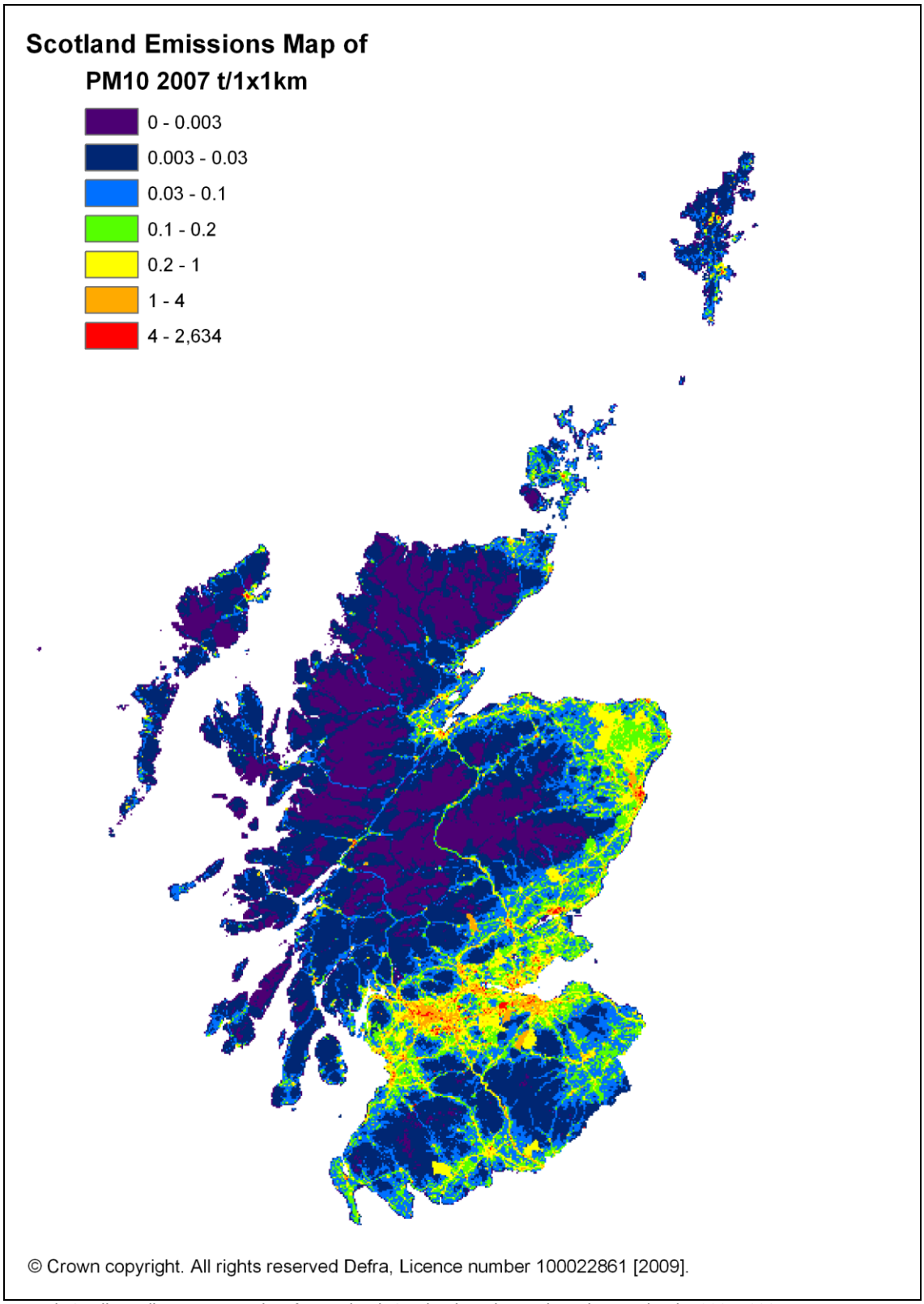
Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007

Figure 9.1.3 - Time series of Scotland PM_{10} emissions 1990-2007

Scotland's PM_{10} emissions have declined by 52% since 1990 and account for 10% of the UK total. 26% of PM_{10} emissions in Scotland come from transport sources (down by 27% since 1990), whilst 21% stem from commercial and residential combustion (mainly of coal and solid fuels, down by 63% since 1990). Emissions from power generation (1A1a) were 25% of the Scotland total emission in 1990, but have been reduced to 15% of the Scotland total in 2007. Reduction in emissions from the iron & steel combustion sector (1A2a) of 99.8% over 1990-2005 are primarily due to the closure of the Ravenscraig steelworks in 1992.



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2007

Figure 9.1.4 Map of PM_{10} Emissions in Scotland, 2007

9.2 SEPA SPRI data for Scotland (Releases to Air)

The SEPA National air quality report 2008 summarises information from the more detailed pollutant release data from regulated processes in Scotland, which are available on the SPRI website (http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx. The sections below provide information on the largest industrial sources of NOx and PM_{10}. Note, however, that these releases generally arise from tall chimneys and are well dispersed before reaching ground level. In towns and cities, more local emissions at low level from, for example, vehicles may be much more significant in relation to the contribution to ambient pollution concentrations.

9.2.1 Industrial sources of NOx in Scotland

The majority of Scotland's industrial NOx emissions are generated in east central Scotland, where the largest emitters of NOx are the Longannet and Cockenzie power stations near Edinburgh. The annual mass emissions from the 10 largest industrial sources of NOx in Scotland are given below in Table 9.2.1.

Table 9.2.1 Largest industrial sources of NOx emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Cockenzie Power Station	10,700	12,100	11,400	20,294	22,054
Scottish Power Generation Ltd, Longannet Power Station	23,500	19,400	19,087	22,731	14,876
INEOS Manufacturing Scotland Ltd (Chemicals),Grangemouth	1,120	1,110	1,323	1,110	3,247
INEOS Manufacturing Scotland Ltd (Refinery),Grangemouth	5,250	3,269	3,349	3,466	3,047
Scottish and Southern Energy, Peterhead Power Station	1,990	1,980	2,130	2,750	2,110
Scottish & Southern Energy Plc, Lerwick Power Station	2,650	1,530	1,946	1,643	1,676
Lafarge Cement UK, Dunbar Works	1,110	1,695	1,270	1,221	1,459
Ardagh Glass Ltd, Irvine	962	638	475	742	994
Shell UK Ltd, St Fergus Gas Plant	102	992	1,010	922	899
ExxonMobil Chemical Ltd, Mossmorran	1,500	1,840	1,594	1,651	798
O – I Manufacturing UK Ltd, Alloa	807	784	777	821	792

Source SEPA's National air quality report 2008

9.2.2 Industrial sources of PM_{10} in Scotland

The majority of the PM_{10} emitted from industrial processes in Scotland are generated in east central Scotland, with the largest contributions coming from the power generation sector. However, SEPA state that there is no evidence to show that these sources are having a detrimental impact on local air quality. Table 9.2.2 lists the annual mass emissions from the 10 largest industrial sources of PM in Scotland.

Table 9.2.2 Largest industrial sources of PM10 (and smaller PM) emissions in Scotland (tonnes/yr)

Source	2002	2004	2005	2006	2007
Scottish Power Generation Ltd, Cockenzie Power Station	637	738	697	1,257	1,323
Scottish Power Generation Ltd, Longannet Power Station	1,140	700	662	943	555
INEOS Manufacturing Scotland Ltd (Refinery), Grangemouth	212	202	191	194	200
INEOS Manufacturing Scotland Ltd (Chemicals), Grangemouth	244	235	253	158	144
Lafarge Cement UK, Dunbar Works	70	103	33	65	122
The Cheese Company, Lockerbie Creamery	N/A	BRT	BRT	95	98
The Caledonian Cheese Company Ltd, Stranraer	N/A	N/A	BRT	BRT	73
Scottish & Southern Energy, Peterhead Power Station	No data	20	67	64	68
O – I Manufacturing UK Ltd, Alloa	No data	72	68	54	55
Norbord Ltd, Pulp and Board Plant, Cowie	No data	76	159	140	51

Note: BRT = Below Reporting Threshold
Source SEPA's National air quality report 2008

10 Clean Air Act

As part of the SAQD contract during 2009, AEA has undertaken a review on behalf of Scottish Government to assess the Clean Air Act 1993. This review[23] is prompted by the need to update the Clean Air Act so that it can become the effective legislative measure to ensure that the use of biomass combustion can be rolled out in a manner which takes full account of possible air quality issues associated with biomass burning.

The report also examined issues for the assessment of emissions from biomass combustion plant. In particular, the study has examined:

- Interim administrative measures which would support the implementation of the Clean Air Act 1993 in the absence of Parliamentary time to alter the Act itself
- Sections of the Clean Air Act to identify where change may be desirable and to provide suggestions as to the types of change Scottish Government may wish to consider to reduce the barriers to biomass uptake while protecting public health
- Tools to assist Local Authorities, industry planners and other stakeholders in Scotland to implement biomass heating in an appropriate manner
- Measurement methods for particle matter; including a suggested test programme to explore the significance of differences in measurements. The aim here being to enable appliances tested to non-UK Standards to be assessed against objective criteria
- Measurement methods for oxides of nitrogen emissions
- Measurement protocols for solid fuel appliances.

The report summarises the findings of the study in a series of recommendations for consideration by Scottish Government.

[23] Support to Scottish Government on the Clean Air Act
http://www.scottishairquality.co.uk/documents/reports2/288100630_CAA_SG_R_Issue1_final__30_June_2010_.pdf

11 Conclusions

AEA is continuing to develop an Air Quality Database and Website for Scotland on behalf of The Scottish Government. The web site and database are available at www.scottishairquality.co.uk.

During 2009, the database and website have been expanded and developed considerably- a number of new features such as the low graphics version, the mobile phone version and the capability for providing SMS text alerts have been added to the site. Comments and suggestions from stakeholders received during the annual seminar and at other times have also been incorporated.

Air pollution data for 79 automatic monitoring sites throughout Scotland are available in the database for all or part of 2009. This is an increase of 17 sites over 2008.

All automatic data within the Scottish database are subject to the same QA/QC procedures as at the national network air quality monitoring stations within the UK Automatic Urban and Rural Network. This ensures that all data in the database are quality assured and all traceable to UK national calibration standards for the various pollutants.

A summary of ratified data for 2009 is provided. Where exceedences of the Scottish Air Quality Objectives occur then these are in areas where the relevant Local Authority has already declared, or is in the process of declaring, an Air Quality Management Area. Where Air Quality Management Areas are declared then the Local Authority will produce an Air Quality Action Plan and undertake the necessary actions to move towards compliance with the Air Quality Objectives in the future.

We have also provided, in this report, a summary of data for a much wider range of pollutant species which are currently monitored within Scotland.

The data in the database have been utilised to provide information on nationwide pollution episodes and on trends in air quality over many years. In general, pollutant concentrations have decreased considerably – but levelled off in recent years. However, both NOx and PM_{10} overall average concentrations still show a continuing slight decrease.

For the first time, Scottish monitoring data have been used to produce pollution climate maps for both oxides of nitrogen and PM_{10}. In addition, also for the first time, source apportionment and annual projection factors, based on Scottish data, have been produced to accompany these maps.

As requested by Scottish Government, links have been established with the SEPA Pollution Release inventory for Scotland (SPRI). Links to the SPRI are now available from the Scottish air quality website and in this report we have included a summary of both the National Atmospheric Emissions Inventory data for Scotland and the SPRI data.

As an extension to the contract during 2009, AEA were requested to undertake a short study of the Clean Air Act. This legislation is seen as a vital tool to ensure that, in the medium and long term, biomass combustion can be rolled out in the UK without any serious degradation to air quality.

It is anticipated that the Scottish Air Quality Database and Website will continue to expand, though probably not at the same rate as in these first 3-years, and continue to provide a valuable national resource of air quality data for The Scottish Government, Local Authorities, health professionals, EIA and SEA practitioners. We also hope that the database and website will increasingly become a valuable education resource for schools and an information service for the general public.

Appendices

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Appendix 1
National Monitoring Network Sites in Scotland

Table A1.1. AURN Measurement Sites in Scotland 2009

Site Name	Site Type	Species Measured	Grid Reference
Aberdeen	URBAN BACKGROUND	NO NO_2 NO_X O_3 PM_{10}	394416,807408
Aberdeen Union St Roadside[1]	ROADSIDE	NO NO_2 NO_X	396345,805947
Auchencorth Moss	RURAL	O_3 PM_{10}(grav) $PM_{2.5}$(grav)	322050,656250
Bush Estate	RURAL	NO NO_2 NO_X O_3	324500,663500
Dumfries	ROADSIDE	CO NO NO_2 NO_X	297012,576278
Edinburgh St Leonards[2]	URBAN BACKGROUND	CO NO NO_2 NO_X O_3 PM_{10} $PM_{2.5}$ SO_2	326265, 673136
Eskdalemuir	RURAL	NO NO_2 NO_X O_3	323500,602800
Fort William	RURAL	NO NO_2 NO_X O_3	210830,774410
Glasgow Centre	URBAN CENTRE	CO NO NO_2 NO_X O_3 PM_{10} $PM_{2.5}$ SO_2	258902,665028
Glasgow City Chambers	URBAN BACKGROUND	NO NO_2 NO_X	259528,665308
Glasgow Kerbside	KERBSIDE	NO NO_2 NO_X PM_{10}	258708,665200
Grangemouth	URBAN INDUSTRIAL	NO NO_2 NO_X PM_{10} SO_2	293840,681032
Grangemouth Moray[3]	URBAN BACKGROUND	NO NO_2 NO_X PM_{10}	296436,681344
Inverness	ROADSIDE	PM_{10}(grav) NO NO_2 NO_X	265720,845680
Lerwick	RURAL	O_3	445337,113968
Peebles	SUBURBAN	NO NO_2 NO_X O_3	324812,641083
Strath Vaich	REMOTE	O_3	234787,875022

1 PM_{10} at this site is part of Scottish Government Network
2 PM_{10} at this site is part of Scottish Government Network.
3 SO_2 at this site is part of the Scottish Government Network

Table A1.2. Automatic Hydrocarbon Network Sites in Scotland 2009

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322050, 656250
Glasgow Kerbside	KERBSIDE	Benzene and 1,3-butadiene	258708, 665200

*EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.

Table A1.3. PAH Monitoring Sites in Scotland 2009

Site	Address	Grid Reference
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow	St Enoch Square Glasgow G2 8BX	258964, 665018
Kinlochleven 2	Electrical Substation Kinlochleven	219305,761905
Auchencorth Moss	Rural site in Scotland, south of Edinburgh	322050,656250

Table A1.4. Heavy Metals Monitoring Network Sites in Scotland 2009

Site	Site type and grid ref	Address	Metals measured
Eskdalemuir	Rural 323588,602997	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn
Motherwell	Urban Background 275764,656282	Civic centre, Motherwell	As, Cd, Cr, Cu, Fe, Hg[Vap + Part], Mn, Ni, Pb, Pt, V, Zn

Table A1.5. Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322000,656200
Banchory	Rural site, NE Scotland	NO676985

Table A1.6. Rural Metal Deposition Monitoring sites in Scotland 2009

Site	Location Grid Ref.	Heavy metals			Mercury	
		In Particles	In Rain	In Cloud	In Air	In Rain
Inverpolly	218776,908833		✓			
Banchory	367694,798519	✓	✓		✓	✓
Bowbeat	328289,647302		✓	✓		
Auchencorth Moss	322050,656250	✓	✓		✓	✓

Table A1.7. The Precipitation Network Sites in Scotland 2009 (formerly Acid Deposition Network)

Site Name	Grid Ref	Species included
Shetland - new	445449,113965	HNO_3, SO_2, HCl (gases) NO_3, NO_2, SO_4^{2-}, Cl^- (aerosols) Ca, Mg, Na (base cations)
Rum - new	140865,799220	
Halladale was Forsinain	290285,948838	
Strathvaich Dam	234787,875022	
Lagganlia - new	285684,803720	
Glensaugh	366329,780027	
Edinburgh St Leonards – new	326265, 673136	
Bush – new	324588,663503	
Auchencorth Moss – new	322188,656202	
Carradale - new	179870,637801	
Eskdalemuir	323588,602997	

Table A1.8. Acid Gas and Aerosol Network and Ammonia Network Sites in Scotland 2009

Name	Grid Ref	Ammonia	Nitric Acid
Shetland	445449,113965	✓	✓
Halladale	290285,948838	✓	✓
Inverpolly B	218776,908733	✓	
Strathvaich Dam	234787,875022	✓	✓
Ellon Ythan	394500,830400	✓	
Pitmedden	388300,827800	✓	
Lagganlia	285684,803720	✓	✓
Allt a Mharcaidh	289184,804320	✓	
Rum	140865,799220	✓	✓
Glensaugh	366329,780027	✓	✓
Glenshee Hotel	311187,769916	✓	
Glen Shee	312187,769016	✓	
Tummel	274483,761116	✓	
Rannoch	260380,753315	✓	
Loch Awe	196673,711509	✓	
Edinburgh Johnston Terrace	325389,673404	✓	
Edinburgh Medical School	326388,672605	✓	
Edinburgh St Leonards	326265, 673136	✓	
Bush 2	324789,663804	✓	
Bush 1	324671,663524	✓	✓
Auchencorth Moss	322188,656202	✓	✓
Carradale	179870,637801	✓	✓
Auchincruive B	238478,622899	✓	
Auchincruive 3	237977,623399	✓	
Sourhope	386796,621798	✓	
Eskdalemuir	323588,602997	✓	✓
Dumfries	254679,565792	✓	
Carradale	179870,637801	✓	✓

Appendix 2
Intercalibration, Audit and Data Ratification Procedures

A2.1 Intercalibration and Audit procedures

The audit and intercalibration procedures adopted by AEA rely upon the principle that a set of recently certified gas cylinders (called "audit gas") is taken to all the stations in a monitoring network. This gas is certified at the AEA Gas Calibration Laboratory. At each station, analyser response to audit gas is recorded to check if the expected concentration (i.e. the certified value for the cylinder) is obtained. The analyser response to audit gas is obtained using calibration factors obtained from the site operator. The audit procedure checks the validity of the provisional data, the correct overall operation of the analyser and the reliability of calibrations undertaken routinely at that station. These site audit procedures are compliant with the requirements of the CEN standard methods of measurement and are used throughout the UK AURN network.

The results of the audit exercises form an integral part of the data management system and are fed directly into the data ratification process.

After the audit exercise, data from all the stations visited are traceable to recently calibrated UKAS accredited gas calibration standards (the audit gas).

A2.1.1 Detailed instrumentation checks

The following instrument functional checks are undertaken at an audit:

- Analyser accuracy and precision, as a basic check to ensure reliable datasets from the analysers.
- Instrument linearity, to check that doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser is not linear, data cannot be reliably scaled into concentrations.
- Ozone analyser calibration against a traceable ozone photometer
- Instrument signal noise, to check for a stable analyser response to calibration gases.
- Analyser response time, to check that the analyser responds quickly to a change in gas concentrations.
- Leak and flow checks, to ensure that ambient air reaches the analysers, without being compromised in any way.
- NO_X analyser converter efficiency, via gas phase titration, to ensure reliable operation. The converter must be more than 95% efficient to ensure that the NO_2 data are of the required accuracy.
- TEOM k_0 evaluation. The factor is used to calculate particulate mass concentrations.
- Particulate analyser flowrates. Any error in the flow through these particulate analysers is directly reflected in an error in the final measure of particulate concentration.
- SO_2 analyser hydrocarbon interference, certain hydrocarbons are known to interfere with the SO_2 detector.
- Evaluation of site cylinder concentrations, with reference to the certified audit gas taken to the stations. This procedure allows for the correction of data from stations where the site calibration cylinder concentration is slowly changing and for identification of any unstable cylinders that require replacement.
- Assessing changes in local site environment. During the visit, a record of any changes in the site environment, for example any increase or decreased traffic flow due to road layout changes, construction activity, encroachment of the site by vegetation etc.
- Assessment of station infrastructure and operational procedures. Any deficiencies in site infrastructure or operational procedures, which may affect data quality or safe operation of the site, are noted.
- Ensure Local Site Operators (LSO) understand calibration procedures correctly. It is the calibrations by the LSOs that are used to scale pollution datasets and hence, it is important to check that these are undertaken reliably.

The procedures used to determine instrument performance are documented in AEA Work Instructions. These methods are regularly updated and improved and have been evaluated by the United Kingdom Accreditation Service (UKAS). Tests are performed on the analysers, cylinders and ambient air inlet systems. Checks are made on the environment around the site, including the continued representative nature of the site and safety assessments. The data collected from the instrument and cylinder tests are collated on site, using a controlled and protected Excel spreadsheet, which

automatically undertakes all calculations and alerts the audit staff to any unusual results. The completed spreadsheets are then returned for further checking, before being used within the data management process and in production of accredited Certificates of Calibration.

A2.1.2 UKAS Accreditation

AEA holds UKAS accreditation to ISO 17025 for the on-site calibration of the gas analysers (NO_X, CO, SO_2, O_3), for flow rate checks on particulate (PM10) analysers and for the determination of the spring constant, k_0, for the TEOM analyzer.

ISO17025 accreditation provides complete confidence that the analyser calibration factors are traceable to national metrology standards, that the calibration methods are sufficient and fit for purpose, and that the uncertainties are appropriate for data reporting purposes.

AEA also holds ISO17025 accreditation for laboratory certification of NO, NO_2, CO and SO_2 gas cylinders.

A2.1.3 Zero air

The reliability of the zero air supply at each station is of fundamental importance in the determination of ambient concentrations. A reference zero source is held at the AEA Gas Calibration Laboratory, which is traceable to international standards. A transfer standard, checked against this standard, is used to evaluate the site zero sources at the QA/QC audits. The zero air supply at a site will be either:

- A zero air cylinder.
- A series of chemical scrubbers, connected to a pumped delivery system.
- A pollutant specific chemical scrubber system to connect directly into the analyser.

A2.1.4 Ozone photometers

Ozone photometers are calibrated every six months against the NIST Reference Photometer, held at NPL, before use at the station audits.

A2.2 Data Acquisition and Processing

The Scottish local authority monitoring stations are polled three times a day to retrieve 15-minute averages of raw output from instruments. This is a balance between regular updating of the database and web site yet minimising the associated telecoms costs. UK National network stations are polled hourly as these data are used for the air quality forecast system.

The data are transmitted via MODEM or internet connection, depending on type of logging system used at the site, and automatically appended to the air quality site database.

The results of automatic overnight autocalibration checks are also retrieved and databased.

Appropriate scaling factors, based on the most recent calibration information are applied to the pollutant measurements to produce concentrations in the relevant units.

From the 15-minute values, the hourly averaged results are calculated. This is the averaging period used for the reporting of both validated and ratified data for all pollutants. Additionally the 15-minute data files are provided for SO_2 to allow direct comparison with the 15-minute objective.

Once the raw data from the stations has been acquired the next step in the data management process is data validation.

A2.2.1 Validation of Data

All incoming data from the monitoring station are automatically screened prior to the release of validated data sets. Experienced staff will check the data daily, to monitor satisfactory data acquisition and to investigate instances of suspect data. This daily checking ensures rapid diagnosis of any instrument malfunctions.

The automatic screening procedures, and many years experience of our staff, enables us to ensure that only the highest quality data are released to the Scottish Air Quality Database and Website as validated data.

Should equipment or site problems be identified, it is possible for data management staff to contact the monitoring station manually, in order to access further information. If necessary, the relevant LSO is contacted to undertake further investigation.

A2.3 Data ratification

This section provides details of the procedures and the software tools we use for data ratification.

Our software runs a number of protocols to automatically flag data anomalies in the provisional data received from the stations, these are examined in detail during the ratification process. These include identifying the following:

- Negative data
- High data peaks
- Calibrations which are more than 5% different from previous values
- Peaks with a maximum 15-minute concentration significantly above the hourly mean value
- Measurements which are outside the normal range of expected data e.g. elevated ozone concentrations during the winter months
- Long periods of constant or zero concentrations
- Data gaps of more than six hours.

The AEA HIS data ratification software automatically produces a data ratification report for the selected monitoring stations giving the following information:

- Station, pollutants measured and start date
- Latest annual QC audit results for the station
- Results of initial electronic data screening
- LSO calibration dates and any comments

- List of all gaps in the data
- Any other issues relating to the station.

A2.3.1 Ratification tasks and output

When ratifying data the following are closely examined:

- Issues that have been flagged up automatically by the software
- zero and sensitivity factors used on each day
- General review of the result to make sure that there are no other anomalies.

A2.3.2 Ratified Data Checking

Once the data have been initially ratified proforma reports is produced and passed to the data checker The role of the data checker is to:

- Assess if there are any station problems if not the data can be marked as ratified.
- Return the station to the data ratifier if there are any issues requiring further action by the data ratifier.
- Forward the report to the project Quality Circle if there are data quality issues which require a group discussion to resolve.

Following the Quality Circle meeting the data are then corrected if required and uploaded as ratified to the database and web site.

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