Scottish Air Quality Database Report 2008

A report to the Scottish Government

AEA

The Scottish Government

Title	Scottish Air Quality Database Annual Report 2008
Customer	The Scottish Government
Customer reference	
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File reference	ED43060/ ED48748
Reference number	AEAT/ENV/R/2812 Issue 1

Ken Stevenson
AEA Technology plc
Caledonian Road
Glengarnock
Ayrshire
KA14 3DD
Telephone 0870 190 6574
Facsimile 0870 190 5151

ken.stevenson@aeat.co.uk

t: 0870 190 5150
f: 0870 190 5151

Author	Name	Paul Willis Andrew Kent Stephen Stratton David Hector Ken Stevenson
Approved by	Name	Ken Stevenson
	Signature	
	Date	4 June 2009

Executive summary

AEA has been commissioned by The Scottish Government to undertake a 3-year project to develop an Air Quality Database and Website for Scotland. This work follows from the Pilot Project undertaken in 2006 and incorporates feedback received from a wide range of stakeholders during the pilot.

This report presents the activities undertaken during the second year of the project – April 2008 – April 2009.

The database and website were launched on 2 April 2007. Continuous expansion and improvements to the website have been undertaken since the launch and these will continue throughout the duration of the project. In particular, during 2008 the presentation of the location of the monitoring sites has been migrated to a Google Maps$_{TM}$ platform to provide greatly improved navigation and increased map resolution.

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.

Air pollution data for 62 automatic monitoring sites throughout Scotland are available in the database for all or part of 2008.

A summary of ratified data for 2008 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.

The widely used TEOM analyser for measurement of PM_{10} was shown not to be equivalent to the EU reference method for PM_{10} measurement. Whilst a default correction factor of 1.3 has been used for many years, the recent measurements of the volatile component of PM_{10} with TEOM FDMS analysers has allowed a system to be developed to correct TEOM data such that the resulting corrected data are equivalent to the EU reference method. In order to assist Scottish Local Authorities and to provide a consistent approach to the use of this correction technique throughout all sites in the Scottish Database, AEA has undertaken this correction for all participating Local Authorities. A summary of these results is provided in this report.

The only significant widespread pollution episodes in the UK during 2008 were for ozone and occurred during May and July. The May episode is discussed for stations in Scotland within this report. However, the July episode did not significantly impact on Scotland and hence, is not discussed.

During 2008, the data from the Scottish Partisol Study have undergone final adjustment and ratification and these data have been used to provide improved background maps of PM_{10} and $PM_{2.5}$ throughout Scotland. It is anticipated that The Scottish Government will ask a small number of local authorities to use the Scottish background maps to evaluate the impact of any reduction in PM_{10} on the ability of LAs to meet national air quality objectives.

Also, 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.

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 was collected by a wide range of organisations for a number of purposes and was 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 year of the project[2], 2007, is available on the website.

This is the second annual report of this project and summarises the progress made during 2008 in the following project tasks:

- Improvements to the database and to website functionality
- Harmonised QA/QC of Local Authority monitoring site data
- Overview of air quality in Scotland in 2008
- Air Quality mapping in Scotland
- Air Quality trends for Scotland.

A major innovation during 2008 was to re-launch the website with a Google Maps$_{TM}$ interface on the home page. This is described in Chapter 2.

The database has grown by 15 sites during 2008 and a further 9 will be added during 2009. The database already provides a valuable resource for the general public, local and national government, academic researchers and other stakeholders. The full list of sites for which data are available is provided in Chapter 4 and a summary of these data, for 2008, is provided on a pollutant-by-pollutant basis in Chapter 6.

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:

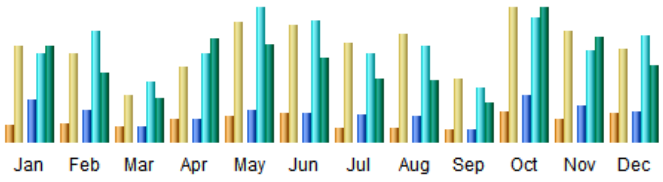
- Accurate and reliable
- Comprehensive
- User-friendly
- Easily navigable
- As interactive as possible
- Able to meet the needs of the general public as well as technical, local government and regulatory user communities.

Recent development work in 2008/9 has focussed on improving the direct user interface to monitoring results through the use of Google$_{TM}$ technology. This has resulted in substantial improvements to the functionality, website navigation, and generally improved content and user experience.

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 2008.



Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan	490	2704	17556	36468	758.11 MB
Feb	526	2495	13283	45785	551.84 MB
Mar	440	1330	6746	24674	347.26 MB
Apr	670	2101	9408	36733	815.24 MB
May	723	3398	13515	55307	771.88 MB
Jun	799	3277	12019	50319	664.76 MB
Jul	407	2794	11242	36351	495.43 MB
Aug	408	3044	10834	39467	485.25 MB
Sep	360	1764	5456	22340	315.14 MB
Oct	851	3777	19555	51562	1.03 GB
Nov	665	3127	14846	37789	828.55 MB
Dec	802	2617	12336	44074	608.63 MB
Total	7141	32428	146796	480869	7.52 GB

Figure 2.1 Air Quality Scotland Website Hits 2008.

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 April, May, June, and October, November, December 2008. The number of visitors per month varied between around 400 and 850, 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.
- Testing some of the new tools for review and assessment which were released for consultation towards the end of 2008.

The monthly activity is lower than the initial 3000 or more unique visitors just after the site launch, but has settled down to 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 a core group who are active in using the full functionality of the pages.

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 2008 with no extended breakdowns or downtime reported.

2.3 Website Upgrades During 2008

A number of enhancements to the website were carried out in 2008, 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 Google Maps$_{TM}$ Functionality to the Home Page

The website underwent a major re-design in 2008 in order to incorporate Google Maps technology into the functionality. The original website had a mainly non-interactive home page with simple links through to the functional areas where latest data could be viewed. However, it was conceived that by incorporating a Google Map design into the home page it could become far more interactive with direct access to the underlying data.

The re-design was carried out through a consultation process which gave all the Scottish Local Authorities and other project stakeholders a chance to comment on the draft version before it was moved to the live website.

The new design is illustrated in Figure 2.2 below.

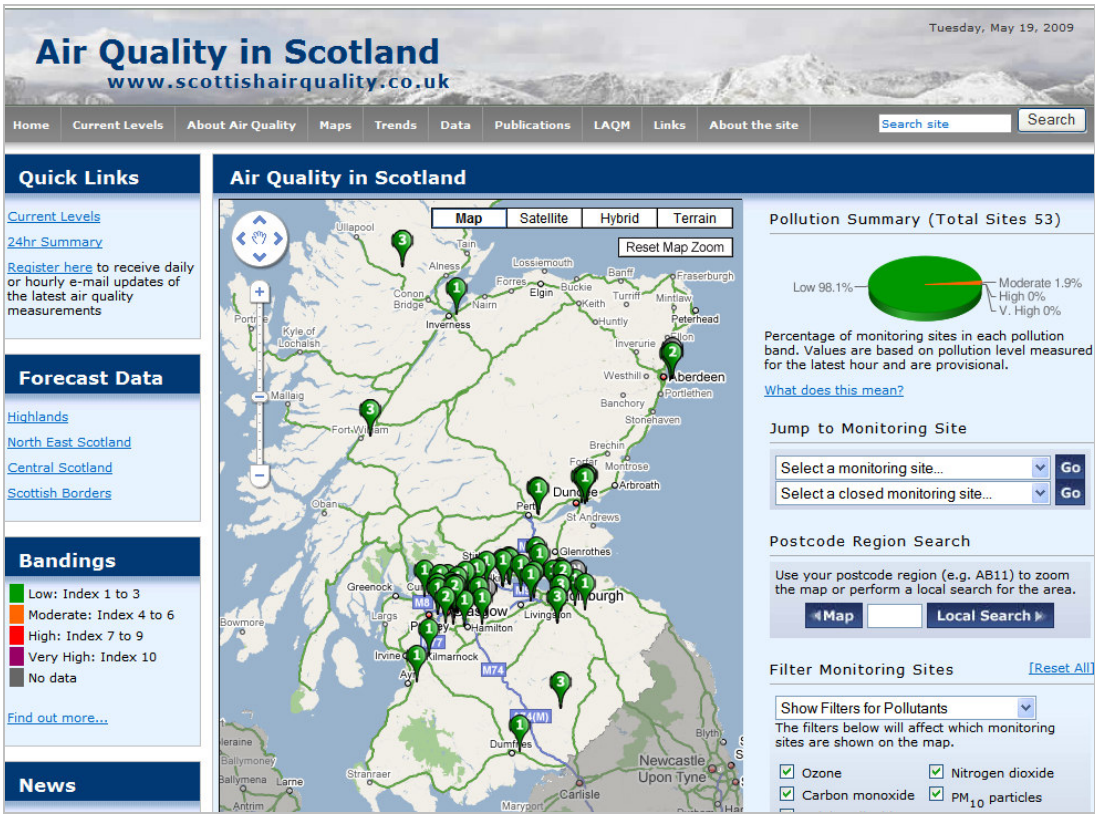


Figure 2.2 New website home page with Google Map.

The home page now incorporates the following new features:

- An interactive Google Map display of the Scottish air quality monitoring site locations, colour coded by the latest air quality level. The map has zoom and pan functions to enable users to look in more detail down to street level at any area of the map. It also provides an alternative satellite or terrain view so that a better picture of any monitoring site and surrounding features can be obtained if required.
- A direct zoom to a particular monitoring site location from a drop-down list, so that prior knowledge of the site location is not required in order to interrogate the data. A separate list enables interrogation of information for closed monitoring sites which are not shown on the map.
- A postcode search for monitoring sites within a particular area. The output is a series of mini-maps for each of the locations within the area of choice. The radius of the search area (in miles) can be adjusted as required.
- The display of site locations can be filtered by either site location or pollutant measured in order to provide a simplified display of more comparable site types.

- When a location is selected from the map or drop-down menus, tabs for data interrogation appear automatically below the map display.
- The graphics for the latest data summary, plots and site photographs have been improved.

2.3.2 Google Maps Site Location Tool

Following consultation on the Google Map development it became clear that some of the monitoring site locations were not accurate enough for the new display. The high-resolution maps and satellite images available for most urban areas of Scotland enabled the local authorities to see that the co-ordinates in the database had not put the location marker either quite on the right part of a street or building, for example. It was therefore decided to use the power of the Google Map technology to develop a tool in a password protected area where the local authority could position the site markers accurately, with the new co-ordinates automatically e-mailed back to update the database. This was successfully achieved with almost twenty of the site locations being updated in this way. Figure 2.3 below illustrates the site location tool.

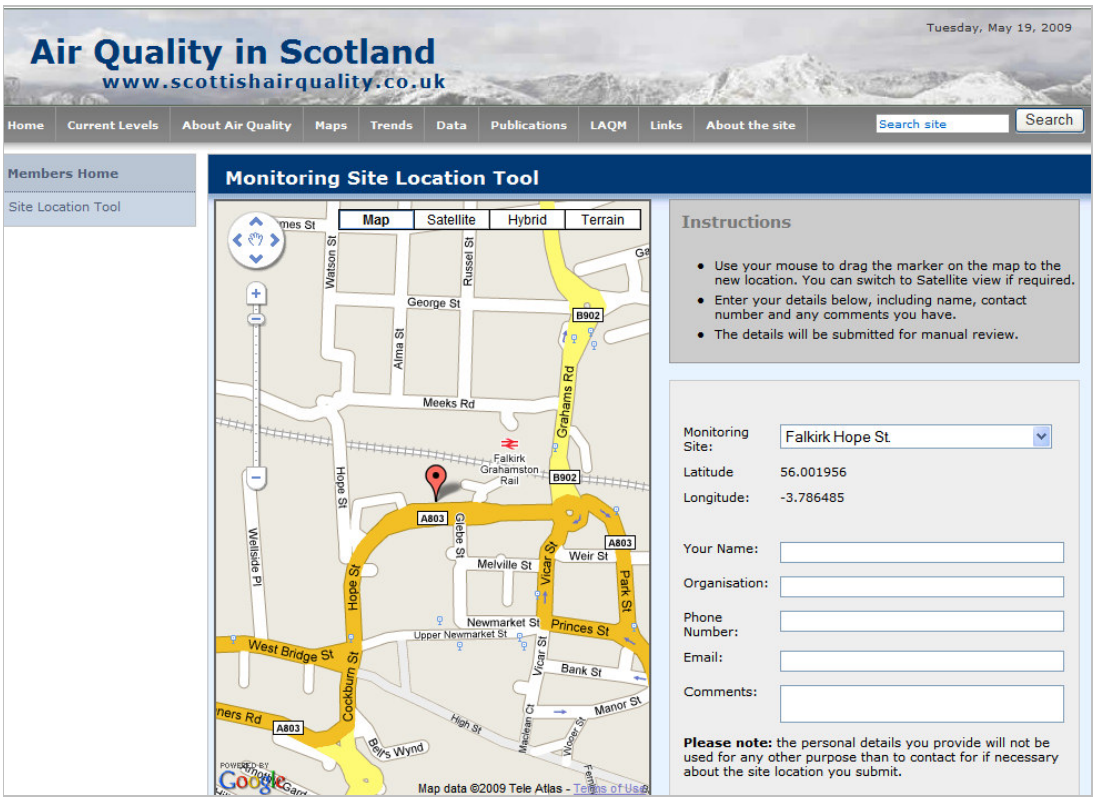


Figure 2.3 Google Map Site Location Tool.

2.3.3 Addition of Statistics Tab

The tabs for data interrogation of a particular monitoring station now include a statistics summary to enable users to see a quick overview of the air quality level for current or previous years.

The statistics tab includes simple summaries such as annual mean and monthly mean concentrations, together with the relevant data captures. It also includes comparison of results for each pollutant against the relevant Air Quality Strategy Objectives.

An optimised printable view of the results is available, together with a downloadable CSV file for loading into a spreadsheet or database if required.

An example of the statistics tab view is shown in Figure 2.4 below.

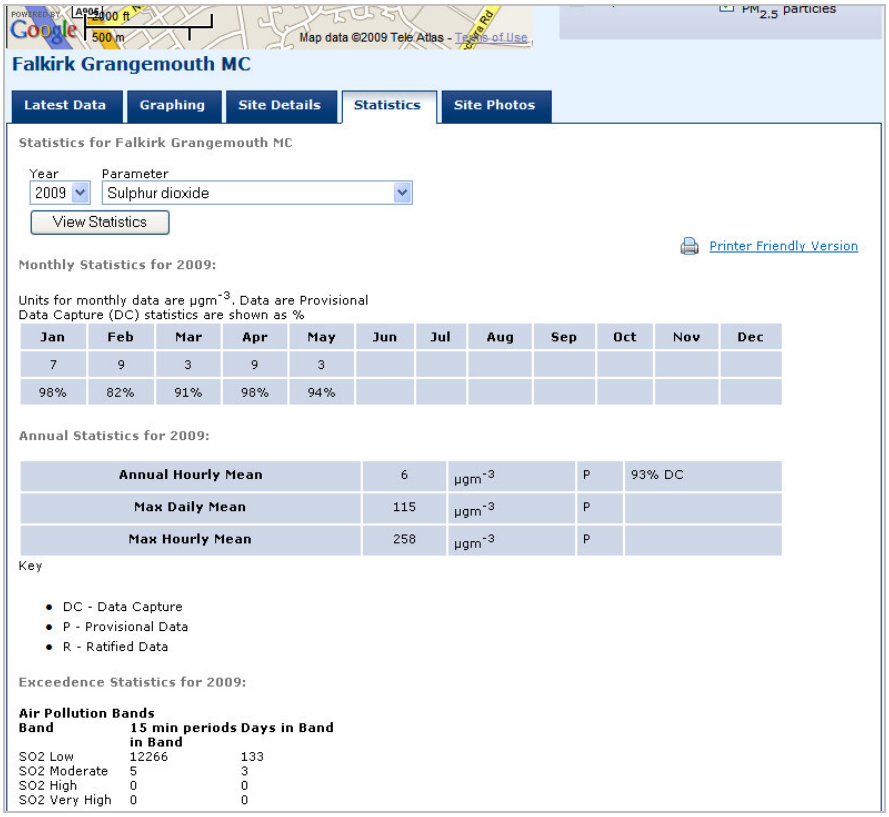


Figure 2.4 Statistics tab view.

The fully interactive and downloadable database of measurements and statistics for all sites and pollutants is still available from the "Data" section of the website for those who wish to obtain the underlying data for more detailed analysis or modelling.

2.4 Future Website Developments

For 2009 a number of further possible website developments are currently under consideration. These include options to enhance both the statistical power of the database and the graphical user interface as follows:

- A "low graphics" or "text-only" version of the website for those users who want to access the site using dial-up modems, mobile phones or PDAs.
- An SMS text alert service for the public and scientific community to be informed of any increases in pollutants above health threshold values.
- Further development of the option to switch the home page display between measured air quality and estimated emissions of air pollutants (from the SPRI)
- 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 (as described above).
- Alerts to inform when new reports, news or website developments become available.

These options, and their feasibility to implement within the scope of this contract, will be discussed and agreed with Scottish Government and the website stakeholders over the course of 2009.

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 Perth on Wednesday 18 March 2009. 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 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[3]) is also produced as part of this project. The newsletter for 2008 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. The newsletter for 2008 also provided a brief overview of recent work on the air quality impacts of biomass boilers. Hard 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

The Scottish Government

AEA

Scottish Annual Air Quality Seminar 2009

Date Wednesday 18 March 2009

Time 10.30

Location The Quality Hotel, Perth Station

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	Ken Stevenson (AEA)
	AQ Mapping for Scotland	Andrew Kent (AEA)
	AQ Trends and website update	Paul Willis (AEA)
LUNCH 12.30 – 13.15		
5. 13.15 - 13.45	New Technical Guidance for Review and Assessment	Steve Moorcroft (AQC)
6. 13.45 – 14.00	Scottish Study on Impacts of Biomass Burning	Geeta Puri/Andrew Taylor (SG)
TEA 14.00 – 14.15		
6. 14.15 – 14.45	Scottish Pollutant Release Inventory (SPRI)	Bob Boyce (SEPA)
7. 14.45 – 15.45	Local Authority Air Quality Action Plan Experience	
	• Fiona Maguire - North Lanarkshire Council	
	• James Crawshaw - Glasgow City Council	
	• General Discussion	
8. 15.45 – 16.00	Closing remarks	Geeta Puri (SG)

CLOSE 16.00

Figure 3.1 Agenda for the Scottish Air Quality Seminar on 18 March 2009

4 Data Availability in 2008

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

At the end of 2008 the Scottish Air Quality Database contained data for a total of 62 automatic monitoring sites. This is an increase of 15 sites from 2007, however, 12 of these sites joined the Database part way through 2008 and 5 sites were closed or relocated during the year. A further 3 sites have joined the database already during 2009 and a further 3 are in the process of joining. During the remainder of 2009 a further 9 additional Local Authority sites will also be added to the database.

For the 15 National Network 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 2008, 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 Scottish Air Quality Database Data Availability in 2008

Site Name	Pollutants	Type	East	North	Data in 2008
Aberdeen	NO_2 O_3 PM10	Urban Background	394416	807408	Jan – Dec
Aberdeen Anderson Drive	NO_2 PM10	Roadside	392506	804186	Jan – Dec
Aberdeen Market Street	NO_2 PM10	Roadside	394408	805893	Jan – Dec
Aberdeen Union Street	NO_2 PM10	Roadside	393656	805967	Jan – Dec
Aberdeen Wellington Road*	NO_2 PM10	Roadside	394395	804779	Jan – Dec
Auchencorth Moss	O_3 PM10 PM2.5	Rural	322050	656250	Jan – Dec
Ayr High Street*	NO_2 PM10	Roadside	233725	622120	Jan – Dec
Bush Estate	NO_2 O_3	Rural	324500	663500	Jan – Dec
Dumfries	CO NO_2 PM10	Roadside	297012	576278	Jan – Dec
Dundee Broughty Ferry Road	PM10 SO_2	Roadside	341970	730997	Jan – Dec
Dundee Lochee Road	NO_2	Kerbside	338861	730773	Jan – Dec
Dundee Mains Loan	PM10	Urban background	340972	731893	Jan – Dec
Dundee Seagate	NO_2	Kerbside	340487	730446	Jan – Dec
Dundee Union Street	NO_2 PM10	Kerbside	340236	730090	Jan – Dec
Dundee Whitehall Street	NO_2	Kerbside	340279	730155	Jan – Dec
East Dunbartonshire Bearsden	NO_2 PM10	Kerbside	254269	672067	Jan – Dec
East Dunbartonshire Bishopbriggs	NO_2 PM10	Roadside	260995	670130	Jan – Dec
East Dunbartonshire Kirkintilloch*	NO_2 PM10	Roadside	265700,	673500	Jan – Dec
Edinburgh Haymarket	NO_2 PM10	Roadside	323890	673180	Jan – Dec
Edinburgh Roseburn	NO_2 PM10	Roadside	322939	673233	Jan – Dec
Edinburgh St John's Road	NO_2	Kerbside	320100	672890	Jan – Dec
Edinburgh St Leonards	CO NO_2 O_3 PM10 SO_2	Urban background	326200	673200	Jan – Dec
Eskdalemuir	NO_2 O_3	Rural	323500	602800	Jan – Dec
Falkirk Grangemouth MC	NO_2 PM10 SO_2	Urban background	292816	682009	Jan – Dec
Falkirk Hope Street	NO_2 PM10 SO_2	Roadside	288688	680218	Jan – Dec
Falkirk Park Street	NO_2 PM10 SO_2	Roadside	288892	680070	Jan – Dec
Fife Cupar	NO_2 PM10	kerbside	337401	714572	Jan – Dec
Fife Dunfermline	NO_2	Roadside	309910	687745	Aug – Dec
Fife Rosyth*	NO_2 PM10	Roadside	311752	683515	Jan – Dec
Fort William	NO_2 O_3	Suburban	210849	774421	Jan – Dec
Glasgow Abercromby Street*	PM10	Roadside	260420	664175	Jan – Dec
Glasgow Anderston	CO NO_2 PM10 SO_2	Urban background	257925	665487	Jan – Dec
Glasgow Battlefield Road	NO_2 PM10	Roadside	258417	661385	Jan – Dec
Glasgow Broonhill*	PM10	Roadside	255030	667195	Jan – Dec
Glasgow Byres Road	CO NO_2 PM10	Roadside	256553	665487	Jan – Dec
Glasgow Centre	CO NO_2 O_3 PM10 SO_2	Urban centre	258902	665028	Jan – Dec
Glasgow City Chambers	CO NO_2	Urban background	259528	665308	Jan – Dec
Glasgow Kerbside	CO NO_2 PM10	Kerbside	258708	665200	Jan – Dec
Glasgow Nithdale Road*	PM10	Roadside	257883	662673	Jan – Dec
Glasgow Waulkmillglen Reservoir	NO_2 O_3 PM10	Rural	252520	658095	Jan – Dec
Grangemouth	CO NO_2 PM10 SO_2	Urban industrial	293840	681032	Jan – Dec

Site Name	Pollutants	Type	East	North	Data in 2008
Inverness	CO NO_2 PM10	Roadside	265720	845680	Jan – Dec
Lerwick	O_3	Rural	445337	1139683	Jan – Dec
Midlothian Dalkeith*	NO_2 SO_2 PM10	Kerbside	333159	667305	Jan – Dec
Midlothian Pathhead*	SO_2 PM10	Kerbside	339558	664230	Jan – Dec
N Lanarkshire Chapelhall	NO_2 PM10	Roadside	278174	663124	Oct – Dec
N Lanarkshire Coatbridge Ellis St	NO_2	Roadside	273086	665077	Oct – Dec
N Lanarkshire Coatbridge Whifflet	NO_2 PM10	Urban background	273668	663938	Oct – Dec
N Lanarkshire Croy	NO_2 PM10 SO_2	Roadside	272775	675738	Oct – Dec
N Lanarkshire Harthill	CO NO_2 PM10 SO_2	Roadside	288051	663975	Oct – Dec
Paisley Glasgow Airport*	NO_2	Airport	248294	666533	Jan – Dec
Paisley Central Road	NO_2	Roadside	248445	664191	Jan – Dec
Paisley Gordon Street*	NO_2 PM10	Roadside	248316	663615	Jan – Dec
Perth Atholl Street	NO_2 PM10	Roadside	311688	723625	Jan – Dec
Perth High Street	NO_2 PM10	Roadside	311582	723931	Jan – Dec
South Lanarkshire East Kilbride*	NO_2 PM10	Roadside	264390	655658	Feb – Dec
Strath Vaich	O_3	Remote	234829	874785	Jan – Dec
West Dunbartonshire Clydebank	NO_2 PM10	Roadside	249724	672042	Feb - Dec
West Dunbartonshire Glasgow Road	NO_2	Roadside	240236	675195	May - Dec
West Lothian Broxburn*	NO_2 PM10	Roadside	308364	672248	Jan – Dec
West Lothian Linlithgow*	NO_2 PM10	Roadside	299926	677087	Jan – Dec
West Lothian Uphall*	NO_2 PM10	Roadside	306219	670160	Jan – Dec

(* Sites added to database in 2008)

Sites that are temporarily closed for relocation or roadworks

- Fife Cupar
- Edinburgh Haymarket
- Aberdeen Market St
- N. Lanarkshire, Harthill
- N Lanarkshire, Ellis Road

Sites still to join the database

- East Lothian, Musselburgh North High St – *In progress*
- Shetland Stanley Hill – *telemetry issues*
- North Ayrshire, Irvine – *New site recently installed*

Sites joined in 2009 already

- Falkirk Haggs
- N. Lanarkshire Motherwell
- East Renfrewshire Sheddens

In addition, the data for the site at Gorgie Road in Edinburgh did not appear on the website during 2008 because of technical difficulties with data telemetry at this site. However, the site was audited and the data were ratified and, the data are now available on the website.

4.2 Volatile Correction Model for PM_{10}

4.2.1 Background

The EU Directive on Ambient Air Quality[4] and the UK Air Quality Strategy[5] set targets and limit values for PM_{10} concentrations in terms of gravimetric measurements referenced to the EU reference method 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 analyzer, 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 studies[6] 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[6]. 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 Beta BAM (with slope correction).

In 2006, King's College London (KCL) proposed 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[7] 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

In order to assist Scottish Local Authorities and to provide a harmonised approach to the use of the VCM in Scotland, AEA has used the VCM to correct all ratified 2008 TEOM data in the Scottish Air Quality Database. However, note that it was not possible to use the VCM to correct TEOM data in Aberdeen as these analysers are more than 130km from any FDMS TEOM analyser during 2008. To address this issue, installation of the FDMS TEOM PM_{10} analyser at the AURN site in Aberdeen was undertaken as a priority and these data will be available to correct any Aberdeen TEOM data for 2009 and onwards.

Daily-average temperature and pressure measurements from the Edinburgh St Leonards AURN site were used as meteorological inputs for the model. Daily-average purge (volatile PM_{10}) measurements from the following nine FDMS sites in central Scotland were used for the purge inputs:

- East Dunbartonshire Kirkintilloch,
- Edinburgh St Leonards,
- Fife Rosyth,
- Glasgow Abercromby,
- Glasgow Broomhill,
- Glasgow Nithsdale Road,
- Paisley Gordon Street,
- West Lothian Broxburn,
- West Lothian Linlithgow.

Outliers in the purge data were identified and excluded from the data-set during the ratification process. Table 4.2 lists the TEOM monitoring sites in Scotland and whether the data were corrected using VCM.

The TEOM's at West Lothian Linlithgow and West Dunbartonshire Clydebank were upgraded to FDMS's in summer 2008 and therefore only data from the first half of 2008 were corrected using VCM. No data were available at West Lothian Uphall prior to Jul 2008.

Table 4.2 VCM Corrected TEOM PM_{10} Data 2008

TEOM Monitoring Site	Period VCM Corrected
Aberdeen Anderson Drive	*
Aberdeen Market Street	*
Aberdeen Union Street	*
Aberdeen Wellington Road	*
Dundee Broughty Ferry Road	2008
Dundee Mains Loan	2008
Dundee Union Street	2008
Edinburgh Haymarket	2008
Edinburgh Queen Street	2008
Edinburgh Roseburn	2008
Fife Cupar	2008
Falkirk Grangemouth MC	2008
Falkirk Hope Street	2008
Falkirk Park Street	2008
Glasgow Anderston	2008
Glasgow Battlefield	2008
Glasgow Byres Road	2008
Glasgow Waulkmillglen	2008
Midlothian Dalkeith	2008
Midlothian Pathead	2008
N Lanarkshire Chapelhall	2008
N Lanarkshire Croy	2008
N Lanarkshire Harthill	2008
N Lanarkshire Motherwell	2008
N Lanarkshire Whifflet	2008
Perth Atholl Street	2008
Perth High Street	2008
W Lothian Linlithgow High St	Jan – Jun 2008
W Lothian Uphall	Jul – Dec 2008
W Dunbartonshire Clydebank	Jan – Jun 2008

*VCM could not be used as no FDMS TEOM data were available from a site within the required 130km

These corrected data have been provided to Local Authorities. These data are not yet available on the Scottish Air Quality website but AEA are in the process of modifying the database so that they can be included.

In using the VCM, AEA decided to correct the PM_{10} data on a daily basis. The reason for this is that initial testing with hourly data indicated that the VCM correction process appeared to introduce additional noise into the hourly data profile. As only daily data are required for the assessment of compliance with the Air Quality Strategy as part of the LAQM process, it was felt that correction of daily average data would provide a more robust assessment.

Where Local Authorities wish to analyse hourly data, for example to investigate diurnal variations or short-term episodes, we suggest that the original TEOM data are used for this purpose. Also, we suggest that Local Authorities continue to calculate data using the methodology they have adopted previously (e.g. factor of 1.3 or 1.14) to assess trends for the next few years. When several years of VCM corrected data are available then trends can be assessed on the basis of these data.

4.3 National Network Monitoring for other pollutants in Scotland

In addition to the 15 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 – 3 sites
- Heavy Metals Monitoring Networks – 3 sites
- Heavy Metals Deposition Network – 3 sites
- Acid Deposition Network – 11 sites
- Ammonia and Nitric Acid Monitoring Network – 26 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 just yet, but as the database develops, these data will be loaded and hence the database will become a consolidation of air quality data from a wide variety of sources and will include these more specialist data. Data will then be available from one easily accessible web portal.

5 QA/QC of the 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. 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. 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.

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 2008

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 2008.

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 Winter 2008 Audits

Fault	Number of Monitoring Sites
FDMS* pump vacuum <21"Hg	5
TEOM** k_0 out by > 2.5%	4
TEOM/FDMS flow out by >10%	3
TEOM/FDMS leak test failure	2
NO cylinder out by >10%	8
NO_x analyser converter <95% efficiency	0
Gas analyser leak test failure	1
Gas analyser sample flow out by >10%	4
Site infrastructure problems	3

* Filter Dynamics Measurement System
** Tapered Element Oscillating Microbalance

These are all typical faults that are found during audit and intercalibration exercises. As can be seen, no NO_x converter faults were identified during 2008. This could be attributed to these faults being identified during the 2007 audit programme, which were subsequently rectified. The site infrastructure faults included a fault with a calibration system and a fault with a manifold suction motor.

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 Air Quality Site Intercalibration and Audits Conducted During 2008

	Jan - Jun 2008	Jul – Dec 2008		Jan - Jun 2008	Jul – Dec 2008
Aberdeen	✓	✓	Glasgow Abercromby Street	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Anderston	✓	✓
Aberdeen Market St	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Byres Road	✓	✓
Ayr High Street	✓	✓	Glasgow Centre	✓	✓
Auchencorth Moss	✓	✓	Glasgow City Chambers	✓	✓
Bush Estate	✓	✓	Glasgow Kerbside	✓	✓
Dumfries	✓	✓	Glasgow Nithsdale Road	✓	✓
Dundee Broughty Ferry Road	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Dundee Lochee Road	✓	✓	Grangemouth	✓	✓
Dundee Mains Loan	✓	✓	Inverness	✓	✓
Dundee Seagate	✓	✓	Kilmarnock	✓	✓
Dundee Union Street	✓	✓	Lerwick	✓	✓
Dundee Whitehall Street	✓	✓	Lerwick Stanley St	✓	✓
East Dunbartonshire Bearsden	✓	✓	Midlothian Dalkeith	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	Midlothian Pathead	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	N Lanarkshire Chapelhall	✓	✓
East Lothian Musselburgh N High St	✓	✓	N Lanarkshire Coatbridge Ellis St	✓	✓
East Renfrewshire Sheddens		✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Edinburgh Gorgie Road	✓	✓	N Lanarkshire Croy	✓	✓
Edinburgh Haymarket	✓	✓	N Lanarkshire Harthill	✓	✓
Edinburgh Roseburn	✓	✓	N Lanarkshire Motherwell	✓	✓
Edinburgh St John's Road	✓	✓	Paisley Central Road	✓	✓
Edinburgh St Leonards	✓	✓	Paisley Glasgow Airport	✓	✓
Eskdalemuir	✓	✓	Paisley Gordon Street	✓	✓
Falkirk Grangemouth MC	✓	✓	Perth Atholl Street	✓	✓
Falkirk Hope St	✓	✓	Perth High Street	✓	✓
Falkirk Park St	✓	✓	S Lanarkshire East Kilbride	✓	✓
Fife Cupar	✓	✓	Strath Vaich	✓	✓
Fife Dunfermline	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Rosyth	✓	✓	West Dunbartonshire Glasgow Rd	✓	✓
Fort William	✓	✓	West Lothian Broxburn	✓	✓
			West Lothian Linlithgow High Street	✓	✓
			West Lothian Uphall	✓	✓

5.4.2 Data ratification

Data ratification is undertaken 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.

Table 5.3 shows the data that have been ratified and are available in the database. No data were available prior to July 2008 at the following sites:

- Aberdeen Wellington Road,
- East Renfrewshire Sheddens,
- Kilmarnock,
- West Lothian Broxburn,
- West Lothian Uphall.

There are no data currently available on the Scottish Archive website for the Musselburgh N High Street and Lerwick Stanley Hill monitoring sites during 2008 due to telemetry issues. We are currently working closely with both Local Authorities to resolve the problem.

Table 5.3 Data Ratification undertaken during 2008

	Jan - Jun 2008	Jul – Dec 2008		Jan - Jun 2008	Jul – Dec 2008
Aberdeen	✓	✓	Glasgow Abercromby Street	✓	✓
Aberdeen Anderson Dr	✓	✓	Glasgow Anderston	✓	✓
Aberdeen Market St	✓	✓	Glasgow Battlefield Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen Wellington Road	No Data	✓	Glasgow Byres Road	✓	✓
Ayr High Street	✓	✓	Glasgow Centre	✓	✓
Auchencorth Moss	✓	✓	Glasgow City Chambers	✓	✓
Bush Estate	✓	✓	Glasgow Kerbside	✓	✓
Dumfries	✓	✓	Glasgow Nithsdale Road	✓	✓
Dundee Broughty Ferry Road	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓
Dundee Lochee Road	✓	✓	Grangemouth	✓	✓
Dundee Mains Loan	✓	✓	Inverness	✓	✓
Dundee Seagate	✓	✓	Kilmarnock	No Data	✓
Dundee Union Street	✓	✓	Lerwick	✓	✓
Dundee Whitehall Street	✓	✓	Lerwick Stanley Hill	No Data	No Data
East Dunbartonshire Bearsden	✓	✓	Midlothian Dalkeith	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	Midlothian Pathead	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	N Lanarkshire Chapelhall	✓	✓
East Lothian Musselburgh N High St	No Data	No Data	N Lanarkshire Coatbridge Ellis St	✓	✓
East Renfrewshire Sheddens	No Data	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Edinburgh Gorgie Road	✓	✓	N Lanarkshire Croy	✓	✓
Edinburgh Haymarket	✓	✓	N Lanarkshire Harthill	✓	✓
Edinburgh Roseburn	✓	✓	N Lanarkshire Motherwell	✓	✓
Edinburgh St John's Road	✓	✓	Paisley Central Road	✓	✓
Edinburgh St Leonards	✓	✓	Paisley Glasgow Airport	✓	✓
Eskdalemuir	✓	✓	Paisley Gordon Street	✓	✓
Falkirk Grangemouth MC	✓	✓	Perth Atholl Street	✓	✓
Falkirk Hope St	✓	✓	Perth High Street	✓	✓
Falkirk Park St	✓	✓	S Lanarkshire East Kilbride	✓	✓
Fife Cupar	✓	✓	Strath Vaich	✓	✓
Fife Dunfermline	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Rosyth	✓	✓	West Dunbartonshire Glasgow Rd	✓	✓
Fort William	✓	✓	West Lothian Broxburn	No Data	✓
			West Lothian Linlithgow High Street	✓	✓
			West Lothian Uphall	No Data	✓

All ratified data for 2008 have now been uploaded to the Scottish Air Quality website.

6 Air Pollution in Scotland 2008

6.1 Annual Average Summary Statistics

Tables 6.1 – 6.5 show the 2008 annual average data statistics for NO_2, PM_{10}, 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.

Nitrogen Dioxide

Table 6.1 Ratified data annual average concentration and data capture for NO_2 in 2008 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2008 (μgm^{-3})	No. hours > 200μgm^{-3}	Data capture NO_2 2008 (%)
Aberdeen	Urban Background	25	0	98
Aberdeen Anderson Drive	Roadside	25	2	99
Aberdeen Market Street	Roadside	73	94	76
Aberdeen Union Street	Roadside	55	20	95
Aberdeen Wellington Road*	Roadside	40	0	44
Ayr High Street*	Roadside	21	0	92
Bush Estate	Rural	8	0	90
Dumfries	Roadside	37	4	95
Dundee Lochee Road	Kerbside	53	4	92
Dundee Seagate	Kerbside	52	0	82
Dundee Union Street	Kerbside	43	11	100
Dundee Whitehall Street	Kerbside	47	0	76
East Dunbartonshire Bearsden	Kerbside	41	3	99
East Dunbartonshire Bishopbriggs	Roadside	33	0	90
East Dunbartonshire Kirkintilloch*	Roadside	37	0	100
Edinburgh Gorgie Road	Roadside	43	0	54
Edinburgh Haymarket	Roadside	41	1	87
Edinburgh Roseburn	Roadside	28	0	93
Edinburgh Queen Street	Roadside	32	0	87
Edinburgh St John's Road	Kerbside	75	166	91
Edinburgh St Leonards	Urban background	31	6	96
Eskdalemuir	Rural	5	0	93
Falkirk Grangemouth MC	Urban background	25	0	82

Site Name	Type	Annual Average NO_2 2008 (μgm^{-3})	No. hours > 200μgm^{-3}	Data capture NO_2 2008 (%)
Falkirk Hope Street	Roadside	24	0	99
Falkirk Park Street	Roadside	31	0	95
Fife Cupar	kerbside	46	3	91
Fife Dunfermline	Roadside	30	0	96
Fife Rosyth*	Roadside	26	0	79
Fort William	Suburban	11	0	88
Glasgow Anderston	Urban background	32	1	78
Glasgow Battlefield Road	Roadside	32	0	95
Glasgow Byres Road	Roadside	43	6	99
Glasgow Centre	Urban centre	35	0	77
Glasgow City Chambers	Urban background	48	0	98
Glasgow Kerbside	Kerbside	82	72	95
Glasgow Waulkmillglen Reservoir	Rural	12	0	77
Grangemouth	Urban industrial	17	0	99
Kilmarnock	Urban Background	13	0	12
Inverness	Roadside	21	0	99
Midlothian Dalkeith*	Kerbside	28	0	97
N Lanarkshire Chapelhall	Roadside	36	0	98
N Lanarkshire Coatbridge Ellis St	Roadside	31	0	95
N Lanarkshire Coatbridge Whifflet	Urban background	24	0	99
N Lanarkshire Croy	Roadside	25	0	98
N Lanarkshire Harthill	Roadside	22	0	93
Paisley Central Road	Roadside	87	715	89
Paisley Glasgow Airport*	Airport	25	1	89
Paisley Gordon Street*	Roadside	36	0	75
Perth Atholl Street	Roadside	60	25	98
Perth High Street	Roadside	27	1	96
South Lanarkshire East Kilbride*	Roadside	37	2	76
West Dunbartonshire Clydebank	Roadside	24	0	97
West Dunbartonshire Glasgow Rd	Roadside	19	0	99
West Lothian Broxburn*	Roadside	38	0	44
West Lothian Linlithgow*	Roadside	20	0	95
West Lothian Uphall*	Roadside	21	0	39

Shaded sites indicate data only available for part year

Table 6.1 shows nitrogen dioxide data for the 56 sites utilising automatic monitoring in 2008, although data for 4 of these (Aberdeen Wellington Road, Kilmarnock, West Lothian Broxburn, West Lothian Uphall) are only available for part of the year and the overall data capture is less than 50%.

A total of 16 roadside automatic sites exceeded the AQS Objective for the NO_2 annual mean ($40\mu gm^{-3}$). These were Aberdeen Market Street, Aberdeen Union Street, Dundee Lochee Road, Dundee Seagate, Dundee Union Street, Dundee Whitehall street, East Dunbartonshire Bearsden, Edinburgh Gorgie Rd, Edinburgh Haymarket, Edinburgh St Johns Road, Fife Cupar, Glasgow Byres Road, Glasgow City Chambers, Glasgow Kerbside, Paisley Central Road, and Perth Atholl Street, all of which are close to busy roads.

At 6 of these sites, (Aberdeen Market Street, Aberdeen Union St, Edinburgh St. John's Road, Glasgow Kerbside, Paisley Central Road, and Perth Atholl Street) the Air Quality Strategy (AQS) Objective of not more than 18 exceedences of $200\mu gm^{-3}$ for the hourly mean was also exceeded.

All of the above named Local Authorities have declared, or are in the process of declaring Air Quality Management Areas for exceedences of the NO_2 objective.

Particulate Matter –PM_{10}

Table 6.2 Ratified data annual average concentration and data capture for PM_{10} in 2008 for monitoring sites in the Scottish Air Quality Database

Site Name	Site Classification	PM_{10} Analyser Type	Annual Average PM_{10} 2008 (μgm^{-3} gravimetric equivalent)*	Annual Average PM_{10} 2008 (μgm^{-3} gravimetric equivalent VCM)	No. days > 50μgm^{-3} (**)	Data capture PM_{10} 2008 (%)
Aberdeen	Urban Background	TEOM	18	-	2	99
Aberdeen Anderson Dr	Roadside	TEOM	18	-	0	97
Aberdeen Market St	Roadside	TEOM	80	-	148	69
Aberdeen Union St	Roadside	TEOM	22	-	1	88
Aberdeen Wellington Road	Roadside	TEOM	26	-	3	41
Auchencorth Moss	Rural	FDMS	7	-	0	96
Ayr High Street	Roadside	FDMS	16	-	0	65
Dundee Broughty Ferry Road	Roadside	TEOM	18	15	0	96
Dundee Mains Loan	Urban Background	TEOM	13	11	0	100
Dundee Union Street	Kerbside	TEOM	21	17	0	100
East Dunbartonshire Bearsden	Kerbside	BAM (Heated Inlet)	21	-	3	79
East Dunbartonshire Bishopbriggs	Roadside	BAM (Heated Inlet)	17	-	2	94
East Dunbartonshire Kirkintilloch	Roadside	FDMS	20	-	4	55
East Renfrewshire Sheddens	Roadside	FDMS	15	-	1	54
Edinburgh Haymarket	Roadside	TEOM	22	18	3	86
Edinburgh Queen Street	Roadside	TEOM	22	18	0	84
Edinburgh Roseburn	Roadside	TEOM	18	15	0	90
Edinburgh St Leonards	Urban Background	FDMS	15	-	0	97
Falkirk Grangemouth MC	Urban Background	TEOM	18	15	0	79
Falkirk Hope St	Roadside	TEOM	18	15	3	99
Falkirk Park St	Roadside	TEOM	20	16	6	95
Fife Cupar	Kerbside	TEOM	23	19	1	97
Fife Rosyth	Roadside	FDMS	15	-	0	78
Glasgow Abercromby	Roadside	FDMS	19	-	8	93
Glasgow Anderston	Urban Background	TEOM	17	14	1	79
Glasgow Battlefield Road	Roadside	TEOM	20	16	1	86
Glasgow Broomhill	Roadside	FDMS	19	-	8	94
Glasgow Byres Road	Roadside	TEOM	24	20	7	100
Glasgow Centre	Urban centre	TEOM/FDMS	21	18***	6	94
Glasgow Kerbside	Kerbside	TEOM	31	25	40	98
Glasgow Nithsdale Road	Roadside	FDMS	21	-	7	93
Glasgow Waulkmillglen Reservoir	Rural	TEOM	14	12	0	81
Grangemouth	Urban industrial	TEOM	17	14	0	98
Kilmarnock	Urban Background	BAM (Un-heated Inlet)	-	-	-	-
Midlothian Dalkeith	Roadside	TEOM	18	15	0	83

Site Name	Site Classification	PM_{10} Analyser Type	Annual Average PM_{10} 2008 (μgm^{-3} gravimetric equivalent)*	Annual Average PM_{10} 2008 (μgm^{-3} gravimetric equivalent VCM)	No. days > 50μgm^{-3} (**)	Data capture PM_{10} 2008 (%)
Midlothian Pathead	Kerbside	TEOM	24	20	4	95
N Lanarkshire Chapelhall	Roadside	TEOM	26	21	7	97
N Lanarkshire Coatbridge Whifflet	Urban Background	TEOM	18	15	2	99
N Lanarkshire Croy	Roadside	TEOM	23	19	17	98
N Lanarkshire Harthill	Roadside	TEOM	20	17	5	89
N Lanarkshire Motherwell	Roadside	TEOM	21	18	4	100
Paisley Gordon Street	Roadside	FDMS	15	-	1	73
Perth Atholl Street	Roadside	TEOM	26	21	3	98
Perth High Street	Roadside	TEOM	20	16	1	97
South Lanarkshire East Kilbride	Roadside	FDMS	25	-	4	63
West Dunbartonshire Clydebank	Roadside	TEOM/FDMS	14	14***	1	87
West Lothian Broxburn	Kerbside	FDMS	16	-	1	45
West Lothian Linlithgow High Street	Roadside	TEOM/FDMS	17	16***	3	79
West Lothian Uphall	Urban Background	TEOM	15	12	0	48

* TEOM data is adjusted using gravimetric equivalent factor of 1.3
FDMS data adjusted is using gravimetric equivalent factor of 1.0
BAM (heated inlet) data is adjusted using gravimetric equivalent factor of 1.3
BAM (un-heated inlet) data is adjusted using gravimetric equivalent factor of 0.8333
** Based on VCM if available or on measurements adjusted as above
*** Weighted average of FDMS and VCM corrected TEOM data
Shaded sites indicate data only available for part year

Table 6.2 shows gravimetric equivalent particulate matter – PM_{10} - data from 49 sites utilising automatic monitoring in 2008. Of these, 3 (Aberdeen Wellington Rd, West Lothian Broxburn, West Lothian Uphall) have less than 50% data capture and hence are not included in the analysis below. As discussed in Section 4.2.2, all TEOM data have been adjusted using VCM, except for the Aberdeen data. Gravimetric equivalent TEOM data using the 1.3 adjustment factor[a] have also been included for comparison. As can be seen, using VCM has resulted in a significant decrease in measured PM_{10} concentrations at all TEOM monitoring sites when compared to using the 1.3 adjustment factor. Of the 25 TEOM sites operational for all of 2008 corrected with VCM, 8 change from exceedence of the Annual Average Objective (18μgm^{-3}) to no exceedence based on VCM data.

Overall, 14 sites exceeded the Annual Average PM_{10} Objective, based on the best available assessment of gravimetric PM_{10} concentration.

One site - Aberdeen Market Street – exceeded the UK AQS Objective of 40μgm^{-3} (gravimetric equivalent) for the annual mean PM_{10} and two sites – Aberdeen Market Street and Glasgow Kerbside – exceeded the UK daily objective of not more than 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. Based on the 2008 data, all of these Authorities still have monitoring sites which currently show an exceedence of the PM_{10} annual average objective.

[a] Although Local authorities in Scotland can choose to use either a factor of 1.14 or 1.3 for their TEOM data, to avoid confusion we only show data with one conversion factor in the database. We have chosen to use the 1.3 factor, at present, so that the Scottish data are consistent with that for the remainder of the UK.

Carbon Monoxide

Table 6.3 Ratified data annual average concentration and data capture for CO in 2008 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2008 (mgm^{-3})	Data capture CO 2008 (%)
Edinburgh St Leonards	Urban background	0.2	90
Glasgow Anderston	Urban background	0.2	72
Glasgow Byres Road	Roadside	0.3	95
Glasgow Centre	Urban centre	0.3	83
Kilmarnock	Urban Background	0.3	13.4
N Lanarkshire Harthill	Roadside	0.2	89
West Lothian Uphall	Roadside	0.3	45

Shaded sites indicate data only available for part year

Table 6.3 shows carbon monoxide was monitored using automatic techniques at 7 sites in 2008. Sites Kilmarnock and West Lothian Uphall only have data for the second half 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.

Sulphur Dioxide

Table 6.4 Ratified data annual average concentration and data capture for SO_2 in 2008 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average SO_2 2008 (μgm^{-3})	Data capture SO_2 2008 (%)
Dundee Broughty Ferry Road	Roadside	3	98
Edinburgh St Leonards	Urban Background	3	99
Falkirk Grangemouth MC	Urban Background	9	77
Falkirk Hope St	Roadside	5	98
Falkirk Park St	Roadside	5	90
Glasgow Anderson	Urban Background	2	77
Glasgow Centre	Urban Centre	2	98
Kilmarnock	Urban Background	3	25
Midlothian Dalkieth	Kerbside	3	95
Midlothian Pathhead	kerbside	8	91
N Lanarkshire Croy	Roadside	2	98
N Lanarkshire Harthill	Roadside	1	90
West Lothian Uphall	Roadside	2	45

Shaded sites indicate data only available for part year

Table 6.4 shows sulphur dioxide data from the 13 sites utilising automatic monitoring for 2008. Sites Kilmarnock and West Lothian Uphall only have data for the second half 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 2008. All except one site (Falkirk Grangemouth Municipal Chambers) met the requirements of the Air Quality Strategy for 15-minute mean. At this site there were 49 exceedeces of the Air Quality Strategy 15min Objective whereas only 35 are permitted. Falkirk has declared an Air Quality Management Area for sulphur dioxide, based on data from previous years.

Ozone

Table 6.5 Ratified data annual average concentration and data capture for O_3 in 2008 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	Urban Background	50	30	99
Auchencorth Moss	Rural	60	25	98
Bush Estate	Rural	58	12	98
Edinburgh St Leonards	Urban background	49	14	96
Eskdalemuir	Rural	57	18	90
Fort William	Suburban	56	30	99
Glasgow Centre	Urban centre	33	2	98
Glasgow Waulkmillglen Reservoir	Rural	56	9	85
Lerwick	Rural	70	34	96
Strath Vaich	Remote	73	67	85

Shaded sites indicate data only available for part year

Table 6.5 shows ozone data from 10 sites utilising automatic monitoring for 2008. 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 2008, the target value for the 8hr running mean Objective was exceeded on more than the permitted ten days at all monitoring sites, except Glasgow Centre and Glasgow Waulkmillglen Reservoir.

7 UK Ozone Pollution Episodes 2008

Ozone episodes in the UK are usually characterised by high temperatures and air masses re-circulating over northern Europe and the UK. These conditions typically result in summer episodes as the ozone precursor chemicals react in the presence of sunlight and high temperatures. During 2008 two UK wide ozone episodes were observed, one in May and one in July. These episode periods are fully discussed in the report Air Pollution Forecasting – Ozone Pollution Episodes Report (May and July 2008)[8].

During the second ozone episode during 23-31 July no sites in Scotland experienced concentrations greater than Index 5 (see below) and hence, this episode is not discussed in this report.

Ozone is measured at 10 sites in Scotland. The locations of these sites are shown in Figure 7.1

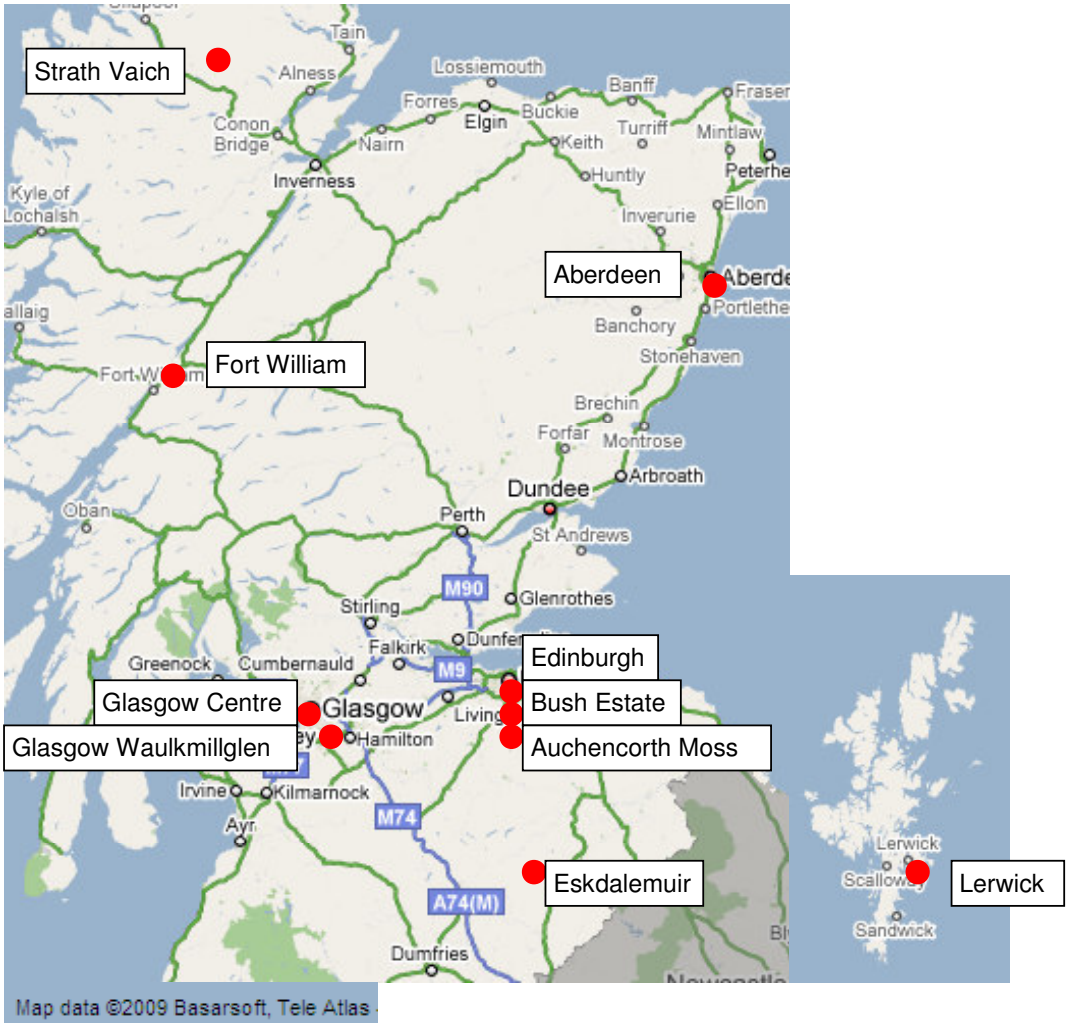


Figure 7.1 Location of ozone monitoring sites in Scotland

7.1 Ozone Air Quality Bands and Health Effects

Ozone concentration (and other pollutants) are described in the daily air quality bulletins in terms of their band (LOW, MODERATE, HIGH or VERY HIGH) and index (1-10). The ozone concentrations corresponding to these bands and indexes are listed below.

Band	Index	Ozone	
		8 hourly or hourly mean*	
		μgm^{-3}	ppb
LOW	**1**	**0-33**	**0-16**
	2	**34-65**	**17-32**
	3	**66-99**	**33-49**
MODERATE	**4**	**100-125**	**50-62**
	5	**126-153**	**63-76**
	6	**154-179**	**77-89**
HIGH	**7**	**180-239**	**90-119**
	8	**240-299**	**120-149**
	9	**300-359**	**150-179**
VERY HIGH	**10**	**360 or more**	**180 or more**

These bands have been set by UK Department of Health in conjunction with The Scottish Government and relate to the possible health effects of pollutants at these particular concentrations. The specific Health Descriptors associated with each band are provided below:

Banding	Index	Health Descriptor
Low	**1, 2, or 3**	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
Moderate	**4, 5, or 6**	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	**7, 8, or 9**	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	**10**	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

7.2 Ozone data and temperature for Scotland during the episode

Figure 7.2 shows maximum hourly average ozone concentrations for each day at monitoring sites in Scotland during the episode period in May. Maximum daily temperatures in Central Scotland are also plotted. The figures shows that the high ozone periods generally coincide with elevated temperatures. Peak concentrations occurred on 8 and 9 May 2008 with concentrations at Eskdalemuir (8 May) and Strath Vaich (9 May) rising above Index 5 in the MODERATE ozone band. In the UK, highest ozone concentrations during this period were recorded at the Hull Freetown monitoring station where the maximum hourly concentrations reached 194µgm^{-3} (HIGH band, Index 7) on 9 May.

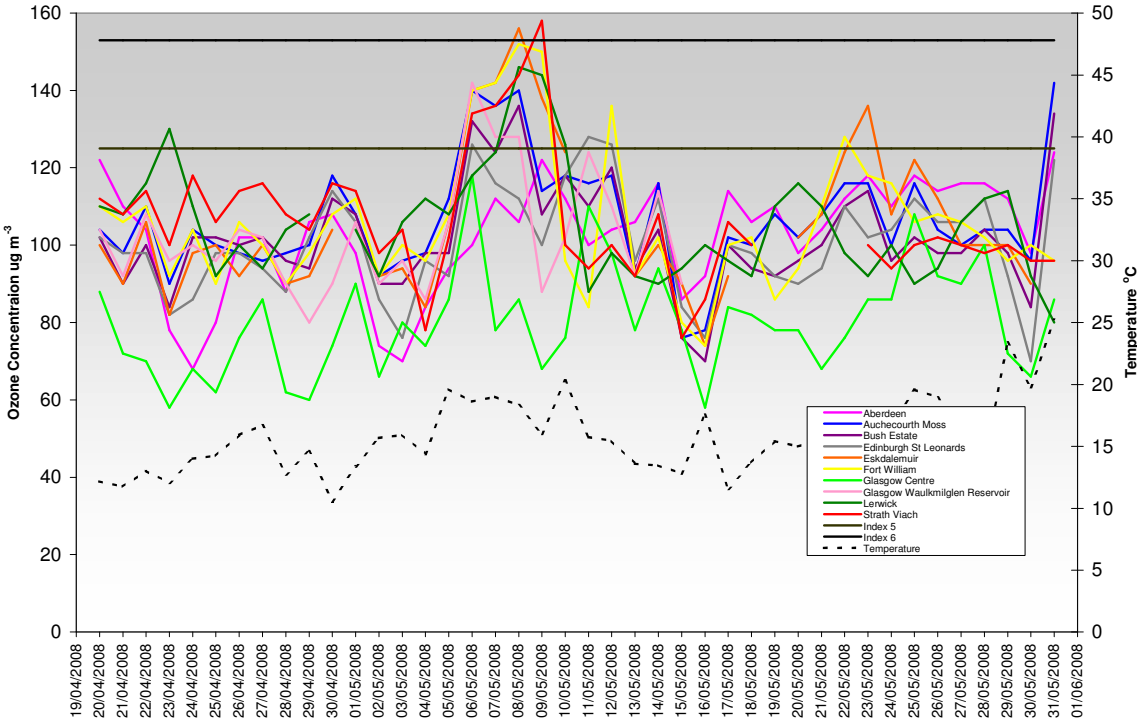


Figure 7.2. Ozone Concentrations against maximum daily temperature in Scotland during May 2008 episode

Figure 7.3 shows the number of ozone monitoring sites in Scotland with concentrations in the various index ranges throughout the episode period. On 6-8 May, 5-7 of the 10 monitoring sites had concentrations in Index 5 or Index 6 - MODERATE band.

Hence, during this episode period mild effects on health, unlikely to require action, may have been noticed amongst sensitive individuals.

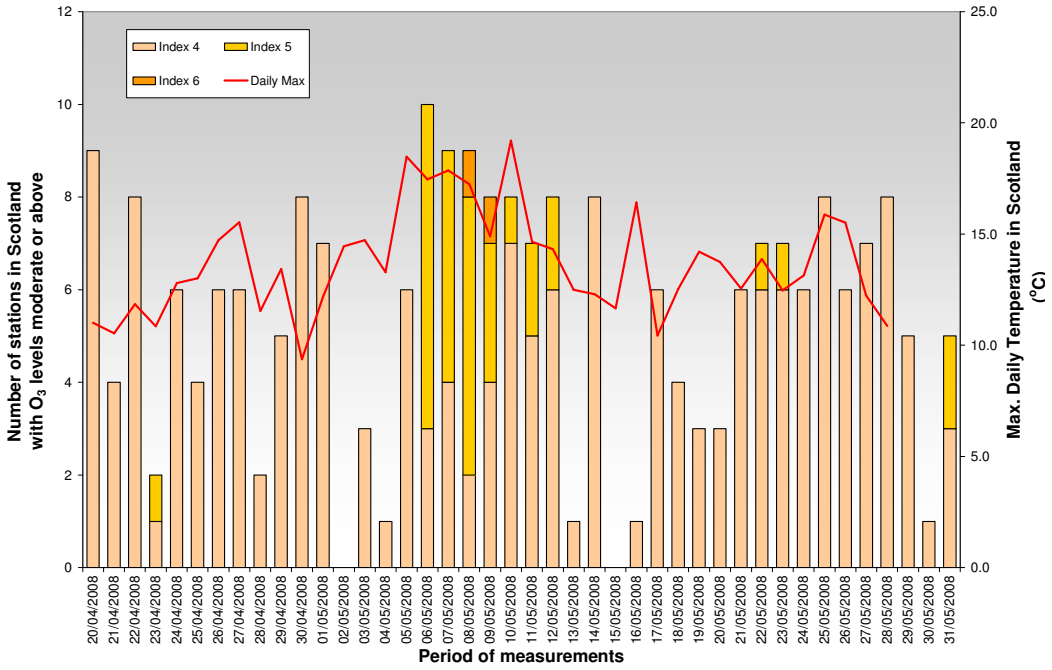


Figure 7.3. Ozone Concentration Index in Scotland during the May 2008 episode

May and July 2008 were both unusually warm months. Met Office monthly weather summaries provide the following information:

May Mean temperatures generally 2 to 3 °C above average, but only 1 to 2 °C above average across eastern parts of Scotland and NE England. Provisionally, the warmest May in the series back to 1914 for the UK, Scotland and Northern Ireland.

July Mean temperatures ranged from close to average across SW England and S Wales to over 1 °C above average across Scotland.

Globally, May 2008 was the eighth warmest on record. Temperatures in Europe were up to 3°C higher than average, with the exception only of Spain and Portugal. Similarly, much of Europe experienced above average temperatures in July, and globally this month was the fifth warmest July since records began.

7.3 Air Mass Back trajectories

Air quality forecasting in the UK relies on the analysis of air masses. AEA uses back-trajectory plots to show the movement of air masses over the past few days. Air masses originating and travelling over low-pollution areas, such as the Atlantic Ocean, tend to bring clean air to the UK. Conversely, air masses that have travelled over polluted land or have been circulating over a small area for a long period of time are likely to bring polluted air with them.

Figure 7.4 shows 96-hour back trajectory plots showing the movement of air masses prior to arriving in the UK, for example days before and during the May 2008 ozone pollution episode.

Until the 5 May these trajectories showed relatively clean air being brought into the UK from the Atlantic. From the 6 May the air circulating over Europe, combined with high temperatures, was the cause of increased ozone concentrations.

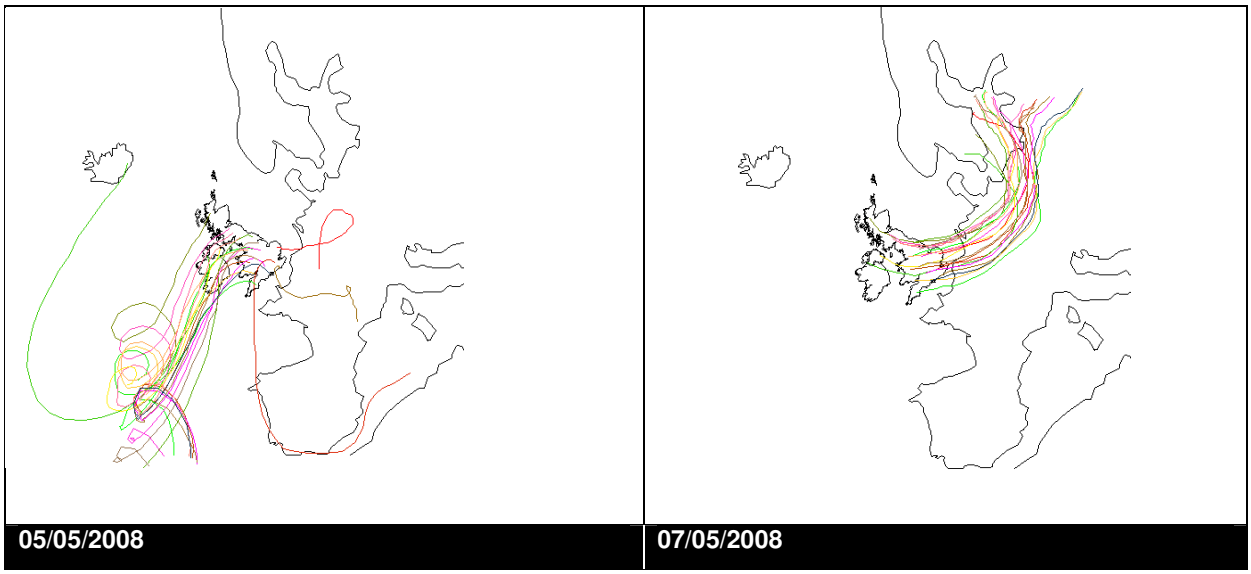


Figure 7.3 Example 96-hours air mass back trajectories during the May episode

8 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.

In 2008, the focus of this part of the work has been on incorporating the data from The Scottish Government Gravimetric Partisol sampling programme into the mapping process to produce updated PM_{10} and $PM_{2.5}$ maps for Scotland and to compare these with corresponding maps for the UK as a whole. For the Scottish Government measurement programme, measurements of PM_{10} and $PM_{2.5}$ were undertaken at 5 existing AURN sites (Inverness, Fort William, Bush Estate, Eskdalemuir and Dumfries) for one-year at each location. These measurements considerably increased the body of particulate data available for Scotland[9].

The sampling equipment and procedures used for the additional Scottish Government measurements were identical to those used for measurements in the AURN. However, during the course of the measurement programme evidence emerged of issues with the data determined with these samplers in the UK. This has been the subject of detailed investigations, which have been fully reported. Now that these investigations are complete, the Scottish data have been revisited to provide a reliable dataset which is consistent with similar measurements made throughout the UK.

These new data have now been incorporated into updated PM_{10} and $PM_{2.5}$ maps for Scotland[10]. In addition, the maps used a dispersion kernel derived with Scottish meteorological data obtained from RAF Leuchars.

In conformance with the International Standard for Gravimetric PM_{10} measurements, the data were collected on quartz filters. However, in the UK Particulate sampler equivalence programme, gravimetric samplers were referenced to emfab filters as permitted by the new international standard for $PM_{2.5}$ measurement. As the UK is going forward with gravimetric PM_{10} and $PM_{2.5}$ measurements based on the emfab filters, the quartz-based data have been reduced by $2.5\mu gm^{-3}$ in the mapping exercise to achieve consistency with the emfab based measurements in the future.

The background and roadside maps thus produced are presented in Figure 8.1 and Figure 8.2 for PM_{10} and $PM_{2.5}$ respectively.

The Scottish Government will be asking a small number of local authorities to use the Scottish background maps to evaluate the impact of any reduction in PM_{10} on the ability of LAs to meet national air quality objectives.

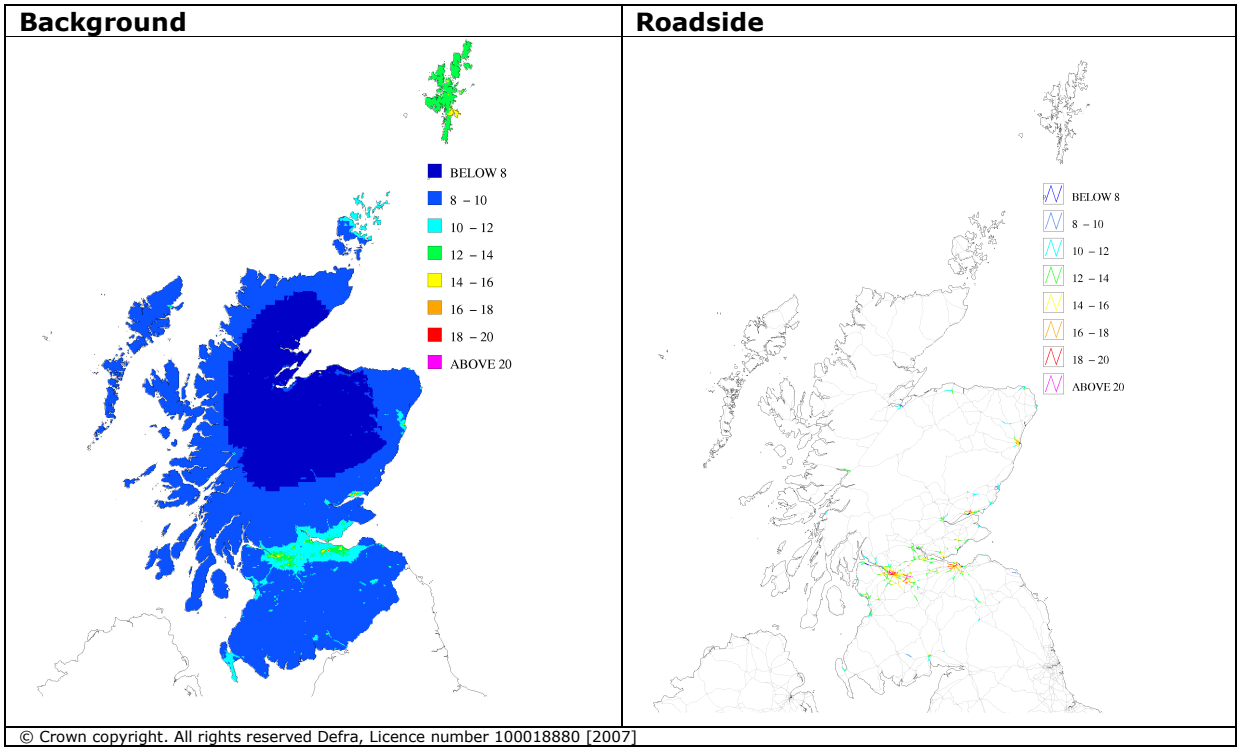


Figure 8.1 – Gravimetric PM_{10} maps for 2007 μgm^{-3} (Scotland-specific model)

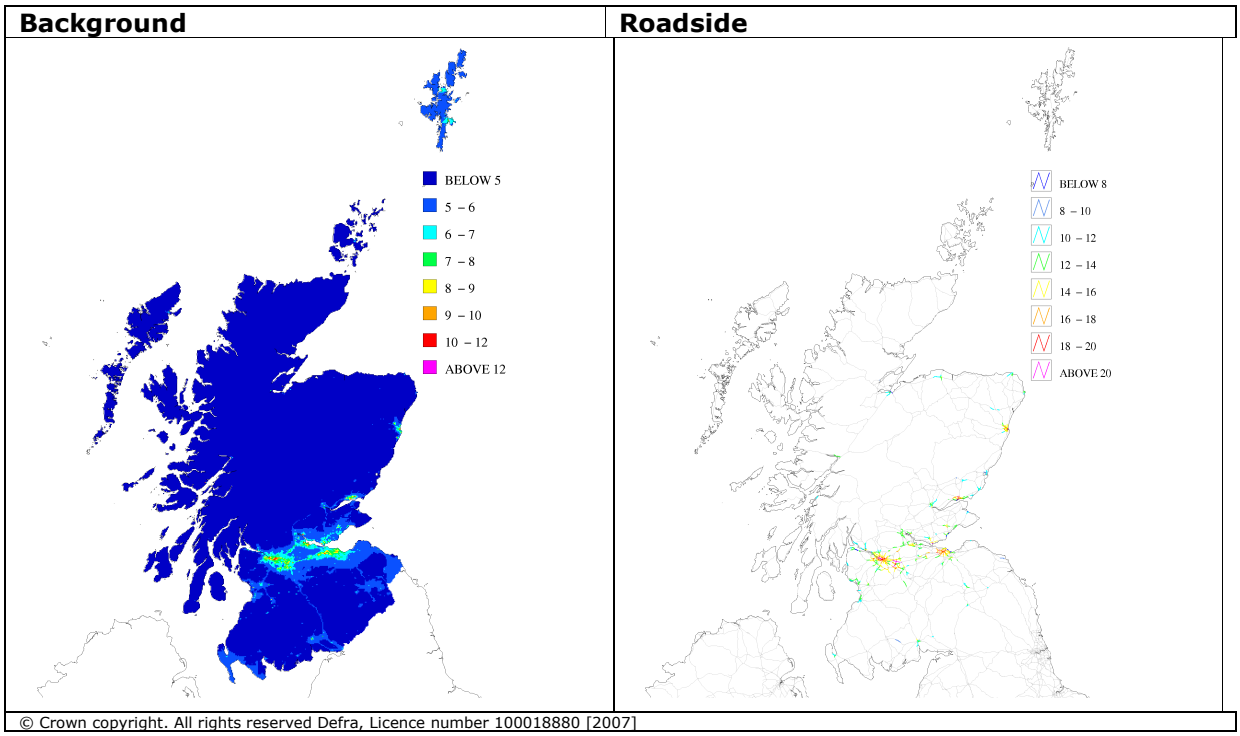


Figure 8.2 – Gravimetric $PM_{2.5}$ maps for 2007 μgm^{-3} (Scotland-specific model)

For the purposes of the EU Air Quality Directive, Scotland has been split into 2 agglomerations (urban areas with population greater than 250,000) - Edinburgh Urban Area and Glasgow Urban Area and 4 zones - Scottish Borders, Central Scotland, North East Scotland and Highland. Whilst the concept of zones and agglomerations has no specific relevance in terms of the Air Quality Strategy and the Air Quality Objectives for Scotland, it never the less provides a useful framework for discussing the results.

The model outputs have been compared against the Air Quality Objectives for Scotland to determine the extent of exposure to specific concentrations. At background locations the area and population exposed are assessed. At roadside locations, the number of road links and the length of road exposed are assessed.

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

No exceedences of the annual mean PM_{10} objective of 18µgm^{-3} at background locations were identified by the Scotland-specific model. However, the model identified 67 road links exceeding this Objective across Scotland, 60% of which (41 road links) were located in Glasgow Urban Area. These 67 road links represent a length of road measuring 82.6km. No roadside exceedences of this Objective were identified by the model in the Highland or Scottish Borders zones. There were no exceedences of 22µgm^{-3} (equivalent to 7 exceedences of the daily Air Quality Objective for PM_{10}) at background locations but for roadside locations there were 5 roads modelled to exceed this, representing almost 10 km, most of which were in the Glasgow Urban Area.

For $PM_{2.5,}$ the Scotland specific model did not identify any exceedences of the annual mean $PM_{2.5}$ Objective of 12µgm^{-3} at background locations but did identify a small number of roadside exceedences. These roadside exceedences include 7 road links in total (4 in Glasgow Urban Area and 3 in Central Scotland zone) which represent 12.6km in length.

The corrected Scottish Partisol data (and corrected UK Partisol data) have also been incorporated into the process for preparing updated UK-wide particulate matter maps for 2007. The detailed report on the Scottish pollution mapping for 2007 shows that there are only small differences between the Scotland-specific and UK-wide maps.

9 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.

9.1 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 40µgm^{-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 9.1 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.

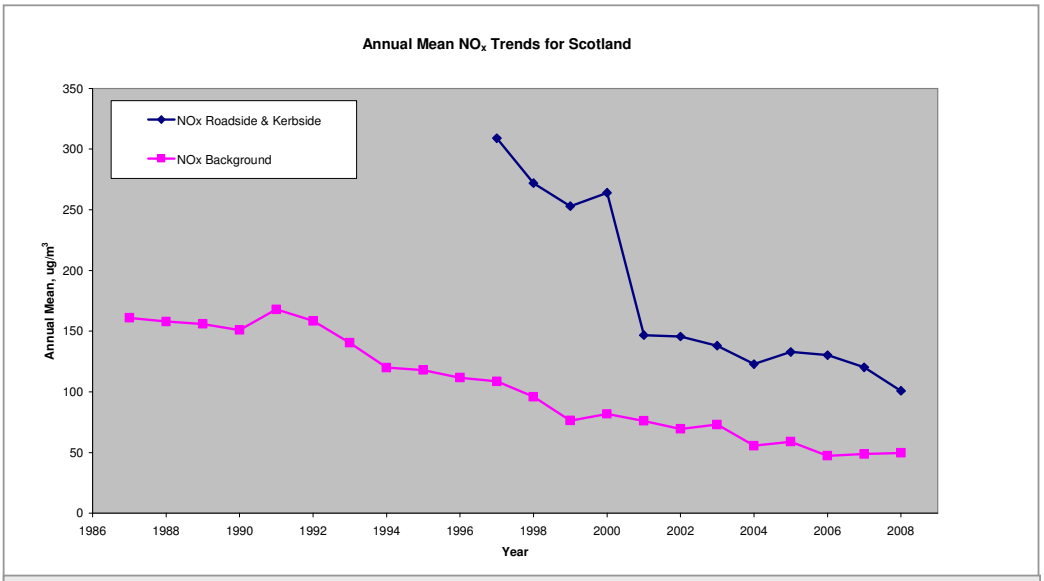


Figure 9.1 – Trends in NO_x annual means at urban background and roadside sites in Scotland: 1987 - 2008.

Despite the limitations in the number of monitoring stations in the early years, it is clear that there has been a smooth and 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 9.2 below shows the corresponding trends for NO_2, which also indicate 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. 2008 does however provide encouragement in that average roadside concentrations of NO_2 in Scotland were below 40µgm^{-3} for the first time. This is despite evidence of a levelling-off in the reduction in concentrations in recent years, which UK experts[11] believe may be due to an increase in the proportion of NO_2 emitted directly to the atmosphere. Resulting from:

a) The increased market penetration of diesel cars and the retrofitting of pollution control devices, such as catalytically regenerative traps to buses, and
b) Increasing background O_3.

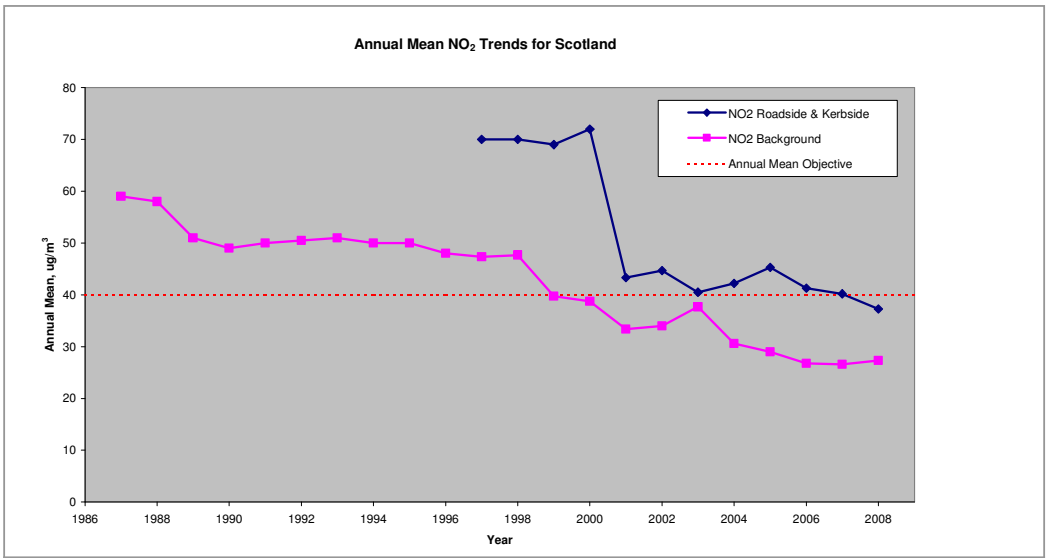


Figure 9.2: Trends in NO_2 annual means at urban background and roadside sites in Scotland: 1987 - 2008.

9.2 Particulate Matter (PM_{10})

Trends in PM_{10} particulate matter across Scotland are illustrated in Figure 9.3. 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 2008 figures show that for the first time average background PM_{10} concentrations across Scotland are below the 18µgm^{-3} objective.

For roadside sites the trend is less clear, mainly due to a large increase in the number of monitoring sites available from 2005 onwards. This indicator appears to show a decreasing trend from 1997 to 2004, and then a step change up to a slightly higher concentration in 2005 and 2006 followed by

decreases again in 2007 and 2008: however, this should be interpreted with caution as it is probably due to the fact that many new roadside PM_{10} sites were set up in 2005, at locations where particulate concentration were likely to be high.

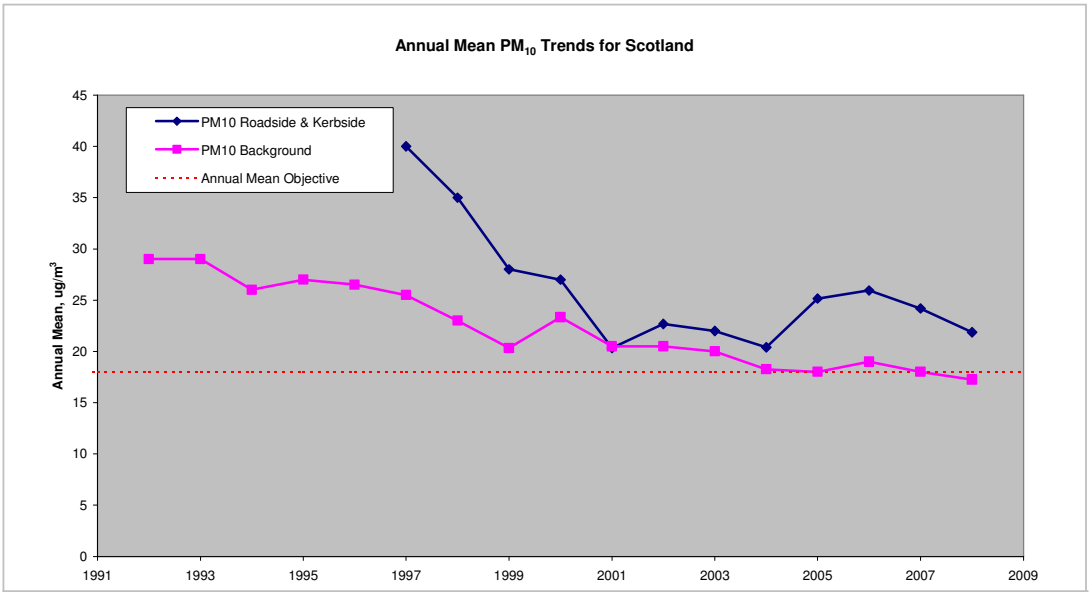


Figure 9.3 Annual Mean PM_{10} Concentrations in Scotland at urban background and roadside/kerbside locations from 1992 to 2008.

9.3 Ozone

Finally, Figure 9.4 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 NOx 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.

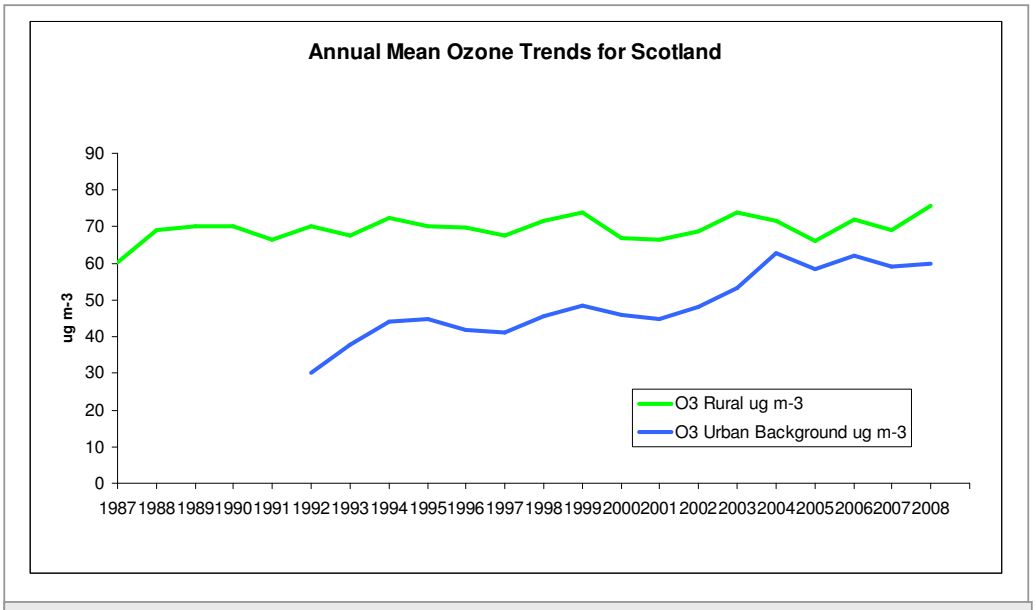


Figure 9.4: Trends in Ozone at Rural and Urban Background Sites in Scotland: 1987 - 2008.

10 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 2008, the database and website have been expanded and developed considerably. Comments and suggestions from stakeholders received during the annual seminar and a further period of consultation have been incorporated.

Air pollution data for 62 automatic monitoring sites throughout Scotland are available in the database for all or part of 2008. This is an increase of 15 sites over 2007. Currently 5 sites are temporarily closed for relocation and 3 sites are in the final stages of joining the database. In addition, a further 9 sites are to be added in 2009. This will bring the total number of sites in the database to about 80 by the end of 2009.

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.

During 2008 all PM_{10} data in the Scottish database collected with TEOM analyses have been corrected using the Volatile Correction Model to obtain gravimetric equivalent data. These data have been provided to the relevant Local Authorities and will be available from the website in due course.

A summary of ratified data for 2008 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.

The data 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. Encouragingly, for the first time the mean nitrogen dioxide levels for both urban background and roadside/kerbside locations in Scotland are below the Air Quality Strategy Objective level of $40\mu gm^{-3}$. The mean PM_{10} concentration for urban background levels is also below the Scottish Annual mean Objective of $18\mu gm^{-3}$ for the first time since records began in the early 1990's. Conversely, and of concern for public health, urban ozone levels have increased as a result of the reduction in NO_x concentrations in urban areas. Increasing background ozone pollution is largely out of the control of local and national government, but international and global initiatives are being put in place to reduce the emissions of air pollutants which act as the precursors to ozone formation.

The corrected data from Partisol samplers used the Scottish Government Gravimetric PM_{10} and $PM_{2.5}$ monitoring campaign in 2007 have been utilised to calculate updated PM_{10} and $PM_{2.5}$ pollution maps for Scotland. These data have also been incorporated into the process for preparing updated UK-wide particulate matter maps for 2007. Differences between the Scotland specific pollution mapping for 2007 and the UK maps were small and hence, at present the UK-wide maps are currently being utilised by Local Authorities for the Local Air Quality Management Review and Assessment process. However, the Scottish Government will be asking a small number of local authorities to use the Scottish background maps to evaluate the impact of any reduction in PM_{10} on their ability to meet national air quality objectives.

As the number of monitoring sites in the database continues to increase, the evaluation of spatial and temporal trends in air pollution levels across Scotland will become more robust.

It is anticipated that the Scottish Air Quality Database and Website will continue to expand and provide a valuable national resource of air quality data for The Scottish Government, Local Authorities, health professionals, EIA and SEA practitioners.

11 References

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 http://www.scottishairquality.co.uk/documents/reports2/207080626_Scottish_Air_Quality_2007_-_Final_Report_23-06-08.pdf

3 Air Pollution in Scotland 2008 http://www.scottishairquality.co.uk/reports.php?n_action=report2 .

4 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

5 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

6 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

7 Green D et al. VCM Application to hourly time resolution and AURN FDMS purge measurements May 2008 KCLERG\MT\VCM\DEFRA2 http://www.airquality.co.uk/reports/cat13/0902231025_VCM_Application_to_Hourly_and_AURN_FDMS_Purge_Measurements.pdf

8 Yardley R et al. Air Pollution Forecasting: Ozone Pollution Episodes Report (May and July 2008 AEAT/ENV/R/2730 February 2009 http://www.airquality.co.uk/reports/cat12/0902121158_Ozone_report_FINAL_Feb09.pdf

9 Stevenson K et al. Measurement of PM_{10} and $PM_{2.5}$ in Scotland with Gravimetric Samplers AEAT/ENV/R/2702 Issue 1 To be published

10 Kent A et al. Gravimetric PM_{10} and $PM_{2.5}$ mapping for Scotland, 2007. AEAT/ENV/R/2742 Issue 1. To be published

11 AQEG 2007 Trends in primary nitrogen dioxide in the UK - December 2007 http://www.defra.gov.uk/environment/airquality/panels/aqeg/publications/index.htm

Appendices

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Appendix 1
National Monitoring Network Sites in Scotland

Table A1.1. AURN Measurement Sites in Scotland

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)	322000,656200
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	326200,673100
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[3]	URBAN INDUSTRIAL	NO NO_2 NO_X PM_{10} SO_2	293840,681032
Inverness	ROADSIDE	PM_{10}(grav) NO NO_2 NO_X	265720,845680
Lerwick	RURAL	O_3	445337,113968
Strath Vaich	REMOTE	O_3	234700,875000

1 PM10 at this site is part of Scottish Government Network
2. PM10 at this site is part of Scottish Government Network. Additional measurements of benzene concentrations integrated over a two-week period as part of the Non-automatic Hydrocarbon Monitoring network.
3 Additional measurements of benzene concentrations integrated over a two-week period as part of the Non-automatic Hydrocarbon Monitoring network. Additional passive sampling of 1,3-butadiene.

Table A1.2. Automatic Hydrocarbon Network 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 A1.3. PAH Monitoring Sites in Scotland

Site	Address	Grid Reference
Edinburgh	West Richmond Street Gardens	326282,673125
Glasgow	St Enoch Square Glasgow G2 8BX	258964, 665018
Kinlochleven 2	Electrical Substation Kinlochleven	219305,761905

Table A1.4. Species measured at PAH sampler locations

Acenaphthene, Acenaphthylene, Anthanthrene, Anthracene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(j)fluoranthene, Benzo(k)fluoranthene, Benzo(b)naph(2,1-d)thiophene, Benzo(ghi)perylene, Benzo(c)phenanthrene, Benzo(a)pyrene,	Benzo(e)pyrene, Chrysene, Cyclopenta(c,d)pyrene, Dibenzo(ah/ac)anthracenes, Dibenzo(ae)pyrene, Dibenzo(ah)pyrene Dibenzo(ai)pyrene, Dibenzo(al)pyrene, Fluoranthene, Fluorene, Indeno(123cd)pyrene, 1-Methyl Anthracene,	2-Methyl Anthracene, 9-Methyl Anthracene, 5-Methyl Chrysene, 1-Methyl Phenanthrene, 2-Methyl Phenanthrene, 4,5-Methylene Phenanthrene, Perylene, Phenanthrene, Pyrene, Retene,

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

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
Glasgow	Urban Background 261337,664435	Glasgow, St Annes, St Annes Primary School, 37 David Street Glasgow G40 2UN	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 A1.6. Rural Metal Deposition Monitoring sites in Scotland

Site	Location Grid Ref.	Heavy metals			Mercury	
		In Particles	In Rain	In Cloud	In Air	In Rain
Inverpolly	218700,908900		✓			
Banchory	367600,798500	✓	✓		✓	✓
Bowbeat	328300,647300		✓	✓		
Auchencorth Moss	322000,656200	✓	✓		✓	✓

Table A1.7. Acid Deposition Monitoring sites in Scotland

Site Name	Grid Ref	Species included
Achanarras	315150,955050	pH, SO_4, NO_3, NH_4, Na, Mg, Ca, Cl, K, PO_4, nss-SO_4, H, conductivity
Glensaugh	366029,779670	
Eskdalemuir	323500,602800	
Strathvaich Dam	234700,875000	
Allt a' Mharcaidh	287500,803500	
Whiteadder	366180,663130	
Loch Dee	246630,578135	
Polloch	179250,768950	
Balquhidder 2	254550,720750	
Loch Chon	242960,708370	
Lochnagar	325400,786120	
Forsinain	290395,948735	

Table A1.8. Ammonia and Nitric Acid Monitoring Sites in Scotland

Name	Grid Ref	Ammonia	Nitric Acid
Shetland	450000,114000	✓	✓
Halladale 1	289400,951400	✓	✓
Inverpolly	218700,908800	✓	
Strathvaich Dam	234800,875000	✓	✓
Ellon Ythan	394500,830400	✓	
Pitmedden	388300,827800	✓	
Lagganlia	885600,203700	✓	✓
Allt a Mharcaidh	289500,802400	✓	
Rum	140800,799250	✓	✓
Glensaugh	366400,779900	✓	✓
Glenshee Hotel	311100,769900	✓	
Glen Shee	311700,769300	✓	
Tummel	274400,761100	✓	
Rannoch	260300,753300	✓	
Loch Awe	196600,711500	✓	
Edinburgh Johnston Terrace	325300,673400	✓	
Edinburgh Medical School	326388, 672605	✓	
Edinburgh St Leonards	326200,673100	✓	
Bush 2	324700,663800	✓	
Bush 1	324500,663500	✓	✓
Auchencorth Moss	322000,656200	✓	✓
Carradale	179800,537800	✓	✓
Auchincruive	237900,623400	✓	
Sourhope	386700,621800	✓	
Eskdalemuir	323500,602800	✓	✓
Coalburn	369300,578200	✓	
Dumfries	254600,565800	✓	

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.

AEA group
Glengarnock Technology Centre
Caledonian Road
Lochshore Business Park
Glengarnock
Ayrshire
KA14 3DD

Telephone: 0870 190 6574
Fax: 0870 190 5151