Scottish Air Quality Database

Annual Report 2014

Report for the Scottish Government

RICARDO-AEA

The Scottish Government

ED 57729 | Issue Number 1 | Date 22/07/2015

Customer:

Scottish Government Scottish Government

Customer reference:

ED57729

Confidentiality, copyright & reproduction:

Contact:

Stuart Sneddon
Ricardo-AEA Ltd
Gemini Building, Harwell, Didcot, OX11 0QR, United Kingdom

t: +44 (0) 1235 75 3015

e: stuart.sneddonstuart.sneddon@ricardo-aea.com

Ricardo-AEA is certificated to ISO9001 and ISO14001

Authors:

David Hector, Stephen Stratton, Rebeca Rose, Alison Loader, Alistair Dorman Smith

Approved By:

Stuart Sneddon

Date:

22 July 2015

Ricardo-AEA reference:

Ref: ED57729- Issue Number 1

Executive summary

Ricardo-AEA was commissioned by the Scottish Government to undertake a 3-year project (Apr 2007 – Apr 2010) to develop an Air Quality Database and Website for Scotland. The contract was renewed for another 3 years in April 2010 and a further 3 years in April 2013.

This report presents the activities undertaken during the seventh year of the project - April 2014 to March 2015. In addition to the core work undertaken under the project, there has been significant additional activity and further developments during the year. These have included updates and enhancements to; the Scottish Air Quality website (http://www.scottishairquality.co.uk); Social Media feeds; the Scottish air quality apps; the air quality forecasting facility; and the Educational webpages and packages.

Air Quality Monitoring in Scotland

All automatic data within the Scottish Air Quality Database (SAQD) are subject to the same QA/QC procedures as data from the national network air quality monitoring stations within the UK Automatic Urban and Rural Network (AURN). This ensures that all data in the database are quality assured and are traceable to UK national calibration standards for the various pollutants. At the end of 2014 the Scottish Air Quality Database contained data for a total of 88 live automatic monitoring sites.

A summary of ratified data for 2014 is provided in this report. The pattern of measured concentrations is similar to previous years in that where exceedances of the Scottish Air Quality Objectives occur, these are in areas where the relevant Local Authority has already declared, or is in the process of declaring an Air Quality Management Area (AQMA). Where AQMAs 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. By April of 2015 a total of 32 AQMAs were in place across 14 local authorities in Scotland.

The website and this annual report also contain a summary of data from a wider range of pollutants measured in Scotland as part of several national network monitoring programmes.

Air Quality Mapping of Scotland

Ricardo-AEA provide mapped concentrations of modelled background air pollutant concentrations on a 1 km x 1 km basis for the whole of Scotland. Modelled roadside air pollutant concentrations are provided for road links in Scotland. The air pollution maps are derived from a combination of (1) measurements from Scotland's network of air quality monitoring stations, and (2) spatially disaggregated emissions information from the UK National Atmospheric Emissions Inventory (NAEI).

Maps show that there were no modelled exceedances of the Scottish annual mean NO_2 objective of 40 µg m^{-3} at background locations.

The Scotland-specific model predicted that the Scottish annual mean NO_2 air quality objective was exceeded along 99 road links (125 km of road). The majority of exceedances were predicted to occur in the Glasgow Urban area where exceedances were modelled for 68 road links (84 km of road). Overall exceedances of the Scottish annual mean NO_2 air quality objective were modelled in four of the six zones and agglomerations in Scotland.

Exceedances of the Scottish annual mean PM_{10} objective of 18 µg m^{-3} were modelled at nineteen, 1 km^2 grid squares in Scotland. Fifteen grid squares were located in Central Scotland within an area around the junction of M8 and M9 and M8 in the direction of Livingston.

The Scotland specific model has predicted similar exceedances in the annual mean PM_{10} concentration in this cluster of grid squares in previous years. Modelled concentrations in this area for 2012 were lower than the concentrations reported here for 2013, but modelled concentrations in 2011 were similar.

On the whole the extent of the exceedance of the Scottish PM_{10} air quality objective was typically of the order of 1 to 2 µg m^{-3}, but was as high as 4 µg m^{-3} in one grid square.

Air Quality Trends for Scotland

Data held within the database covering many years have been used to assess possible trends in air pollution throughout Scotland. Air quality trends have been examined on the basis of individual monitoring sites, and subsets of long-running sites, rather than the composite data set. For this report, smoothed trend and Theil-Sen analysis has been used; utilising the Openair data analysis tool to quantify pollutant trends at individual sites.

In terms of concentrations of NOx the longest-running urban background monitoring site in Scotland is Aberdeen, Errol Place (in operation from late 1999 onwards). NOx concentrations at this site increased slightly in its earlier years of operation but have shown a general decrease since 2002. The pattern for NO_2 is in some respects similar to that observed for NOx, in that it peaks around 2002 with a subsequent decrease, however, NO_2 appears to show more variation.

Three urban non-roadside sites have been monitoring NOx since 2004 or earlier: Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth. Over the period from 2004 to 2014, all three sites show a negative trend (i.e. decreasing NOx). The actual decrease year-on-year is small, however the trend is statistically highly significant (at the 0.001 level) at Aberdeen Errol Place and Edinburgh St Leonards (though not Grangemouth).

In the case of NO_2, all sites again show a slight negative trend, though the year-on-year decrease is even smaller than for total NOx.

Three long-running rural sites have monitored oxides of nitrogen since 2005 or earlier: Bush Estate, Eskdalemuir and Glasgow Waulkmillglen Reservoir. While the sites at Bush Estate and Eskdalemuir show small but highly significant downward trends, this is not the case for Glasgow Waulkmillglen Reservoir, where, by contrast, concentrations are increasing.

At Scotland's longest running traffic-related urban site Glasgow Kerbside (since 1997), there is considerable fluctuation in NOx, but some indication of an overall downward trend. By contrast, in the case of NO_2, there is no such apparent downward trend over this period.

Looking at a subset of nine long-running sites at urban traffic locations (Aberdeen Anderson Drive, Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road, Glasgow Byres Road, Glasgow Kerbside, Inverness, Perth Atholl Street and Perth High Street) five of the sites show a downward trend in NOx (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road and both the Perth sites). However, Glasgow Byres Road and Glasgow Kerbside show no trend, and both Aberdeen Anderson Drive and Inverness show slight but significant upward trends.

In the case of NO_2, there is more between-site variation in trends. Four of the sites (Dumfries, East Dunbartonshire Bishopbriggs, Perth Atholl Street and Perth High Street) show statistically significant downward trends. Inverness shows a small but statistically significant upward trend and the remaining four show no significant trend at all. This is similar to observations in the previous year's report; it may indicate that trends in concentrations of this pollutant depend greatly on conditions at the various sites.

The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place (since 1999). This shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013. There is some indication of a recent up-turn.

Looking at the subset of longest running urban non-roadside sites, all sites show a negative trend significant at 0.001.

In terms of long term traffic related sites, all sites also show statistically significant downward trend, indicating a year on year decrease.

The longest-running traffic-related PM_{10} monitoring site in Scotland is Glasgow Kerbside (since 1997). Although concentrations are lower in recent years than in the late 1990s, the decrease has not been consistent.

In contrast to PM_{10}, for which concentrations at most long-running sites show a downward trend, in the case of $PM_{2.5}$ the situation appears to vary more from site to site. In particular, two of the sites (Aberdeen Errol Place and Auchencorth Moss) show highly statistically significant upward trends in this particulate size fraction, since 2009.

Only Glasgow Kerbside shows a clear and statistically significant downward trend. Although the trend is significant at the 0.01 level, most of the decrease appears to have occurred since the start of 2011. When compared to other similar sites in the UK, Glasgow Kerbside trend is not typical. Other similar UK sites show no significant trend and there is also considerable variation from site to site.

For all long running rural ozone sites (Bush estate, Eskdalemuir and Strath Vaich), though fluctuating considerably, plots show a small but statistically significant upward trend.

Emissions of Pollution Species

Scotland's NO_x emissions have declined by 65% since 1990 and currently account for 9% of the UK total. 29% of these emissions stemmed from road transport combustion sources and 27% from power generation. These two sectors also represent the main sources of decline in NO_x emissions.

Since 2009, the decreasing trend in NO_x emissions appears to have slowed in all sectors with the exception of transport. Energy sources of NO_x emissions have increased from 2011 to 2012.

Emissions of PM_{10} have declined by 59% since 1990 and account for 10% of the UK total. At 37%, emissions from commercial, domestic and agricultural combustion were the main source of PM_{10} in 2012. Emissions from power generation accounted for 25% of total emissions in 1990 but have significantly reduced to 8% in 2012.

Table of contents

Appendices

1 Introduction

The Scottish Government undertakes considerable monitoring of a wide range of air pollutant species as part of a joint UK programme run in conjunction with Defra, the Welsh Government and the Department of the Environment in Northern Ireland. In addition a large number of Local Authorities in Scotland monitor air quality within their geographical boundaries as part of the requirements of the Local Air Quality Management system. Prior to 2006, air quality data in Scotland outside of the nationally operated sites were collected by a wide range of organisations for a number of purposes and were widely dispersed. Consequently and following experience gained across the rest of the UK it was recognised 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, now Ricardo-AEA, to undertake a pilot programme to develop an air quality database for Scotland.

The pilot study developed the initial Scottish Air Quality Database (SAQD) 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 Report1. 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 the following components:

- Independent audits 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 Ricardo-AEA were commissioned to undertake the next stage which was to further develop and extend the SAQD and website incorporating all stakeholder comments and to bring selected Local Authority sites in line with the national QA/QC requirements. Reports relating to earlier years of the project are available on the website (www.scottishairquality.co.uk).

This annual report summarises the progress made during 2014 in the on-going project tasks and also highlights the considerable new work undertaken during 2014.

Section 2 provides information on the upgrades and enhancements to the Air Quality in Scotland website (which was re-launched in March 2014), with **Section 3** providing a brief summary of the Annual Air Quality in Scotland seminar where amongst other interest air quality subjects, the upgrades and enhancements of the website and App were officially launched.

The overall number of sites in the database with data available for all or part of 2014 was 88 and these are listed in **Section 4**. Though the number of sites has decreased since 2013 (91) a number of sites have closed and opened over the past year. Additionally the number, types of pollutants measured and method of measurement at several sites across the network have also changed. The corresponding QA/QC programmes (**Section 5**) have expanded and adapted to encompass these additions.

As in 2009 to 2013, the PM_{10} data from TEOM analysers have been corrected using the Volatile Correction Model for all sites in Scotland. Summary statistics for all of the available data are provided in Section 6.

In 2009, a pilot mapping exercise was undertaken including future year projections for 2010, 2015 and 2020. This pilot exercise has been subject to further development in subsequent years and an improved methodology has been used to deliver pollution climate mapping of NOx, NO_2 and PM_{10} including projections. The Scottish pollution climate mapping work is described in **Section 7**.

Section 8 provides a discussion of trends in pollutant concentrations across Scotland, based on the latest available data. As the number of monitoring sites in Scotland has significantly increased since 2006, it has become feasible to undertake pollution climate mapping of NOx, NO_2 and PM_{10} using solely Scottish measurement data.

During 2009, the website was upgraded to include links to the SEPA Scottish Pollution Release Inventory (SPRI) in order to provide information on industrial releases of pollutants in Scotland. This data has been updated for 2012 and this report also includes a section on emissions in Scotland with data from both the National Atmospheric Emissions Inventory (NAEI) and the SEPA SPRI (**Section 9**).

2 The Scottish Air Quality Website

The 'Air Quality Scotland' database and website (www.scottishairquality.co.uk) has been created to provide a comprehensive resource for information covering all aspects of air pollution in Scotland.

The site is funded by the Scottish Government and is designed to be:

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

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

Since the new website launched on 26th March 2014 it has been developed further with new features to enhance the information it provides. These enhancements were launched at the annual air quality seminar on the 26th March 2015.

2.1 Education

Education has been a recent development for Air Quality in Scotland. Interactive education packages have been developed through the creation of two sections which form part of Air Quality in Scotland (Figure 2.1). The first education website 'Air Pollution Detectives' was created for primary school pupils in the primary 5-7 age range. The second website "Clear the Air" was developed in partnership with a number of secondary schools for pupils in the S1-S3 age range. The education packages can be accessed from Air Quality in Scotland website (http://www.scottishairquality.co.uk/education/).

Figure 2.1 Air pollution Detectives and Clear the Air

2.1.1 Air Pollution Detectives

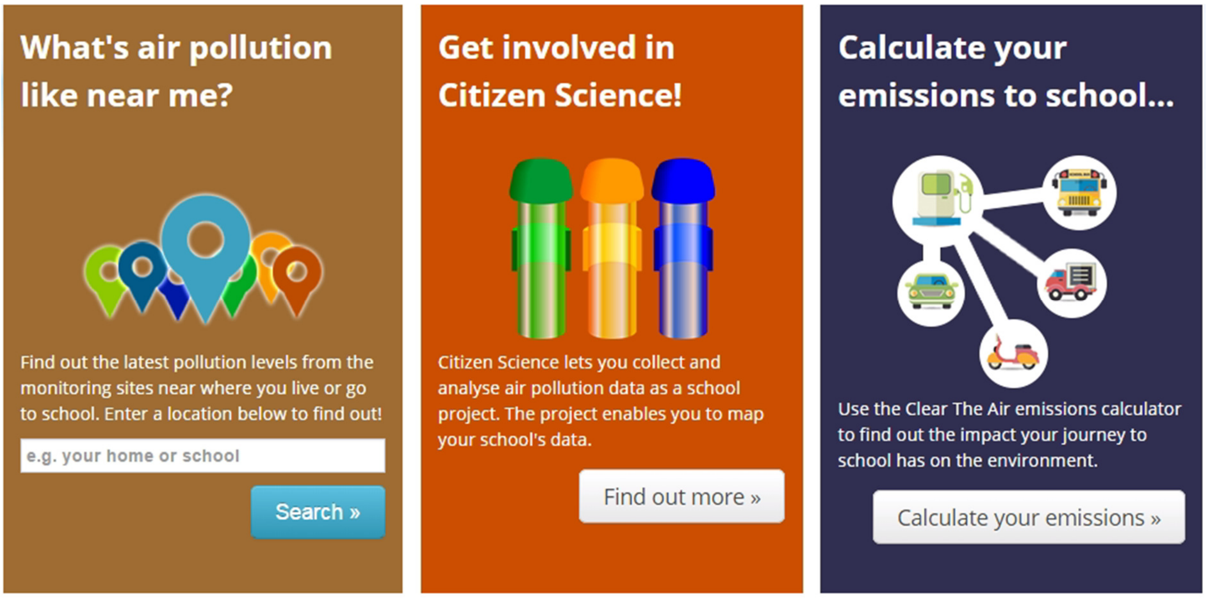
The Air pollution detectives initially launched in 2011 was revised and updated in 2014. The webpage was designed to introduce air quality issues to primary school pupils between the ages of 8-11 years old. The animated interactive webpage provides an introduction to air pollution sources and how pupils' actions can impact the air quality around them. The website is accompanied by a set of teachers notes to enhance the learning experience.

The Air pollution detectives is available at: http://www.scottishairquality.co.uk/education/

2.1.2 Clear the Air

The Clear the Air package includes a series of interactive webinars and exercises designed to be undertaken by pupils. These interactive exercises include 'What air pollution is like near me', 'Calculating your emissions to school' and lastly a class science project which allows air quality monitoring around the school to be carried out using NO_2 Diffusion tubes. Figure 2.2 shows the interactive packages available on the Clear the Air website.

Figure 2.2 Interactive packages available on the Clear the Air website



2.1.3 The Clear the Air - Air Quality Monitoring Pack

The Clear the Air monitoring pack has been designed to give pupils hands on experience with air quality monitoring equipment together with a better understanding of the underlying science. As a class or group, pupils can undertake air quality monitoring around their school grounds, or at or near their homes. Once the results have been analysed the website enables the monitoring data to be input in terms of location and measured concentration via the school's private user portal so that the results can be displayed on a map. The package encourages pupils to discuss the results and the factors influencing the air quality measured within the area. The Clear the Air package is supported by a teachers pack including notes to supplement the monitoring equipment and webinars to help introduce the concept of local air quality and conduct the monitoring. Further information regarding the programme can be obtained at: http://cleartheair.scottishairquality.co.uk/

2.1.4 Clear the Air- Development

The Clear the Air Monitoring package was developed by working closely with selected secondary schools to ensure the package fulfilled the school curriculum. As part of this process BBC Scotland attended the school to observe the pupils undertaking air quality monitoring (Figure 2.3). The full article is available at: http://www.bbc.co.uk/news/uk-scotland-28694606

Figure 2.3 BBC News Scotland report on pupils undertaking air quality monitoring

2.2 Updated Air Pollution Forecasts

New air pollution forecasts (Figure 2.4) have been developed for Scotland allowing a greater level of detail than previously available.

The key enhanced features are:

- New air pollution forecasts for individual local authorities
- New 5-day forecasts now available
- Additional text commentaries from the Ricardo-AEA duty forecaster for today, tomorrow and a general outlook added to the website

The new enhanced forecasts use data from the Met Office UK air pollution forecasts and summarise data from over 1200 modelled locations in Scotland. The new information enhances the previous regional forecasts by showing air pollution forecasts for each local authority in Scotland.

In addition to the new level of geographical detail, new 5 days air pollution forecasts are also available using the Met Office data. The new 5 days local authority forecasts provide a greater level of detail which can benefit the public and those with health issues. Two new pages have also been added to the website to display the new 5 day local authority forecasts, through a summary table and map.

The enhanced level of detail in the new forecasts is also complemented by new text summaries produced by a Ricardo-AEA duty forecaster. The new text summaries are concise text descriptions produced each day for the following 2 days plus a general outlook. This information is shown on the homepage (Figure 2.5) and also in the forecast section.

Figure 2.4 New enhanced Scotland air pollution forecast

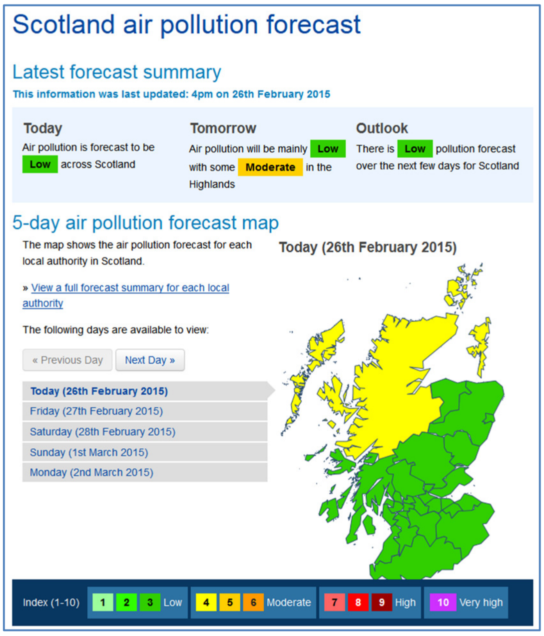
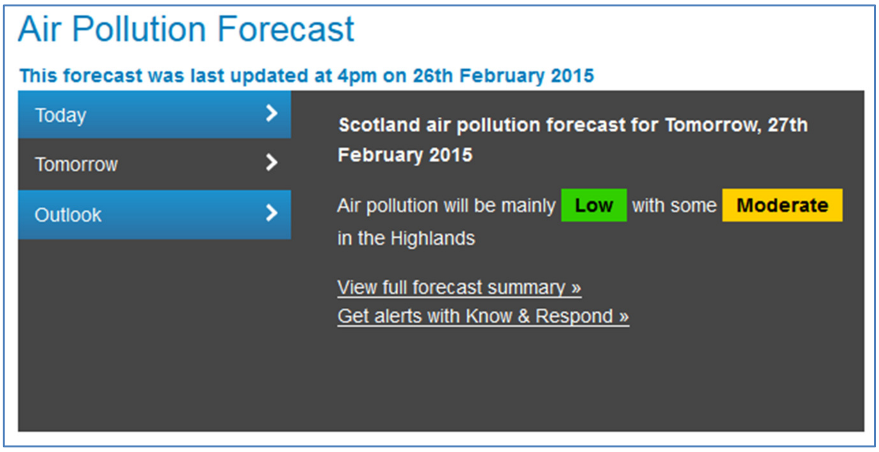


Figure 2.5 Air pollution forecast text summaries

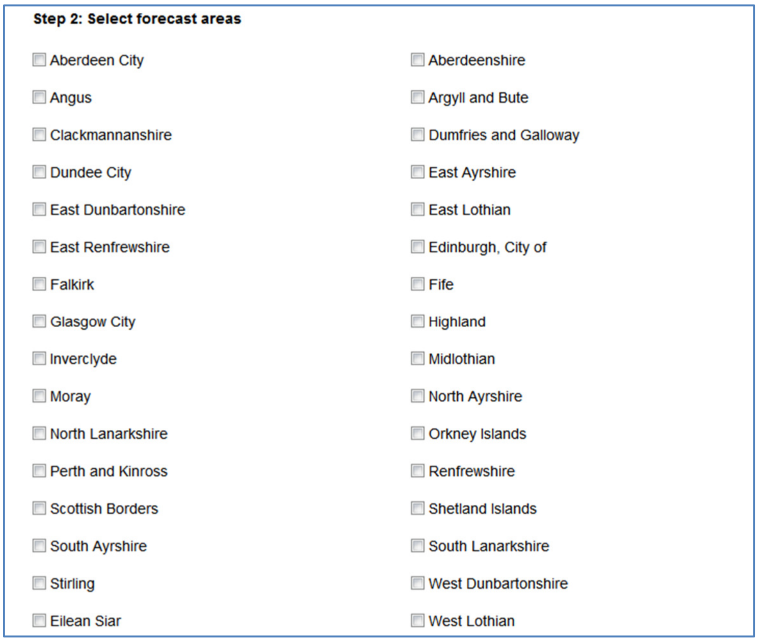


2.3 Know & Respond now based on Local Authorities

The existing Know & Respond alert service has been updated alongside the enhanced air pollution forecasts shown on the website to move from regional to local authority based pollution forecast alerts (Figure 2.6). To help with this transition, users will automatically be migrated to the local authority alerts based on their previous regional subscription.

The features of the Know & Respond service have remained unchanged and alerts continue to be available by SMS, Email and Voicemail. The updates to the app alerts are described in the section below.

Figure 2.6 Sign up page for Know & Respond now showing a list of local authorities to select



Step 2: Select forecast areas

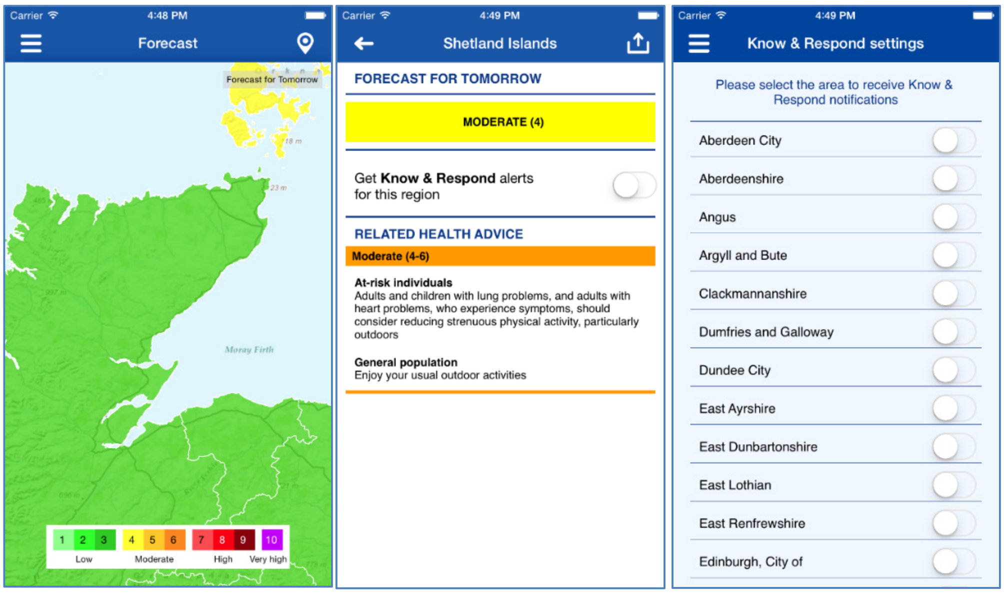
☐ Aberdeen City	☐ Aberdeenshire
☐ Angus	☐ Argyll and Bute
☐ Clackmannanshire	☐ Dumfries and Galloway
☐ Dundee City	☐ East Ayrshire
☐ East Dunbartonshire	☐ East Lothian
☐ East Renfrewshire	☐ Edinburgh, City of
☐ Falkirk	☐ Fife
☐ Glasgow City	☐ Highland
☐ Inverclyde	☐ Midlothian
☐ Moray	☐ North Ayrshire
☐ North Lanarkshire	☐ Orkney Islands
☐ Perth and Kinross	☐ Renfrewshire
☐ Scottish Borders	☐ Shetland Islands
☐ South Ayrshire	☐ South Lanarkshire
☐ Stirling	☐ West Dunbartonshire
☐ Eilean Siar	☐ West Lothian

2.4 Air Quality in Scotland App updated

The Air Quality in Scotland app launched in March 2014 with the new website. It has now been updated to include the updated local authority forecasts and Know & Respond alerts. When subscribing to Know & Respond alerts via the app, users can now subscribe to individual local authorities giving them more targeted information (Figure 2.7). Other features of the app remain unchanged, and it continues to provide the latest measured levels, information about air quality and links to the website.

The app is available for iPhone and Android, further details are available on the website at: http://www.scottishairquality.co.uk/stay-informed/apps

Figure 2.7 Screenshots showing updated sections of the app

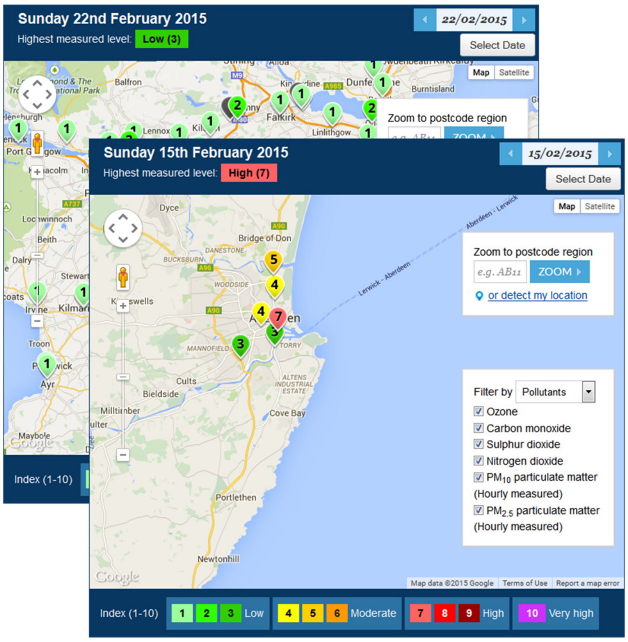


2.5 Historic date functionality

The latest data section of the website has been enhanced with a new date selector providing users with the ability to view the maximum levels measured at each monitoring site for previous days from the Google map (Figure 2.8).

Users can quickly step forwards or backwards through each day using the arrow buttons, or type in a specific date to view. Once a monitoring site has been selected from the enhanced Google map, the available site information shows the either the latest monitoring date (for today), or the maximum levels measured for the selected day.

Figure 2.8 New historic date selectors



2.5.1 Interactive Site graphs

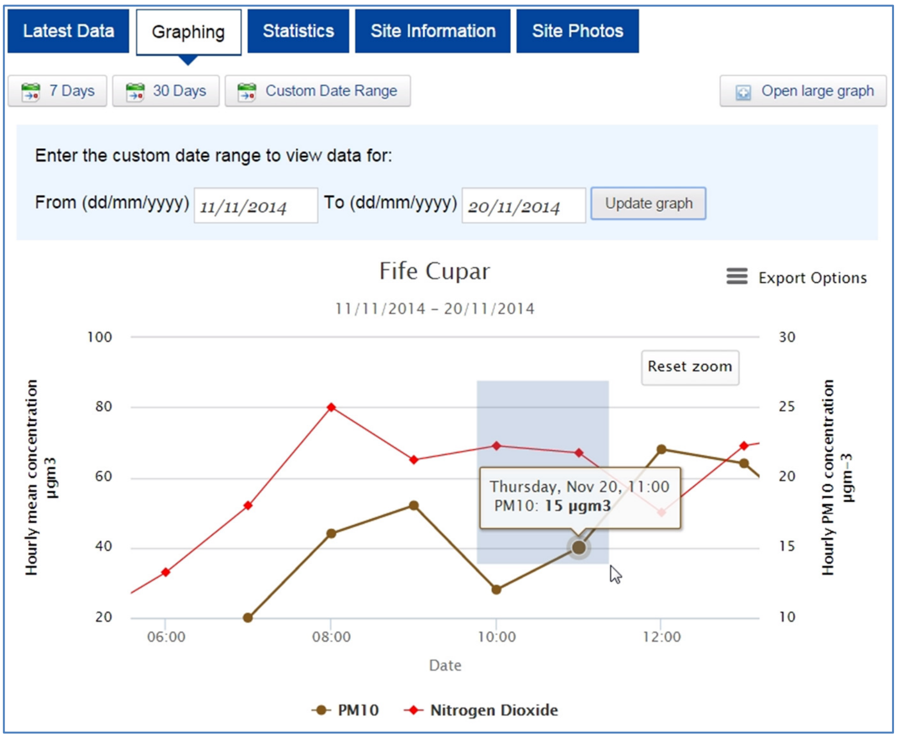
The site graphing functionality has been updated and enhanced so that it is more interactive for users. The new features include:

- Pre-set 7/30 days with custom historic date range functionality
- Interactive hover-over data functionality which provides the day, date, time and concentration data for points selected on the graph
- Zoom in functionality – allowing users to view data down to one single hourly data points
- New download options (PNG, JPG, PDF, SVG, CSV, XLS)

Figures 2.9 and 2.10 illustrate the new functions as described above.

Figure 2.9 New Interactive site graph functions

Figure 2.10 New Interactive site graph Zoom In function



2.6 Usage Statistics

Usage of the website is monitored through the on-line tracking tool “awstats”, and statistics can be accessed by clicking the following link: http://www.scottishairquality.co.uk/cgi-bin/usage.pl. Additionally to awstats, Google Analytics is also used to track and evaluate website usage.

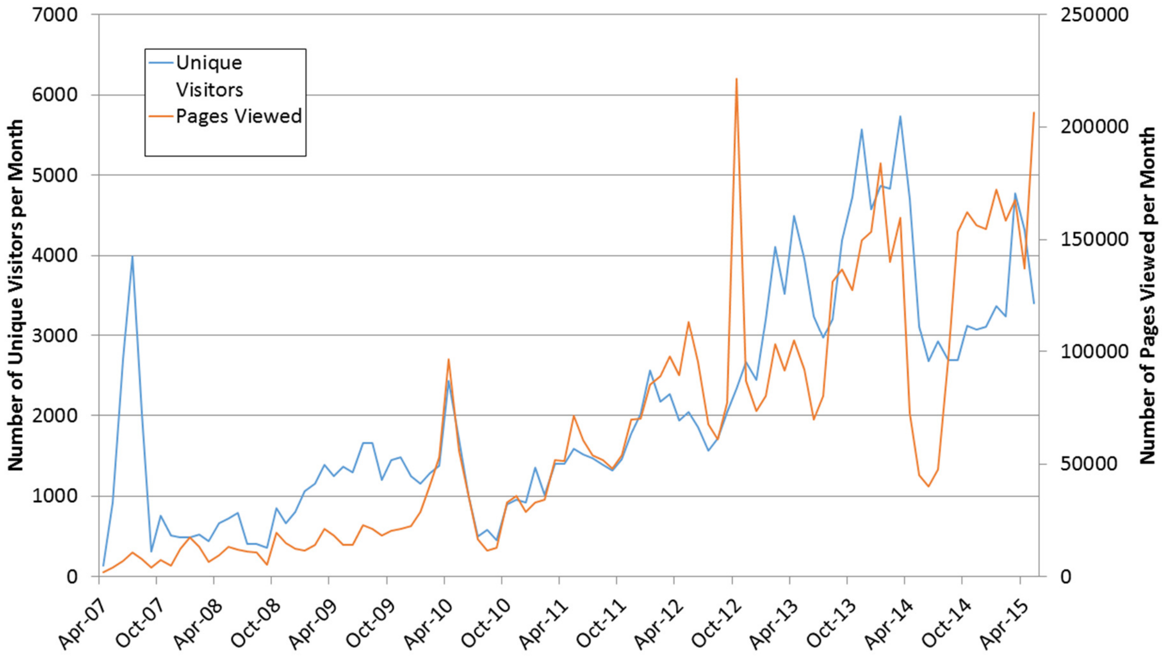
These software tool provides in-depth analysis of the time, date, location and access route of every visit to the website (It does not store any personal information which would require declaring under the Data Protection Act). Figure 2.11 below illustrates how the number of hits has varied during the period April 2007 to May 2015.

The hits will include some automated search engine visits which are required in order to keep the site’s 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 figure 2.11 clearly indicates an upward trend in the number of unique visitors and pages viewed since the site was launched in 2007. The plot also shows that the largest number of unique visitors were recorded during the months of January to April 2014. Whilst the reasons for the distinct trends in activity are not clear, the increased interest in the website during 2013/14 corresponds to an increase in media attention to air quality in general and the launch of the new website. This is in addition to the annual cycle of review and assessment activity which sees local authorities use the site (usually between April and May) to compile data and statistics for their annual reports.

Key users of the website include local authorities, the Scottish Government, SEPA, universities, health professionals, environmental consultants and the general public. The vast majority of the users are from the UK (90%) however there is also significant interest from other countries such as the USA (2%), India, Germany and Spain (1% respectively).

Figure 2.11 Air Quality Scotland Website Hits April 2007 - May 2015



2.7 Website maintenance

On a daily basis the web pages are fully checked by the Ricardo-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 Ricardo-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 Ricardo-AEA's data management software on a daily basis.
- Statistics are automatically recalculated every night:
    - Daily, Monthly & Annual Means etc.
    - All exceedance statistics
- The LAQM pages are 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.
- Requests to subscribe to the discussion forum are reviewed on a daily basis.

We are pleased to report that thanks to the on-going checks and maintenance the web pages were available for over 99% of the time during 2014 with no extended breakdowns or downtime reported.

3 Air Quality Seminar and Newsletter

As part of the Scottish Air Quality Database project, Ricardo-AEA organise, on behalf of Scottish Government, an annual air quality seminar. The latest Scottish Government Annual Air Quality Seminar was held in the Cosla Building, Verity House, Edinburgh on Thursday 26th March 2015. The event was attended by over 70 air quality experts representing the Scottish Government, local authorities, Health Protection Scotland, SEPA, consultancy, academia and students. The objective of the seminar was to launch the new updates to the Air Quality in Scotland website and Apps, discuss some of 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.

As well as the updates and improvements to the Air Quality website and associated Apps, the seminar covered a number of interesting topics in the field of Air Quality. These included; Airborne Particulate matter – Challenges for abatement by Professor Roy M. Harrison (University of Birmingham); Development of a new air quality action planning resource by Jennifer Simpson (Ricardo-AEA); Enhanced Data Visualisation Tools by Dr Collin Gillispie (SEPA); Assessing variations in roadside air quality with sampling heights by Stephen Stratton (Ricardo-AEA); and Development of an EU Air Quality Index by Dr Stuart Sneddon (Ricardo-AEA). All presentations can be found on the Scottish air Quality website (www.scottishairquality.co.uk).

The full agenda for the day is shown in Figure 3.1.

Figure 3.1 Agenda for the Scottish Air Quality Seminar on 26th March 2015

The Scottish Government

RICARDO-AEA

SCOTTISH AIR QUALITY DATABASE AND WEBSITE ANNUAL SEMINAR

Thursday 26 March 2015

Caledonian I Room, COSLA, Verity House, 19 Haymarket Yards, Edinburgh, EH12 5BH

Agenda

09:15	Registration and Coffee	
10:00	Welcome and Introduction	Andrew Taylor – Scottish Government
10:15	Particulate Matter	Professor Roy Harrison – University of Birmingham
10:50	Air Quality in Scotland	Professor David Fowler – Centre for Ecology and Hydrology
11:20	Tea/Coffee Break	
11:35	Forecasting Update and Improvements to K&R	Paul Willis
12:05	Clear the Air Educational Programme	Susannah Telfer
12:35	New Air Quality Action Planning Resource	Jennifer Simpson
13:00	Lunch (Practical Sessions)	
13:50	SEPA Spot – SEPA Air Quality Projects	Colin Gillespie and Ben Jackson - SEPA
14:30	Tea/Coffee Break	
14:45	Scottish Government PM with Height Study	Stephen Stratton
15:15	Development of an EU Air Quality Index	Stuart Sneddon
15:50	Summary	Andrew Taylor – Scottish Government
16:00	Close	

This event is organised by Ricardo-AEA on behalf of the Scottish Government

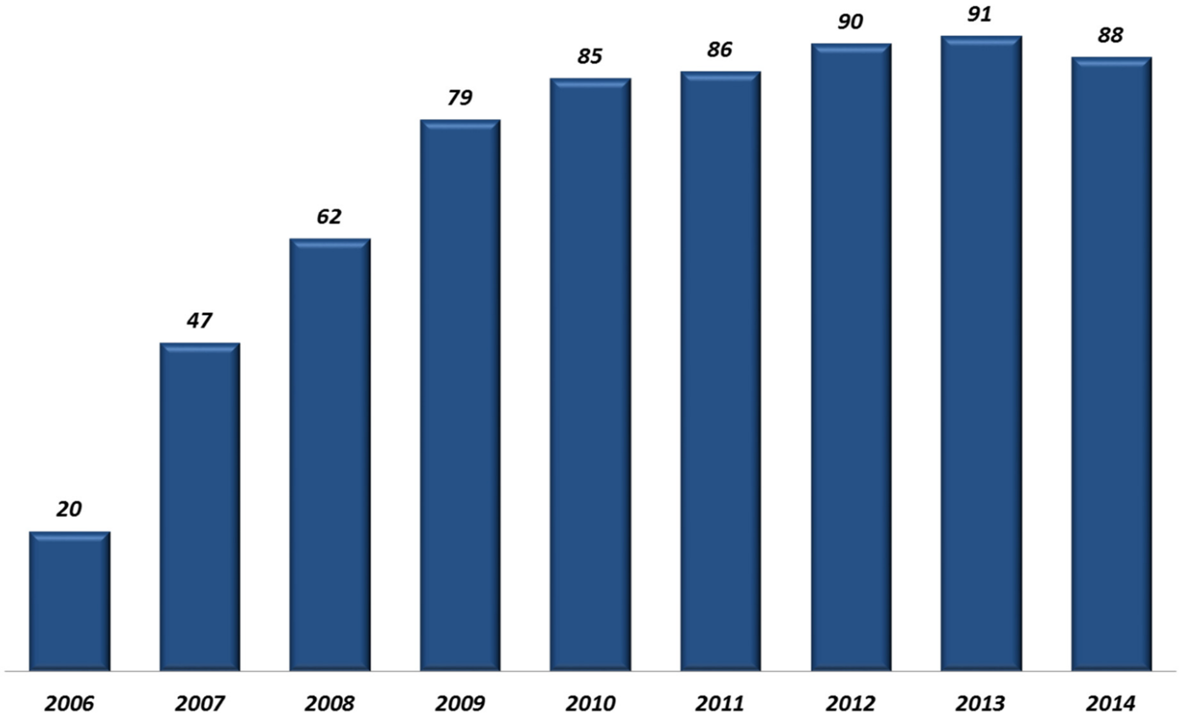
Respondents should be aware that the delegate list for this event is held on a computer. Under the terms of the Data Protection Act, anyone on the mailing list has the right to object to his/her name and address being so held.

4 Data Availability 2014

4.1 Hourly Data for Nitrogen Dioxide, Carbon Monoxide, Sulphur Dioxide, Ozone, PM10 and PM2.5

At the end of 2014 the Scottish Air Quality Database contained data for a total of 88 automatic monitoring sites. In total, 2 new monitoring sites were incorporated into the database during 2014: Inverclyde Greenock A8 and North Lanarkshire Kirkshaws. Five monitoring sites; Paisley Central Road, Falkirk Park Street, East Renfrewshire Sheddens, South Lanarkshire Raith Interchange and North Lanarkshire Cumbernauld were decommissioned during 2014. As a result, the number of live monitoring sites in the database decreased by 3 to 88 sites in 2014. Figure 4.1 shows the growth of the SAQD from 20 sites in 2006 pilot study to 88 sites in 2014.

Figure 4.1 Number of Monitoring Sites within the Scottish Air Quality Database Network 2006 - 2014



For the 16 National Network AURN monitoring stations in the Scottish Database the data are available from the commencement of these stations, which in some cases is as long ago as 1986. However, for Local Authority monitoring stations, data are only available from when the station joined the database project. In many cases the stations commenced much earlier and these earlier data may be available from the relevant Local Authority.

Data availability for 2014, 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 and the monitoring network the site is affiliated to; either the Scottish Air Quality Database Network (SAQD) or the Automatic Urban and Rural Network (AURN).

Table 4.1 also provides the start date for each site. However, not all pollutants are measured over the same period at all sites – measurements of some pollutants may commence or cease during the lifetime of monitoring at the particular site. The dates of availability of data for each pollutant measured at each site can be found by selecting the site on the 'Latest Data' page of the SAQD website (http://www.scottishairquality.co.uk/latest/) and then selecting the "site details" tab.

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

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

Table 4.1 Scottish Air Quality Database Data Availability in 2014

Site Name	Type	East	North	Pollutants	Network	Start Year#	Data in 2014
Aberdeen Anderson Dr	RS	392506	804186	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Aberdeen Errol Place	UB	394416	807408	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	1999	Jan – Dec
Aberdeen King Street	RS	394333	808770	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Aberdeen Market Street 2	RS	394535	805687	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Aberdeen Union St~^	RS	393655	805984	PM_{10}, $PM_{2.5}$	SAQD	2005	Jan – Dec
Aberdeen Union Street Roadside~	RS	393655	805984	NO_2	AURN	2008	Jan – Dec
Aberdeen Wellington Road	RS	394395	804779	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Alloa	RS	288750	693150	PM_{10}	SAQD	2006	Jan – Dec
Auchencorth Moss	R	322167	656123	13BD BENZ O_3 PM_{10} $PM_{2.5}$ TOL XYL	AURN	2006	Jan – Dec
Bush Estate	R	324626	663880	NO_2 O_3	AURN	1986	Jan – Dec
Dumbarton Roadside	RS	240234	675193	NO_2	AURN	2010	Jan – Dec
Dumfries	RS	297012	576278	NO_2	AURN	2001	Jan – Dec
Dundee Broughty Ferry Road	RS	341970	730997	PM_{10} SO_2	SAQD	2006	Jan – Dec
Dundee Lochee Road	KS	330773	738861	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Mains Loan	UB	340972	731893	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Meadowside	RS	340241	730654	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Dundee Seagate	KS	340487	730446	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Union Street	KS	340236	730090	NO_2 PM_{10}	SAQD	2006	Jan – Dec
Dundee Whitehall Street	KS	330155	740279	NO_2	SAQD	2006	Jan – Dec
East Ayrshire Kilmarnock John Finnie St	RS	242691	638095	NO_2 PM_{10}	SAQD	2010	Jan – Dec
East Ayrshire Kilmarnock St Marnock St	RS	242742	637705	NO_2 PM_{10}	SAQD	2012	Jan – Dec
East Dunbartonshire Bearsden	RS	254269	672067	NO_2 PM_{10}	SAQD	2005	Jan – Dec
East Dunbartonshire Bishopbriggs	RS	260995	670130	NO_2 PM_{10}	SAQD	2003	Jan – Dec
East Dunbartonshire Kirkintilloch	RS	265700	673500	NO_2 PM_{10}	SAQD	2007	Jan – Dec
East Dunbartonshire Milngavie	RS	255325	674115	NO_2 PM_{10}	SAQD	2011	Jan – Dec
East Lothian Musselburgh N High St	RS	333941	672836	NO_2 PM_{10}	SAQD	2008	Jan – Dec
East Renfrewshire Sheddens*	RS	257459	657114	PM_{10}	SAQD	2008	Jan – Sep
Edinburgh Currie	UB	317575	667874	NO_2 PM_{10}	SAQD	2013	Jan – Dec
Edinburgh Glasgow Road	RS	313101	672651	NO_2 PM_{10}	SAQD	2012	Jan – Dec
Edinburgh Gorgie Road	RS	323121	672314	NO_2	SAQD	2005	Jan – Dec
Edinburgh Queen Street	RS	324890	674100	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Edinburgh Queensferry Road	RS	318734	674931	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Edinburgh Salamander St	RS	327621	676342	NO_2 PM_{10}	SAQD	2009	Jan – Dec

Site Name	Type	East	North	Pollutants	Network	Start Year[#]	Data in 2014
Edinburgh St John's Road	KS	320100	672890	NO_2	SAQD	2007	Jan – Dec
Edinburgh St Leonards	UB	326250	673132	CO NO_2 O_3 PM_{10} $PM_{2.5}$ SO_2	AURN	2003	Jan – Dec
Eskdalemuir	R	323552	603018	NO_2 O3	AURN	1986	Jan – Dec
Falkirk Banknock	RS	277247	679026	PM_{10}	SAQD	2013	Jan – Dec
Falkirk Grangemouth MC	UB	292816	682009	NO_2 PM_{10} SO_2	SAQD	2003	Jan – Dec
Falkirk Haggs	RS	278977	679271	NO_2	SAQD	2009	Jan – Dec
Falkirk Hope St	RS	288688	680218	NO_2 SO_2	SAQD	2007	Jan – Dec
Falkirk Park St*	RS	288892	680070	NO_2 PM_{10} SO_2	SAQD	2007	Jan – Apr
Falkirk West Bridge Street	RS	288457	680064	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Fife Cupar	RS	337401	714572	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Fife Dunfermline	RS	309912	687738	NO_2 PM_{10}	SAQD	2007	Jan – Dec
Fife Kirkcaldy	RS	329143	692986	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Fife Rosyth	RS	311752	683515	NO_2 PM_{10}	SAQD	2008	Jan – Dec
Fort William	S	210849	774421	NO_2 O_3	AURN	2006	Jan – Dec
Glasgow Abercromby Street	RS	260420	664175	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Anderston^	UB	257925	665487	NO_2 PM_{10} SO_2	SAQD	2005	Jan – Dec
Glasgow Broomhill	RS	255030	667195	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Burgher Street	RS	262548	664168	NO_2 PM_{10}	SAQD	2011	Jan – Dec
Glasgow Byres Road^	RS	256553	665487	NO_2 PM_{10}	SAQD	2005	Jan – Dec
Glasgow Dumbarton Road	RS	255030	666608	NO_2 PM_{10}	SAQD	2012	Jan – Dec
Glasgow Kerbside	KS	258708	665200	BENZ NO_2 PM_{10} $PM_{2.5}$ TOL	AURN	1997	Jan – Dec
Glasgow Nithsdale Road	RS	257883	662673	PM_{10}	SAQD	2007	Jan – Dec
Glasgow Townhead	UB	259692	665899	NO_2 O_3 PM_{10} $PM_{2.5}$	AURN	2013	Jan – Dec
Glasgow Waulkmillglen Reservoir	R	252520	658095	NO_2 O_3 PM_{10}	SAQD	2005	Jan – Dec
Grangemouth	UI	293837	681035	NO_2 PM_{10} $PM_{2.5}$ SO_2	AURN	2001	Jan – Dec
Grangemouth Moray~	UB	293469	681321	NO_2	AURN	2009	Jan – Dec
Grangemouth Moray Scot Gov~	UB	293469	681321	SO_2	SAQD	2007	Jan – Dec
Inverclyde Greenock A8[+]	RS	229335	675710	NO_2 PM_{10}	SAQD	2014	Mar - Dec
Inverness	RS	265720	845680	NO_2 $PM_{10}$$PM_{2.5}$	AURN	2001	Jan – Dec
Lerwick~	R	445337	1139683	O_3	AURN	2005	-
N Lanarkshire Chapelhall	RS	278174	663124	NO_2 PM_{10}	SAQD	2005	Jan – Dec
N Lanarkshire Coatbridge Whifflet	UB	273668	663938	NO_2 PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Croy	RS	272775	675738	CO NO_2 PM_{10} SO_2	SAQD	2006	Jan – Dec
N Lanarkshire Cumbernauld*	UB	274182	674065	NO_2 PM_{10} SO_2	SAQD	2011	Jan – Apr
N Lanarkshire Kirkshaws[+]	RS	272522	663029	NO_2 PM_{10}	SAQD	2014	Jun – Dec
N Lanarkshire Moodiesburn	RS	269929	670386	NO_2 PM_{10}	SAQD	2008	Jan – Dec
N Lanarkshire Motherwell	RS	275460	656785	PM_{10}	SAQD	2007	Jan – Dec
N Lanarkshire Shawhead Coatbridge	RS	273411	662997	NO_2 PM_{10}	SAQD	2009	Jan – Dec
North Ayrshire Irvine High St	KS	232142	638892	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Paisley Central Road*	RS	248445	664191	NO_2	SAQD	2004	Jan – Aug
Paisley Glasgow Airport	A	248296	666544	NO_2	SAQD	2004	Jan – Dec
Paisley Gordon Street	RS	248316	663611	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Paisley St James St	RS	248175	664311	PM_{10}	SAQD	2010	Jan – Dec

Site Name	Type	East	North	Pollutants	Network	Start Year#	Data in 2014
Peebles	S	324812	641083	NO_2 O_3	AURN	2009	Jan – Dec
Perth Atholl Street	RS	311582	723931	NO_2 PM_{10}	SAQD	2004	Jan – Dec
Perth Crieff	RS	286363	721614	NO_2 PM_{10}	SAQD	2010	Jan – Dec
Perth High Street	RS	311688	723625	NO_2 PM_{10}	SAQD	2003	Jan – Dec
Perth Muirton	UB	311688	723625	PM_{10}	SAQD	2012	Jan – Dec
Shetland Lerwick~	R	445337	1139683	NO_2 SO_2	SAQD	2012	-
South Ayrshire Ayr Harbour	RS	233617	622749	NO_2 PM_{10}	SAQD	2012	Jan – Dec
South Ayrshire Ayr High St	RS	233725	622120	NO_2 PM_{10}	SAQD	2007	Jan – Dec
South Lanarkshire East Kilbride	RS	264390	655658	NO_2 PM_{10}	SAQD	2008	Jan – Dec
South Lanarkshire Hamilton	RS	272298	655289	NO_2 PM_{10}	SAQD	2013	Jan – Dec
South Lanarkshire Lanark	RS	288427	643701	NO_2	SAQD	2012	Jan – Dec
South Lanarkshire Raith Interchange*	RS	271108	658235	NO_2 PM_{10}	SAQD	2010	Jan – Apr
South Lanarkshire Rutherglen	RS	261113	661690	NO_2 PM_{10}	SAQD	2012	Jan – Dec
South Lanarkshire Uddingston	RS	269657	660305	NO_2	SAQD	2013	Jan – Dec
Stirling Craig's Roundabout	RS	279955	693012	NO_2 PM_{10}	SAQD	2009	Jan – Dec
Strath Vaich	RS	234829	874785	O_3	AURN	1987	Jan – Dec
West Dunbartonshire Clydebank	RS	249724	672042	NO_2 PM_{10}	SAQD	2007	Jan – Dec
West Lothian Broxburn	RS	308364	672248	NO_2 PM_{10}	SAQD	2008	Jan – Dec
West Lothian Linlithgow High St 2	RS	300419	677120	NO_2 PM_{10}	SAQD	2013	Jan – Dec
West Lothian Newton	RS	309258	677728	NO_2 PM_{10}	SAQD	2012	Jan – Dec

+ Sites added to database in 2014
* Sites closed during 2014
^Changes in number of measured pollutants or monitoring method during 2014
This is the date of the site joining the network. Data for some pollutants may not be available from this date. Also, data for some pollutants may be available from earlier dates from the Local Authority other networks. The period of availability for data for each pollutant measured at each site can be seen on www.scottishairquality.co.uk by selecting the site and the "site details" tab.
~ At these sites, some pollutants are affiliated to the AURN network and some pollutants are affiliated the SAQD Network.
A - Airport
KS – Kerbside
R – Rural
RS – Roadside
S – Suburban
UB – Urban Background
UI – Urban Industrial

4.1.1 Summary of Changes to Monitoring Sites within the Database During 2014

Details of changes to monitoring sites included within the SAQD are summarised below.

Sites opened during 2014:

- Inverclyde Greenock A8 — NO_2, PM_{10} — from 18/03/2014
- N Lanarkshire Kirkshaws — NO_2, PM_{10} — from 28/06/2014

Sites closed during 2014:

- East Renfrewshire Sheddens — PM_{10} — on 03/09/2014
- Falkirk Park Street — NO_2, PM_{10}, SO_2 — on 28/04/2014
- N Lanarkshire Cumbernauld — NO_2, PM_{10}, SO_2 — on 01/05/2014
- Paisley Central Road — NO_2 — on 22/08/2014
- S Lanarkshire Raith Interchange — NO_2, PM_{10} — on 23/04/2014

Sites changes during 2014:

- Monitoring of $PM_{2.5}$ in addition to PM_{10} started at Aberdeen Union St on 11/04/2014
- Monitoring of CO stopped at Glasgow Anderston.
- Monitoring of CO stopped at Glasgow Byres Road.
- The monitoring hut at Edinburgh St Leonards was upgraded between September and December 2014.
- Monitoring at Shetland Lerwick and Lerwick was suspended during 2014 due to building works and the commissioning of a new monitoring hut.

4.2 Volatile Correction Model

4.2.1 Background

The EU Directive on Ambient Air Quality[1] and the Air Quality Strategy for England, Scotland, Wales and Northern Ireland[2] 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 recognised 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 tapered element oscillating microbalance (TEOM) analyser, have been widely used for many years. In setting the value of 1.3 as a correction factor, it was recognised that this was a conservative factor and that TEOMx1.3 data were likely to overestimate PM_{10} concentrations. In Scotland, a lower correction factor of 1.14, which was based on intercomparison data obtained in Edinburgh, has also been widely used.

The results of the formal UK PM_{10} Equivalence Study[3] 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 filter dynamics measurement system (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 analyser to the EU reference method was confirmed in the UK Equivalence study. Note that this study also showed that a number of other PM_{10} analysers could also provide data equivalent to the EU reference method - Partisol 2025, FDMS Model B, Opsis SM200 Beta Attenuation Monitor (BAM), Opsis SM200 sampler (with slope and intercept correction) and the Met One BAM (with slope correction).

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

[1] *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

[2] *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

[3] *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

Further analysis of FDMS purge data from FDMS sites in Scotland, carried out by Ricardo-AEA, has shown that volatile concentrations do not vary significantly across Scotland. As a result, all FDMS data are used to correct all TEOM data.

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

4.2.2 Use of the VCM in Scotland

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

However, additional refinement of the VCM model has been undertaken and hourly meteorological data for all parameters has been sourced. As a result, VCM correction of the 2009 to 2014 datasets has been undertaken on an hourly basis. This also brings into line the processing of the Scottish local authority data with that of the AURN.

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

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

The following data were used as inputs to the VCM:

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

For the 2014 corrections, temperature and pressure data from Edinburgh Airport meteorological monitoring stations were utilised. This site was selected as a good representation weather conditions in the central belt of Scotland.

Hourly average purge measurements from all Scottish FDMS monitoring sites within the Scottish Government-run network (SAQD) and the UK national network (AURN) were used for the correction. Table 4.2 lists the sites used for correcting hourly TEOM data. A total of 35 FDMS sites were used for correcting hourly average TEOM data.

Any outliers in the FDMS purge measurements were identified using Grubbs' Test[4] on daily average data. All hourly data within a day identified as an outlier were then removed from the data set and the average of each hourly purge measurement from the FDMS sites was calculated and used in the VCM calculations.

[4] Grubbs' Test is a statistical method for identifying outliers within a dataset. For more information visit the Engineering Statistics Handbook at:

http://www.itl.nist.gov/div898/handbook/eda/section3/eda35h.htm

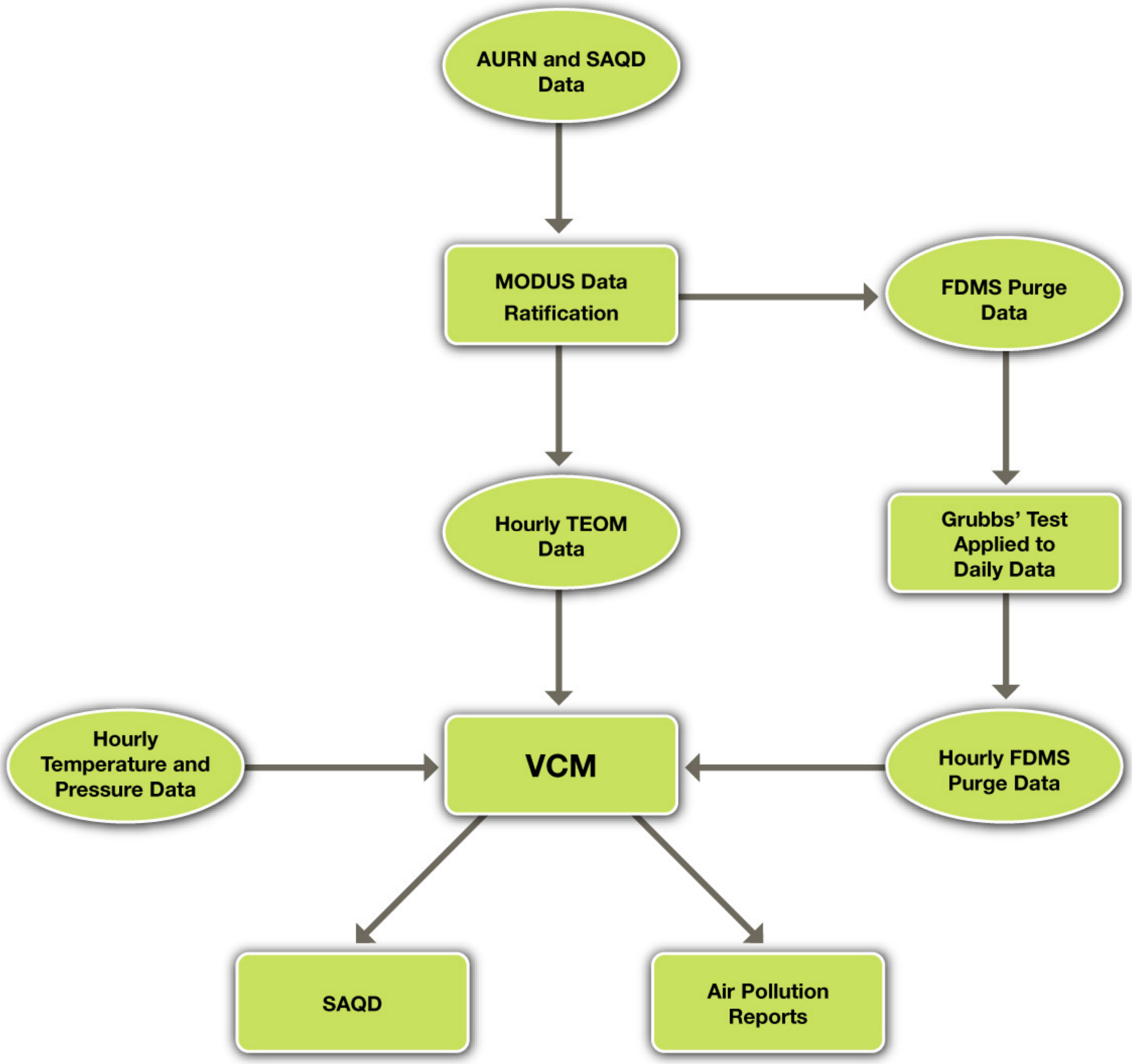
The corrected data for 2014 and calculated summary statistics have been provided to the local authorities. In addition, the SAQD website database now shows all ratified TEOM data for 2014 as VCM corrected data via an additional selection option in the data download pages.

A flow chart showing the overall process employed for VCM correction of 2014 SAQD TEOM data is shown in Figure 4.2. However, note that it is not possible to correct historical data with the VCM as measurements of volatile particle concentrations are not available prior to 2008.

Table 4.2 FDMS Monitoring Sites used for VCM Correcting TEOM Data 2014

FDMS Sites used in VCM	Monitoring Network
Aberdeen	AURN
Auchencorth Moss	AURN
East Ayrshire Kilmarnock John Finnie St	SAQD
East Ayrshire St Marnock St	SAQD
East Dunbartonshire Kirkintilloch	SAQD
East Dunbartonshire Milngavie	SAQD
East Renfrewshire Sheddens	SAQD
Edinburgh Queensferry Road	SAQD
Edinburgh St Leonards	AURN
Fife Cupar	SAQD
Fife Dunfermline	SAQD
Fife Kirkcaldy	SAQD
Fife Rosyth	SAQD
Glasgow Abercromby Street	SAQD
Glasgow Anderston	AURN
Glasgow Broomhill	SAQD
Glasgow Burgher St	SAQD
Glasgow Byres Road	SAQD
Glasgow Kerbside	AURN
Glasgow Nithsdale Road	SAQD
Glasgow Townhead	AURN
Grangemouth	AURN
Paisley Gordon Street	SAQD
Paisley St James St	SAQD
Perth Muirton	SAQD
South Ayrshire Ayr Harbour	SAQD
South Ayrshire Ayr High St	SAQD
South Lanarkshire East Kilbride	SAQD
South Lanarkshire Hamilton	SAQD
South Lanarkshire Raith Interchange	AURN
South Lanarkshire Rutherglen	SAQD
West Lothian Broxburn	SAQD
West Lothian Linlithgow High St 2	SAQD
West Lothian Linlithgow High Street	SAQD
West Lothian Newton	SAQD

Figure 4.2 Process used for VCM Correcting SAQD TEOM Data



5 QA/QC of the Scottish Database

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

The main elements of the QA/QC programme are on-site analyser and calibration gas inter-calibrations every 6 months, daily automatic data collection, and validation and data ratification in 3-monthly blocks.

5.1 On-Site Analyser and Calibration 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.

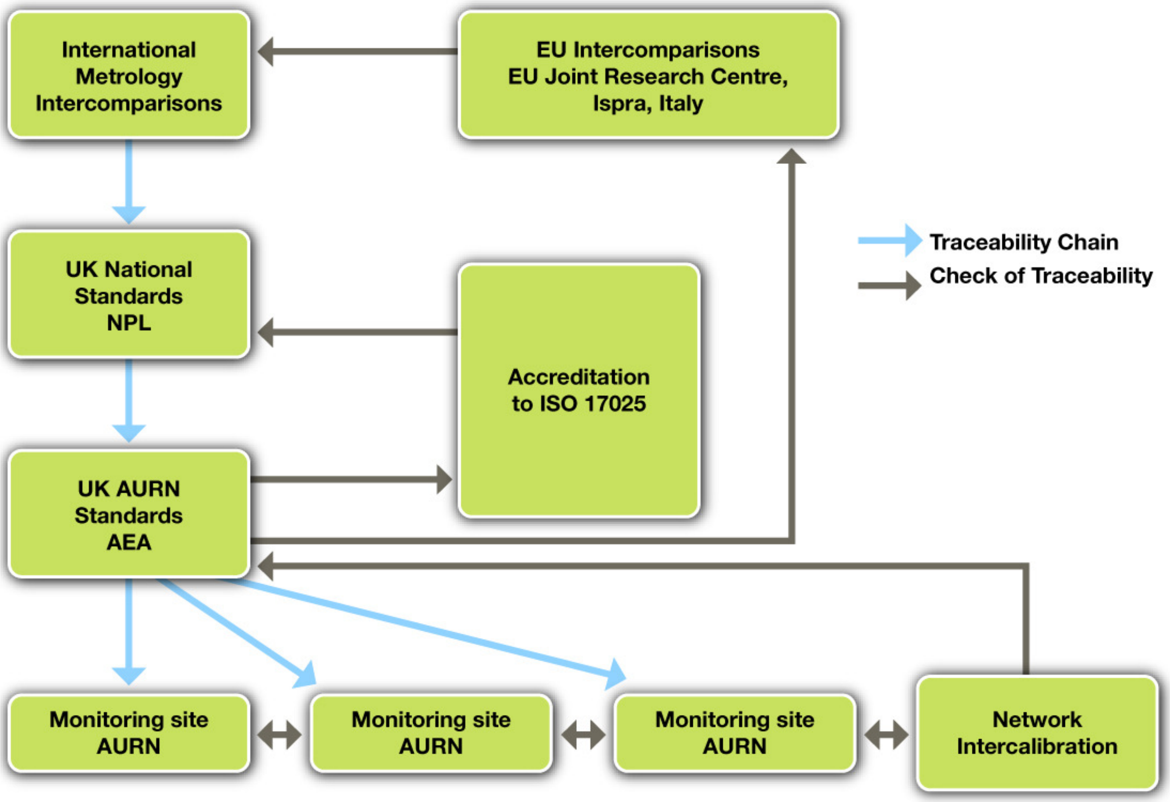
The assessment of the on-site calibration cylinder concentrations against accredited and traceable Ricardo-AEA gas standard cylinders provides the essential final link in the measurement traceability chain (Figure 5.1). This process ensures that all monitoring stations in Scotland are traceable to reference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

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 40 µg m^{-3} of NO_2 would also measure 40 µg m^{-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.

Figure 5.1 Traceability chain for the SAQD monitoring stations



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 Ricardo-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 inter-calibrations – 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 Ricardo-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 3-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 31st 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 2014

As discussed above, site inter-calibrations 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 inter-calibrations and audits undertaken on air quality sites in the Scottish Database during 2014.

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 2014 audits

Fault	Number of Monitoring Sites Winter 2013/14	Number of Monitoring Sites Summer 2014
TEOM** and TEOM FDMS k_0 out by > 2.5%	2	1
Particulate Analyser*** flow out by >10%	4	5
NO_x analyser converter <97% efficiency	0	0
NO cylinder out by >10%	0	1
SO_2 cylinder out by >10%	0	0
CO cylinder out by >10%	0	0
O3 Analyser out by >5%	1	0

* Filter Dynamics Measurement System
** Tapered Element Oscillating Microbalance
*** These include TEOM, FDMS and Beta Attenuation Monitors (BAM)

These are all typical faults that are found during audit and intercalibration exercises and as can be seen from the 2014 figures.

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

Table 5.2 summarises the site inter-calibrations and audits undertaken during 2014, where the period Winter 2013/14 corresponds to Dec-13 to Mar-14 and Summer 2014 corresponds to Jun-14 to Aug-14.

5.4.1 Data Ratification

With the renewal of the Scottish Air Quality Database and Website contract in 2013, data ratification was brought in line with the AURN schedule and is now undertaken at 3-monthly intervals. Hence, as with the inter-calibrations and audits, if the site joins the database part way through a year then data can only be ratified from the date of the site joining the database.

All ratified data for 2014 have now been uploaded to the Scottish Air Quality website and Table 5.3 summarises the ratification undertaken during 2014. The column headings labelled Q1 – Q4 refer to the quarter periods of the calendar year:

- Q1 = January to March;
- Q2 = April to June;
- Q3 = July to September;
- Q4 = October to December.

Table 5.2 Air quality site intercalibration and audits conducted during 2014

Site Name	Winter 2012/13	Summer 2013	Site Name	Winter 2012/13	Summer 2013
Aberdeen Anderson Dr	✓	✓	Glasgow Anderston	✓	✓
Aberdeen Errol Place	✓	✓	Glasgow Broomhill	✓	✓
Aberdeen King Street	✓	✓	Glasgow Burgher Street	✓	✓
Aberdeen Market Street 2	✓	✓	Glasgow Byres Road	✓	✓
Aberdeen Union St	✓	✓	Glasgow Dumbarton Road	✓	✓
Aberdeen Union Street Roadside	✓	✓	Glasgow Kerbside	✓	✓
Aberdeen Wellington Road	✓	✓	Glasgow Townhead	✓	✓
Alloa	✓	✓	Glasgow Nithsdale Road	✓	✓
Angus Forfar	-	-	Glasgow Waulkmillglen Reservoir	✓	✓
Auchencorth Moss	✓	✓	Grangemouth	✓	✓
Bush Estate	✓	✓	Grangemouth Moray	✓	✓
Dumbarton Roadside	✓	✓	Grangemouth Moray Scot Gov	✓	✓
Dumfries	✓	✓	Inverclyde Greenock A8	✓	✓
Dundee Broughty Ferry Road	✓	✓	Inverness	✓	✓
Dundee Lochee Road	✓	✓	Lerwick	✓	✓
Dundee Mains Loan	✓	✓	N Lanarkshire Chapelhall	✓	✓
Dundee Meadowside	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓
Dundee Seagate	✓	✓	N Lanarkshire Croy	✓	✓
Dundee Union Street	✓	✓	N Lanarkshire Cumbernauld	✓	
Dundee Whitehall Street	✓	✓	N Lanarkshire Kirkshaws		✓
East Ayrshire Kilmarnock John Finnie	✓	✓	N Lanarkshire Moodiesburn	✓	✓
East Ayrshire Kilmarnock St Marnock	✓	✓	N Lanarkshire Motherwell	✓	✓
East Dunbartonshire Bearsden	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	North Ayrshire Irvine High St	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	Paisley Central Road	✓	✓
East Dunbartonshire Milngavie	✓	✓	Paisley Glasgow Airport	✓	✓
East Lothian Musselburgh N High St	✓	✓	Paisley Gordon Street	✓	✓
East Renfrewshire Sheddens	✓	✓	Paisley St James St	✓	✓
Edinburgh Currie	✓	✓	Peebles	✓	✓
Edinburgh Glasgow Road	✓	✓	Perth Atholl Street	✓	✓
Edinburgh Gorgie Road	✓	✓	Perth Crieff	✓	✓
Edinburgh Queen Street	✓	✓	Perth High Street	✓	✓
Edinburgh Queensferry Road	✓	✓	Perth Muirton	✓	✓
Edinburgh Salamander St	✓	✓	Sout Ayrshire Ayr Harbour	✓	✓
Edinburgh St John's Road	✓	✓	South Ayrshire Ayr High St	✓	✓
Edinburgh St Leonards	✓	✓	South Ayrshire Maybole	✓	✓
Eskdalemuir	✓	✓	South Lanarkshire East Kilbride	✓	✓
Falkirk Banknock	✓	✓	South Lanarkshire Glespin	✓	✓
Falkirk Grangemouth MC	✓	✓	South Lanarkshire Hamilton	✓	✓
Falkirk Haggs	✓	✓	South Lanarkshire Lanark	✓	✓
Falkirk Hope St	✓	✓	South Lanarkshire Raith Interchange	✓	
Falkirk Park St	✓		South Lanarkshire Rutherglen	✓	✓
Falkirk West Bridge Street	✓	✓	South Lanarkshire Uddingston	✓	✓
Fife Cupar	✓	✓	Stirling Craig's Roundabout	✓	✓
Fife Dunfermline	✓	✓	Strath Vaich	✓	✓
Fife Kirkcaldy	✓	✓	West Dunbartonshire Clydebank	✓	✓
Fife Rosyth	✓	✓	West Lothian Broxburn	✓	✓
Fort William	✓	✓	West Lothian Linlithgow High Street	✓	✓
Glasgow Abercromby Street	✓	✓	West Lothian Newton	✓	✓

Table 5.3 Data ratification undertaken during 2014

Site Name	Q1	Q2	Q3	Q4	Site Name	Q1	Q2	Q3	Q4
Aberdeen Anderson Dr	✓	✓	✓	✓	Glasgow Anderston	✓	✓	✓	✓
Aberdeen Errol Place	✓	✓	✓	✓	Glasgow Broomhill	✓	✓	✓	✓
Aberdeen King Street	✓	✓	✓	✓	Glasgow Burgher Street	✓	✓	✓	✓
Aberdeen Market Street 2	✓	✓	✓	✓	Glasgow Byres Road	✓	✓	✓	✓
Aberdeen Union St	✓	✓	✓	✓	Glasgow Dumbarton Road	✓	✓	✓	✓
Aberdeen Union Street Roadside	✓	✓	✓	✓	Glasgow Kerbside	✓	✓	✓	✓
Aberdeen Wellington Road	✓	✓	✓	✓	Glasgow Townhead	✓	✓	✓	✓
Alloa	✓	✓	✓	✓	Glasgow Nithsdale Road	✓	✓	✓	✓
Angus Forfar	✓	✓	✓	✓	Glasgow Waulkmillglen Reservoir	✓	✓	✓	✓
Auchencorth Moss	✓	✓	✓	✓	Grangemouth	✓	✓	✓	✓
Bush Estate	✓	✓	✓	✓	Grangemouth Moray	✓	✓	✓	✓
Dumbarton Roadside	✓	✓	✓	✓	Grangemouth Moray Scot Gov	✓	✓	✓	✓
Dumfries	✓	✓	✓	✓	Inverclyde Greenock A8	✓	✓	✓	✓
Dundee Broughty Ferry Road	✓	✓	✓	✓	Inverness	✓	✓	✓	✓
Dundee Lochee Road	✓	✓	✓	✓	Lerwick	✓	✓	✓	✓
Dundee Mains Loan	✓	✓	✓	✓	N Lanarkshire Chapelhall	✓	✓	✓	✓
Dundee Meadowside	✓	✓	✓	✓	N Lanarkshire Coatbridge Whifflet	✓	✓	✓	✓
Dundee Seagate	✓	✓	✓	✓	N Lanarkshire Croy	✓	✓	✓	✓
Dundee Union Street	✓	✓	✓	✓	N Lanarkshire Cumbernauld	✓	✓	✓	✓
Dundee Whitehall Street	✓	✓	✓	✓	N Lanarkshire Kirkshaws				
East Ayrshire Kilmarnock John Finnie	✓	✓	✓	✓	N Lanarkshire Moodiesburn	✓	✓	✓	✓
East Ayrshire Kilmarnock St Marnock	✓	✓	✓	✓	N Lanarkshire Motherwell	✓	✓	✓	✓
East Dunbartonshire Bearsden	✓	✓	✓	✓	N Lanarkshire Shawhead Coatbridge	✓	✓	✓	✓
East Dunbartonshire Bishopbriggs	✓	✓	✓	✓	North Ayrshire Irvine High St	✓	✓	✓	✓
East Dunbartonshire Kirkintilloch	✓	✓	✓	✓	Paisley Central Road	✓	✓	✓	✓
East Dunbartonshire Milngavie	✓	✓	✓	✓	Paisley Glasgow Airport	✓	✓	✓	✓
East Lothian Musselburgh N High St	✓	✓	✓	✓	Paisley Gordon Street	✓	✓	✓	✓
East Renfrewshire Sheddens	✓	✓	✓	✓	Paisley St James St	✓	✓	✓	✓
Edinburgh Currie	✓	✓	✓	✓	Peebles	✓	✓	✓	✓
Edinburgh Glasgow Road	✓	✓	✓	✓	Perth Atholl Street	✓	✓	✓	✓
Edinburgh Gorgie Road	✓	✓	✓	✓	Perth Crieff	✓	✓	✓	✓
Edinburgh Queen Street	✓	✓	✓	✓	Perth High Street	✓	✓	✓	✓
Edinburgh Queensferry Road	✓	✓	✓	✓	Perth Muirton	✓	✓	✓	✓
Edinburgh Salamander St	✓	✓	✓	✓	Sout Ayrshire Ayr Harbour	✓	✓	✓	✓
Edinburgh St John's Road	✓	✓	✓	✓	South Ayrshire Ayr High St	✓	✓	✓	✓
Edinburgh St Leonards	✓	✓	✓	✓	South Ayrshire Maybole	✓	✓	✓	✓
Eskdalemuir	✓	✓	✓	✓	South Lanarkshire East Kilbride	✓	✓	✓	✓
Falkirk Banknock	✓	✓	✓	✓	South Lanarkshire Glespin	✓	✓	✓	✓
Falkirk Grangemouth MC	✓	✓	✓	✓	South Lanarkshire Hamilton	✓	✓	✓	✓
Falkirk Haggs	✓	✓	✓	✓	South Lanarkshire Lanark	✓	✓	✓	✓
Falkirk Hope St	✓	✓	✓	✓	South Lanarkshire Raith Interchange	✓	✓	✓	✓
Falkirk Park St	✓	✓	✓	✓	South Lanarkshire Rutherglen	✓	✓	✓	✓
Falkirk West Bridge Street	✓	✓	✓	✓	South Lanarkshire Uddingston	✓	✓	✓	✓
Fife Cupar	✓	✓	✓	✓	Stirling Craig's Roundabout	✓	✓	✓	✓
Fife Dunfermline	✓	✓	✓	✓	Strath Vaich	✓	✓	✓	✓
Fife Kirkcaldy	✓	✓	✓	✓	West Dunbartonshire Clydebank	✓	✓	✓	✓
Fife Rosyth	✓	✓	✓	✓	West Lothian Broxburn	✓	✓	✓	✓
Fort William	✓	✓	✓	✓	West Lothian Linlithgow High Street	✓	✓	✓	✓
Glasgow Abercromby Street	✓	✓	✓	✓	West Lothian Newton	✓	✓	✓	✓

6 Air Pollution in Scotland 2014

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

- Section 6.1 - Automatic monitoring of the pollutants NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and O_3 summary data for 2013.

- Section 6.2 - Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and lead - summary statistics for 2010 or 2011 depending on the availability of data.

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

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

Tables 6.1 – 6.7 show the 2014 annual average data statistics for NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2 and O_3 respectively, for the ratified automatic data from monitoring sites included in the Scottish Air Quality Database. These are shown along with the corresponding data capture for the year.

These data will have been used by local authorities to assess air quality within their area as part of the 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 exceedance and estimate its extent. Where the exceedance is confirmed then the authority will declare an Air Quality Management Area (AQMA). At present, 14 Local Authorities in Scotland have declared a total of 32 AQMAs (see http://www.scottishairquality.co.uk/laqm.php).

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

6.1.1 Nitrogen Dioxide

Table 6.1 Ratified data annual average concentration and data capture for NO_2 in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average NO_2 2014 ($\mu g\ m^{-3}$)	No. hours >200 $\mu g\ m^{-3}$	Data capture NO_2 2014 (%)
Aberdeen Anderson Drive	RS	26	0	76
Aberdeen Errol Place	UB	22	0	94
Aberdeen King St	RS	27	0	94
Aberdeen Market Street 2	RS	40	0	95
Aberdeen Union Street	RS	47	0	92
Aberdeen Wellington Road	RS	48	0	77
Bush Estate	RS	7	0	96
Dumbarton Roadside	RS	8	0	97
Dumfries	RS	30	1	99
Dundee Lochee Road	RS	46	1	100
Dundee Mains Loan	UB	13	0	93
Dundee Meadowside	RS	40	0	100
Dundee Seagate	KS	55	0	99
Dundee Union Street	KS	29	0	97
Dundee Whitehall Street	KS	43	0	98
East Ayrshire Kilmarnock John Finnie St	RS	32	0	69
East Ayrshire Kilmarnock St Marnock St	RS	30	1	83
East Dunbartonshire Bearsden	RS	37	0	99
East Dunbartonshire Bishopbriggs	RS	29	0	93
East Dunbartonshire Kirkintilloch	RS	29	0	97
East Dunbartonshire Milngavie	RS	24	0	97
East Lothian Musselburgh N High St	RS	23	0	90
Edinburgh Currie	UB	7	0	98
Edinburgh Glasgow Road	RS	27	0	99
Edinburgh Gorgie Road	RS	34	0	97
Edinburgh Queen Street	RS	26	0	94
Edinburgh Queensferry Road	RS	46	0	94
Edinburgh Salamander St	RS	27	0	98
Edinburgh St John's Road	KS	59	1	92
Edinburgh St Leonards	UB	19	0	72
Eskdalemuir	RS	2	0	99
Falkirk Grangemouth MC	UB	20	0	99
Falkirk Haggs	RS	32	0	94
Falkirk Hope St	RS	23	0	100
Falkirk Park St	RS	29	0	32
Falkirk West Bridge Street	RS	41	0	89
Fife Cupar	RS	27	0	87
Fife Dunfermline	RS	24	0	100
Fife Kirkcaldy	RS	18	0	98
Fife Rosyth	RS	25	0	89

Site Name	Type	Annual Average NO_2 2014 ($\mu g\ m^{-3}$)	No. hours >200 $\mu g\ m^{-3}$	Data capture NO_2 2014 (%)
Fort William	S	11	0	99
Glasgow Anderston	UB	18	0	35
Glasgow Burgher St	RS	27	0	97
Glasgow Byres Road	RS	41	7	72
Glasgow Dumbarton Road	KS	38	0	87
Glasgow Great Western Road	RS	31	0	57
Glasgow Kerbside	KS	68	14	93
Glasgow Townhead	UB	27	0	99
Glasgow Waulkmillglen Reservoir	RS	11	0	91
Grangemouth	UI	16	0	95
Grangemouth Moray	UB	15	0	92
Inverclyde Greenock A8	RS	27	0	79
Inverness	RS	21	0	99
Lerwick	RS	-	-	-
N Lanarkshire Chapelhall	RS	33	2	98
N Lanarkshire Croy	RS	20	0	90
N Lanarkshire Cumbernauld	RS	28	0	32
N Lanarkshire Kirkshaw	RS	28	0	50
N Lanarkshire Moodiesburn	RS	22	0	100
N Lanarkshire Shawhead Coatbridge	RS	32	0	100
North Ayrshire Irvine High St	KS	29	0	83
Paisley Central Road	RS	32	17	56
Paisley Glasgow Airport	A	22	0	89
Paisley Gordon Street	RS	28	0	85
Peebles	S	6	0	99
Perth Atholl Street	RS	45	0	97
Perth Crieff	RS	23	0	94
Perth High Street	RS	22	0	100
Renfrew Cockles Loan	RS	34	0	99
South Ayrshire Ayr Harbour	RS	9	0	97
South Ayrshire Ayr High St	RS	17	0	93
South Lanarkshire East Kilbride	RS	35	7	94
South Lanarkshire Lanark	RS	22	0	83
South Lanarkshire Hamilton	RS	37	0	96
South Lanarkshire Raith Interchange	RS	56	1	28
South Lanarkshire Rutherglen	RS	43	0	71
South Lanarkshire Uddingston	RS	29	0	100
Stirling Craig's Roundabout	RS	37	3	14
West Dunbartonshire Clydebank	RS	21	0	97
West Lothian Broxburn	RS	28	0	90
West Lothian Linlithgow High Street 2	RS	39	0	52
West Lothian Newton	RS	21	0	92

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedances of Scottish Air Quality Objectives

Table 6.1 shows nitrogen dioxide data for 82 sites utilising automatic monitoring during 2014. Although data for 13 of these are only available for part of the year with the overall data capture less than 75%. These include sites which opened or closed during the year, sites which were closed for part of the year due to roadworks etc. and sites with instrument problems.

Of the remaining 69 sites with more than 75% data capture, 10 of these (kerbside or roadside sites) exceeded the AQS Objective for the NO_2 annual mean (40 µg m^{-3}). The AQS Objective of not more than 18 exceedances of 200 µg m^{-3} for the hourly mean was not exceeded at any site.

Three sites with less than 75% data capture recorded average NO_2 concentrations in excess of the NO_2 annual average objective: Glasgow Byres Road with a data capture rate of 72%, South Lanarkshire Raith Interchange with a data capture rate of 28%, and South Lanarkshire Rutherglen with a data capture rate of 71%

The highest annual average concentrations were measured at Glasgow Kerbside, with a measured annual mean concentration of 68 µg m^{-3}. The greatest number of exceedances of the hourly mean objective was measured at Paisley Central Road with 17 exceedances.

6.1.2 Particulate Matter – PM_{10}

Table 6.2 Ratified data annual average concentration and data capture for PM_{10} in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	PM_{10} Analyser Type*	Annual Average PM_{10} 2014 (µg m^{-3})	No. Days > 50 µg m^{-3}	Data Capture (%)
Aberdeen Anderson Dr	RS	TEOM (VCM)	15	0	99
Aberdeen Errol Place	UB	FDMS	15	0	80
Aberdeen King St	RS	BAM (unheated inlet)	19	5	95
Aberdeen Market St 2	RS	BAM (heated inlet)	26	21	94
Aberdeen Union St	RS	TEOM (VCM)/FDMS	18	0	79
Aberdeen Wellington Road	RS	TEOM (VCM)	21	2	98
Alloa	RS	TEOM (VCM)	16	0	96
Auchencorth Moss	RS	Partisol	7	0	99
Auchencorth Moss PM10 PM25	RS	FDMS	8	0	96
Dundee Broughty Ferry Road	RS	TEOM (VCM)	15	1	86
Dundee Lochee Road	KS	BAM (unheated inlet)	19	1	93
Dundee Mains Loan	UB	TEOM (VCM)	13	1	96
Dundee Meadowside	RS	BAM (unheated inlet)	17	2	98
Dundee Seagate	KS	BAM (unheated inlet)	18	2	97
Dundee Union Street	KS	BAM (unheated inlet)	16	2	95
East Ayrshire Kilmarnock John Finnie St	RS	FDMS	15	0	67
East Ayrshire Kilmarnock St Marnock St	RS	BAM (unheated inlet)	19	2	94
East Dunbartonshire Bearsden	RS	Eberline (heated inlet)	14	1	98

Site Name	Type	PM_{10} Analyser Type*	Annual Average PM_{10} 2014 ($\mu g\ m^{-3}$)	No. Days > 50 µg m^{-3}	Data Capture (%)
East Dunbartonshire Bishopbriggs	RS	Eberline (heated inlet)	17	0	68
East Dunbartonshire Kirkintilloch	RS	FDMS	17	2	92
East Dunbartonshire Milngavie	RS	FDMS	14	0	92
East Lothian Musselburgh N High St	RS	BAM (unheated	17	3	92
East Renfrewshire Sheddens	RS	FDMS	12	0	56
Edinburgh Currie	UB	TEOM (VCM)	11	0	97
Edinburgh Glasgow Road	RS	TEOM (VCM)	16	0	97
Edinburgh Queensferry Road	RS	FDMS	19	1	68
Edinburgh Queen Street	RS	TEOM (VCM)	17	1	96
Edinburgh Salamander St	RS	TEOM (VCM)	21	5	97
Edinburgh St Leonards	UB	FDMS	13	0	70
Falkirk Banknock	UB	TEOM (VCM)	15	3	98
Falkirk Grangemouth MC	UB	TEOM (VCM)	15	0	93
Falkirk Haggs	RS	TEOM (VCM)	16	1	97
Falkirk Park St	RS	TEOM (VCM)	15	0	32
Falkirk West Bridge St	RS	TEOM (VCM)	18	2	85
Fife Cupar	RS	FDMS	17	0	87
Fife Dunfermline	RS	FDMS	15	0	99
Fife Kirkcaldy	RS	FDMS	11	1	87
Fife Rosyth	RS	FDMS	15	0	81
Glasgow Abercromby Street	RS	FDMS	17	0	81
Glasgow Anderston	UB	FDMS	18	0	45
Glasgow Broomhill	RS	FDMS	15	0	98
Glasgow Burgher St	RS	FDMS	16	3	98
Glasgow Byres Road	RS	FDMS	11	0	60
Glasgow Dumbarton Road	RS	TEOM (VCM)	17	0	96
Glasgow Kerbside	KS	FDMS	22	3	71
Glasgow Nithsdale Road	RS	FDMS	15	2	62
Glasgow Townhead	UB	FDMS	13	0	80
Glasgow Waulkmillglen Reservoir	RS	TEOM (VCM)	11	0	31
Grangemouth	UI	FDMS	12	0	96
Inverclyde Greenock A8	RS	TEOM (VCM)	16	0	77
Inverness	RS	Partisol	11	0	98
N Lanarkshire Chapelhall	RS	TEOM (VCM)	19	1	77
N Lanarkshire Coatbridge Whifflet	UB	TEOM (VCM)	13	0	88
N Lanarkshire Croy	RS	TEOM (VCM)	15	3	93
N Lanarkshire Cumbernauld	UB	TEOM (VCM)	15	0	31
N Lanarkshire Kirkshaws	RS	TEOM (VCM)	15	0	47
N Lanarkshire Moodiesburn	RS	BAM (unheated inlet)	11	0	86
N Lanarkshire Motherwell	RS	TEOM (VCM)	15	0	88
N Lanarkshire Shawhead Coatbridge	RS	BAM (unheated inlet)	13	0	73
North Ayrshire Irvine High St	KS	BAM (unheated inlet)	16	0	76
Paisley Gordon Street	RS	FDMS	22	1	42
Paisley St James Street	RS	FDMS	15	0	77

Site Name	Type	PM_{10} Analyser Type*	Annual Average PM_{10} 2014 (µg m^{-3})	No. Days > 50 µg m^{-3}	Data Capture (%)
Perth Atholl Street	RS	TEOM (VCM)	20	1	98
Perth Crieff	RS	BAM (unheated inlet)	19	0	88
Perth High Street	RS	TEOM (VCM)	14	0	96
Perth Muirton	UB	FDMS	10	0	87
Renfrew Cockles Loan	RS	FDMS	16	0	52
South Ayrshire Ayr Harbour	RS	FDMS	13	0	85
South Ayrshire Ayr High St	RS	FDMS	14	0	81
South Lanarkshire East Kilbride	RS	FDMS	18	2	87
South Lanarkshire Hamilton	RS	FDMS	16	0	98
South Lanarkshire Raith Interchange	RS	FDMS	22	1	30
South Lanarkshire Rutherglen	RS	FDMS	19	1	71
Stirling Craig's Roundabout	RS	TEOM (VCM)	16	0	65
West Lothian Broxburn	RS	FDMS	17	2	81
West Lothian Linlithgow High St 2	RS	FDMS	18	1	99
West Lothian Newton	RS	FDMS	22	1	97

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives
*FDMS data are equivalent to gravimetric and hence are not adjusted
Partisol data are equivalent to gravimetric and hence are not adjusted
BAM (heated inlet) data are adjusted using gravimetric equivalent factor of 0.966
BAM (un-heated inlet) data are adjusted using gravimetric equivalent factor of 0.8333

Table 6.2 shows the 2014 gravimetric equivalent particulate matter PM_{10} data from 77 sites utilising automatic monitoring and the Partisol daily sampler. Of these sites, 19 have less than 75% data capture. As discussed in Section 4.2.2, all TEOM data have been adjusted using the VCM.

Of the 59 sites with 75% or greater data capture, 10 sites exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3} and a further 5 equaled this Objective. Of these sites, Aberdeen Market St 2 also exceeded the Daily Objective of 50 µg m^{-3} not to be exceeded more than 7 times in a year.

The maximum PM_{10} annual mean concentration was measured at Aberdeen Market St 2 with a measured annual mean concentration of 26 µg m^{-3} and 21 exceedances of the daily mean objective.

Of the 18 sites with less than 75% data capture Glasgow Anderston equalled the objective, while Paisley Gordon St, Glasgow Kerbside, Edinburgh Queensferry, South Lanarkshire Raith Interchange, and South Lanarkshire Rutherglen measured average PM_{10} concentrations greater than the Annual Average PM_{10} Objective of 18 µg m^{-3}.

No site exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10} and the daily mean objective of no more than 35 exceedances of 50 µg m^{-3}.

Note that at the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for PM_{10} (and $PM_{2.5}$). The results for both sites are shown in Table 6.1.2 under the site names of Auchencorth Moss (for measurements using Partisol samplers) and Auchencorth Moss PM_{10} $PM_{2.5}$ (for measurements using FDMS analysers). As can be seen both methods measured similar annual average PM_{10} concentrations of 7 µg m^{-3} and 8 µg m^{-3}, respectively. No exceedances of the daily objective were measured at the two sites.

6.1.3 Particulate Matter – $PM_{2.5}$

Table 6.3 Ratified data annual average concentration and data capture for $PM_{2.5}$ in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	$PM_{2.5}$ Analyser Type	Annual Average $PM_{2.5}$ 2014 (µg m^{-3} gravimetric equivalent)	Data Capture (%)
Aberdeen Errol Place	UB	FDMS	10	87
Aberdeen Union Street	R	FDMS	13	14
Auchencorth Moss	R	Partisol	4	98
Auchencorth Moss PM10 PM25	R	FDMS	7	86
Edinburgh St Leonards	UB	FDMS	9	66
Glasgow Kerbside	KS	FDMS	16	61
Glasgow Townhead	UB	FDMS	7	89
Grangemouth	UI	FDMS	8	92
Inverness	RS	Partisol	6	95

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

For compliance with the EU Directive, three $PM_{2.5}$ urban background monitoring sites are required in Scotland. These have been established as part of the AURN in Edinburgh, Glasgow and Aberdeen. In addition, for research purposes, additional monitors have been installed at the kerbside site in Glasgow and at the rural site at Auchencorth Moss. Also, with support from the Scottish Government, the daily gravimetric monitoring of $PM_{2.5}$ continues at Inverness and Aberdeen City Council now monitors $PM_{2.5}$ at Aberdeen Union St. Data from nine sites in Scotland are therefore available for all or part of 2014 (Table 6.3).

Data capture rates of less than 75% were measured at Aberdeen Union St, Edinburgh St Leonards and Glasgow Kerbside. $PM_{2.5}$ concentrations in excess of the Scottish AQS Objective of 12 µg m^{-3} as an annual mean was measured at Glasgow Kerbside with a data capture rate of 61%. Figure 6.1 shows the 2014 Annual Average $PM_{2.5}$ and PM_{10} concentrations for all SAQD monitoring sites with more than 75% data capture.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for $PM_{2.5}$. A difference in annual mean $PM_{2.5}$ concentrations were measured by the Partisol sampler and FDMS analyser during 2014, with measured annual average $PM_{2.5}$ concentrations of 4 µg m^{-3} and 7 µg m^{-3}, respectively.

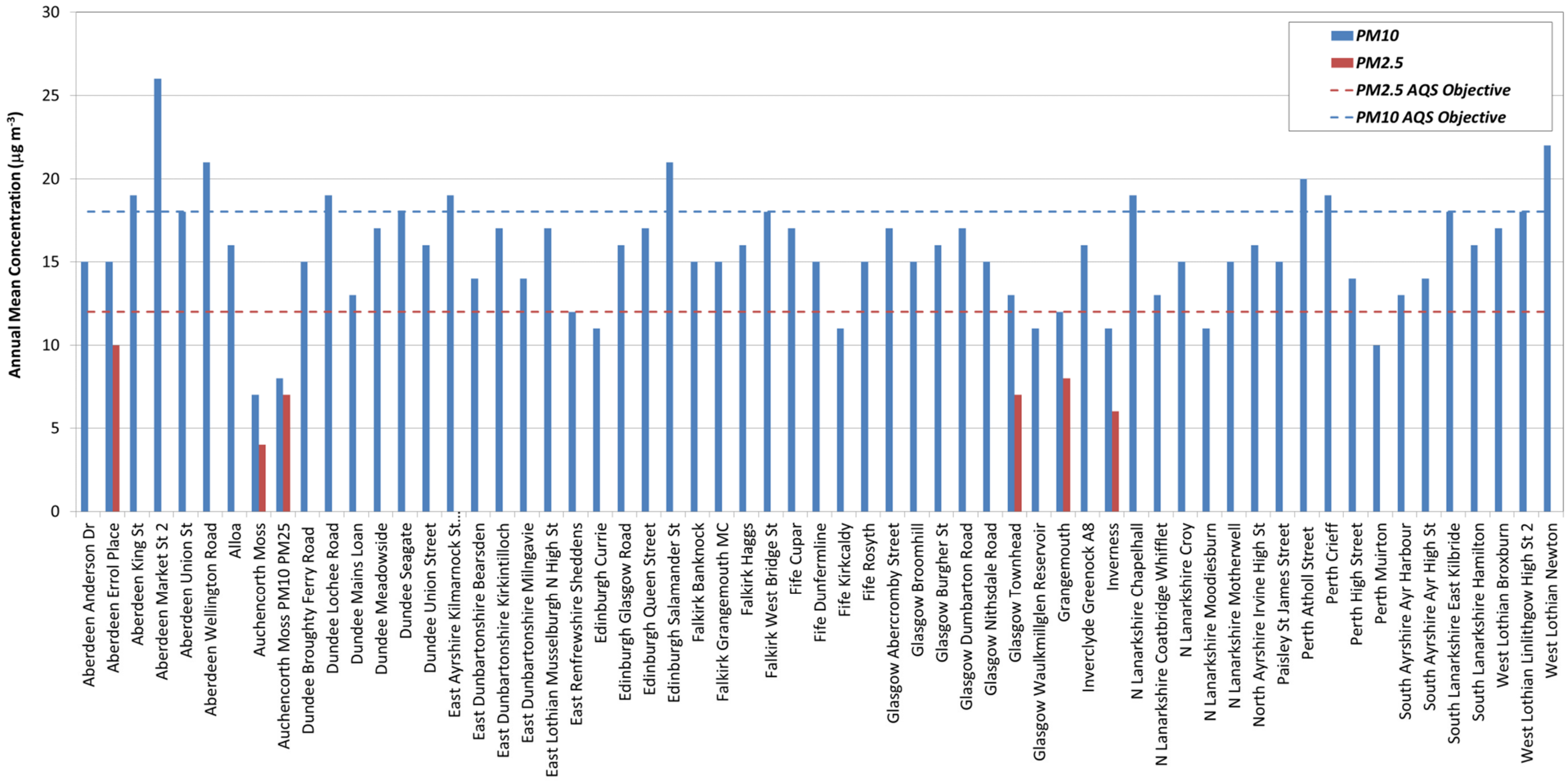
The $PM_{2.5}/PM_{10}$ ratios calculated for each site for the years 2009 to 2014 are shown in Table 6.4. The highest $PM_{2.5}/PM_{10}$ ratios during 2014 for sites with greater than 75% data capture was calculated at Aberdeen Errol Place and Glasgow Kerbside with calculated ratios of 0.69 and 0.70, respectively.

Table 6.4 $PM_{2.5}/PM_{10}$ ratios for 2009 - 2014 annual average concentrations

Site Name	Annual Average PM_{10} 2014 ($\mu g\ m^{-3}$)	Annual Average $PM_{2.5}$ 2014 ($\mu g\ m^{-3}$)	Ratio					
			2014	2013	2012	2011	2010	2009
Aberdeen Errol Place	15	10	0.67	0.69	0.75	0.57	0.54	0.47
Aberdeen Union Street	18	13	0.72	-	-	-	-	-
Auchencorth Moss	7	4	0.57	0.57	0.57	0.71	0.50	0.64
Auchencorth Moss PM10 PM25	8	7	0.88	0.50	0.57	0.50	0.57	0.51
Edinburgh St Leonards	13	9	0.69	0.57	0.69	0.80	0.64	0.50
Glasgow Kerbside	22	16	0.73	0.70	0.63	-	-	-
Glasgow Townhead	13	7	0.54	0.50	0.83	1.22	0.79	0.81
Grangemouth	12	8	0.67	0.64	0.79	0.79	0.79	0.68
Inverness	11	6	0.55	0.50	0.55	0.50	0.50	0.55

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

Figure 6.1 Annual Average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites with more than 75% data capture in 2014



6.1.4 Carbon Monoxide

Table 6.5 Ratified data annual average concentration and data capture for CO in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average CO 2014 (mg m^{-3})	Max. Running 8hr Mean CO 2014 (mg m^{-3})	Data Capture (%)
Edinburgh St Leonards	UB	0.1	1.1	66
N Lanarkshire Croy	UB	0.2	0.5	99

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

Table 6.5 shows carbon monoxide was monitored using automatic techniques at 2 sites during 2014. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

6.1.5 Sulphur Dioxide

Table 6.6 Ratified data annual average concentration and data capture for SO_2 in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average SO_2 2014 (µg m^{-3})	No. 15 min SO_2 > 266µg m^{-3} 2014	No. 1 hr SO_2 > 350µg m^{-3} 2014	No. 24 hr SO_2 > 125µg m^{-3} 2014	Data Capture (%)
Dundee Broughty Ferry Road	RS	3	0	0	0	89
Edinburgh St Leonards	UB	1	0	0	0	72
Falkirk Grangemouth MC	UB	6	30	0	0	99
Falkirk Hope St	RS	4	0	0	0	99
Falkirk Park St	RS	2	0	0	0	17
Glasgow Anderston	UB	2	0	0	0	44
Grangemouth	UI	3	3	0	0	97
Grangemouth Moray	UB	6	5	0	0	99
N Lanarkshire Croy	RS	2	0	0	0	93
N Lanarkshire Cumbernauld	UB	0	0	0	0	32
N Lanarkshire Kirkshaws	RS	0	0	0	0	51
Shetland Lerwick	R	-	-	-	-	0

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6.6 shows sulphur dioxide data from the 12 sites utilising automatic monitoring for 2014. N Lanarkshire Cumbernauld was decommissioned on 01/05/2014 and N Lanarkshire Kirkshaws was commissioned on 28/06/14 and so data are only available for part of the year. Monitoring at Shetland Lerwick was suspended during 2014 due to building works and the commissioning of a new monitoring hut. All sites in Scotland met the requirements of the Air Quality Strategy for the 15 minute, 1-hour and 24-hour mean objectives SO_2 in 2014.

6.1.6 Ozone

Table 6.7 Ratified data annual average concentration and data capture for O_3 in 2014 for monitoring sites in the Scottish Air Quality Database

Site Name	Type	Annual Average O_3 2014 ($\mu g\ m^{-3}$)	No of days with running 8-hr mean >100 ug m^{-3}	Data capture O_3 2014 (%)
Aberdeen Errol Place	UB	46	0	93
Auchencorth Moss	R	58	1	99
Bush Estate	R	59	2	96
Edinburgh St Leonards	UB	55	6	72
Eskdalemuir	R	58	7	99
Fort William	S	56	4	97
Glasgow Townhead	UB	43	3	99
Glasgow Waulkmillglen Reservoir	R	51	1	96
Lerwick	R	-	-	0
Peebles	S	57	8	99
Strath Vaich	R	69	17	87

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

Table 6.7 shows ozone data from 11 sites utilising automatic monitoring for 2014. 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 2014, the air quality objective of not more than 10 days with a maximum 8 hr running mean greater than 100 $\mu g\ m^{-3}$ was exceeded at Strath Vaich. No sites with a data capture rate of less than 75% exceeded the Air Quality Objective. Monitoring at Shetland Lerwick was suspended during 2014 due to building works and the commissioning of a new monitoring hut.

6.2 Other pollutants covered by the Air Quality Strategy – PAH (benzo[a]pyrene), Benzene, 1,3-butadiene and Lead

In this section, we present a summary of data from a range of national monitoring networks. Summaries are provided for pollutants covered by the Air Quality Strategy. As some of these networks are based on sampler measurement techniques and subsequent chemical analysis there is often a considerable delay in the availability of data. Hence, in some cases, the latest data available at the time of preparing this report is for 2013. Where other pollutants are also monitored in these networks, these pollutants are listed, but the data are not provided in this report.

6.2.1 PAH Monitoring Network[5]

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

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

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

The PAH monitoring sites in Scotland are shown in Table 6.8. The sites at Edinburgh and Glasgow are co-located with the Edinburgh St Leonards and Glasgow Centre AURN sites respectively. The Glasgow Centre site was decommissioned in August 2012 and a replacement site, Glasgow Townhead, was commissioned in October 2013. Therefore, PAH data from the Glasgow Centre site have been reported and are only available up to August 2012. The site at Kinlochleven is located close to the closed Aluminium works and the site at Auchencorth Moss is a rural EMEP site as discussed in the automatic hydrocarbon section.

Table 6.8 PAH Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site in Scotland, south of Edinburgh	322167,656123
Edinburgh	145 Pleasance, Edinburgh, EH8 9RU	326265, 673136
Glasgow Townhead	Not available	259692, 665899
Kinlochleven	Electrical Substation, Kinlochleven	219305,761905

Annual average concentrations for Benzo(a)pyrene (B(a)P) for 2012 and 2013 are shown in Table 6.9.

As can be seen the Air Quality Objective for B(a)P of 0.25 ng m^{-3} as an annual average or the EU Directive target value of 1 ng m^{-3} was not exceeded at any site in 2013 or 2014.

Table 6.9 Annual Average Benzo(a)Pyrene concentrations for 2013 - 2014 at 4 sites in Scotland

Site	2013 Annual Mean B(a)P Concentration (ng m^{-3})	2014 Annual Mean B(a)P Concentration (ng m^{-3})
Auchencorth Moss	0.036	0.026
Edinburgh St Leonards	0.084	0.058
Glasgow Townhead	0.169	0.099
Kinlochleven	0.162	0.182

Shaded sites indicate data only available for part year and/or <75% data capture
Highlighted figures (in yellow) indicate exceedance of Scottish Air Quality Objectives

[5] Conolly C. et al Final Contract Report for the UK PAH Monitoring and Analysis Network (2004-2010) [online] Available at http://uk-air.defra.gov.uk/reports/cat05/1103040911_AEA_PAH_Network_Report_2010_Final_v3.1.pdf [Accessed no 30/05/2012]

6.2.2 Benzene

Non- automatic hydrocarbon monitoring

Monitoring of benzene is undertaken on a two weekly basis with pumped tube samplers at 37 sites throughout the UK – The UK Non-automatic Hydrocarbon Network. Two of these sites are located in Grangemouth and Glasgow Kerbside and are co-located with the Grangemouth and Glasgow Kerbside AURN sites. The non-automatic monitoring network provides benzene data for compliance with the EU air quality Directive and Scottish AQS objective of 16.25 µg m^{-3} as an annual mean.

The benzene monitoring method used in this network involves pumping ambient air at a rate of 10 ml min^{-1} through nominally duplicate tubes containing the sorbent Carbopack X, with subsequent laboratory analysis of the benzene content of the tubes.

Results for this site for 2013 and 2014 are provided in Table 6.10.

Table 6.10 Annual Mean Benzene Concentrations in 2013 and 2014 at 2 sites in Scotland in the UK Non-automatic Hydrocarbon Network

Site Name	Annual Mean benzene for 2013 (µg m^{-3})	Annual Mean benzene for 2014 (µg m^{-3})
Glasgow Kerbside	0.89	0.86
Grangemouth	1.12	0.99

6.2.3 Automatic Hydrocarbon Monitoring

Table 6.11 gives the site details for the one automatic hydrocarbon monitoring station in Scotland - Auchencorth Moss; a rural site south of Edinburgh. The data from this site are used both to provide data for ozone precursor hydrocarbon species, in compliance with the EU Air Quality Directive (2008/50/EC). In addition, this site is one of the 2 European Monitoring and Evaluation Programme (EMEP) level II sites (EMEP "supersites") in the UK. The other EMEP supersite is located a Harwell in Oxfordshire. A much wider range of hydrocarbon species is monitored at Auchencorth Moss. However, the rural nature of this site means that often the concentrations are below the detection limit and hence, the data capture is low. Data for the full range of hydrocarbon species monitored at Glasgow Kerbside and Auchencorth Moss can be downloaded from www.scottishairquality.co.uk.

Table 6.11 Location of Automatic Hydrocarbon monitoring sites in Scotland

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322167,656123

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

Table 6.12 indicates that it is unlikely that the EU limit value for benzene of 5 µg m^{-3} was and that the Scottish Objective of 3.25 µg m^{-3} for the annual running mean concentration are unlikely to have been exceeded at Auchencorth Moss during 2014.

Table 6.12 Annual Average Benzene concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2014

Site	2014 Benzene Annual mean concentration (µg m^{-3})	2014 Benzene Maximum running annual concentration (µg m^{-3})	2014 % Data Capture
Auchencorth Moss	0.26	0.26	39

6.2.4 1,3-Butadiene

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

Table 6.13 Annual Average 1,3-butadiene concentration at Auchencorth Moss in the UK Automatic Hydrocarbon Network, for 2014

Site	2014 1,3-butadiene Annual mean concentration (µg m^{-3})	2014 1,3-butadiene maximum running annual concentration (µg m^{-3})	2014 % Data capture
Auchencorth Moss	0.03	0.03	63

Table 6.13 indicates that it is unlikely that the Air Quality Objective for 1,3-butadiene of 2.25 µg m^{-3} has been exceeded in Scotland in 2014. There is no EU Directive covering 1,3-butadiene.

6.2.5 Lead

Lead and a wide range of other metals are monitored in two UK networks – the UK Heavy Metals Monitoring Network (mainly urban sites) and the National Monitoring Network for Heavy Metals (mostly rural sites). The urban network determines airborne particulate concentrations of 15 metals, including the metals lead, nickel, arsenic, cadmium and mercury which are covered by the EU Directive (Directives 2008/50/EC for lead and Directive 2004/107/EC for other metals). The rural network determines the concentration of more than 20 metals both as airborne particulate matter and as deposited material in rainwater samples. Results for all metals monitored in the UK Heavy Metals Monitoring Network and for a selection of metals monitored in the National Monitoring Network for Heavy Metals are available from annual average spreadsheet summaries at www.uk-air.defra.gov.uk.

Urban Heavy Metals

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

Table 6.14 gives details of the monitoring sites in Scotland and Table 6.15 provides a summary of the results for the measurement of lead and other metals for 2013. ***Motherwell South was decommissioned on 31/12/2013.***

Table 6.14 Heavy Metals Monitoring Network Sites in Scotland 2013

Site	Site type and grid ref	Address	Metals measured
Motherwell South	Urban Background 276140,655515	Our Lady's High School, Dalzell Drive, Motherwell, North Lanarkshire, ML1 2DG	As, Cd, Cr, Co, Cu, Fe, Hg(p), Hg(v), Mn, Ni, Pb, Pt, Se, V, Zn

Table 6.15 Annual mean metal concentrations 2013 (Urban Network)

Site	Annual Mean Lead concentration (ng m^{-3})	Annual Mean Nickel concentration (ng m^{-3})	Annual Mean Arsenic concentration (ng m^{-3})	Annual Mean Cadmium concentration (ng m^{-3})	Annual Mean Mercury(p)* concentration (ng m^{-3})	Annual Mean Mercury(v)+ concentration (ng m^{-3})
Motherwell South	2.50	0.56	0.290	0.0864	0.005	2.084

* mercury in particulate phase
\+ total gaseous mercury

Rural Heavy Metals

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

Details of the 3 rural sites in Scotland are provided in Table 6.16 and data for the measurement of lead, nickel, arsenic and cadmium in 2014 are provided in Table 6.17. ***Banchory was decommissioned on 04/01/2014.***

Table 6.16 Rural Network Metals Monitoring Sites in Scotland

Site	Address	Grid Reference
Auchencorth Moss	Rural site, SE Scotland	322167,656123
Eskdalemuir	The Met Office Eskdalemuir Observatory, Langholm, Dumfries & Galloway, DG13 0QW	323552,603018

Table 6.17 Annual Mean metal concentrations 2014 (Rural Network)

Site	Annual Mean Lead Concentration (ng m^{-3})	Annual Mean Nickel Concentration (ng m^{-3})	Annual Mean Arsenic Concentration (ng m^{-3})	Annual Mean Cadmium Concentration (ng m^{-3})
Auchencorth Moss	1.30	0.46	0.303	0.0384
Eskdalemuir	1.26	0.55	0.162	0.0377

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

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

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

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

6.3.1 NO_2 Diffusion Tube Results

There is no specific requirement for local authorities to provide their NO_2 diffusion tube data to a central storage facility. However, through the local authority Air Quality Support contract, a mechanism has been provided for authorities to provide these data. This data entry system is available from http://airquality.aeat.com/NO2admintools/NO2_logon.php. Where these data are provided by the authorities, they are then available for download from the Scottish air quality website (www.scottishairquality.co.uk).

6.3.2 Non-Methane Volatile Organic Compounds (NMVOC)

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

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

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

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

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

6.3.3 Poly-Aromatic Hydrocarbons (PAH)

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

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

6.3.4 Toxic Organic Micropollutants

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

There were six sites in the TOMPs network during 2014; one in Scotland at Auchencorth Moss.

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

6.3.5 Heavy Metals Network

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

Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni), Selenium (Se), Vanadium (V) and Zinc (Zn).

Monitoring of the following heavy metals was suspended at Auchencorth Moss on 01/01/2014:

Aluminium (Al), Antimony (Sb), Barium (Ba), Beryllium (Be), Caesium (Cs), Lithium (Li), Mercury (Hg), Molybdenum (Mo), Rubidium (Rb), Scandium (Sc), Strontium (Sr), Tin (Sn), Titanium (Ti), Tungsten (W) and Uranium (U).

Monitoring of the following heavy metals was suspended at Eskdalemuir on 31/12/2013:

Mercury (Hg) and Platinum (Pt).

6.3.6 United Kingdom Eutrophying & Acidifying Pollutant Network (UKEAP)

This network focuses on the measurement of Eutrophying & Acidifying Pollutants in rural areas. The number of sites in Scotland is different for the various species measured.

The UKEAP has 4 component networks:

- The Precipitation Network (PrecipNet),
- Rural NO_2 network (NO_2-Net),
- Acid Gas and Aerosol Network (AGANET),
- National Ammonia Monitoring Network (NAMN),
- Automatic Mercury Network.

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

The Precipitation Network (Precip-Net)

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

Fortnightly precipitation samples are collected at 38 sites throughout the UK, of which, 13 are in Scotland (see Appendix 1). Sampling is undertaken with using a bulk rainwater collector. The collected rainwater samples are analysed for sulphate, nitrate, chloride, phosphate, sodium, magnesium, calcium, potassium, pH and conductivity.

Rural NO_2 Network (NO_2-Net)

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

Triplicate nitrogen dioxide diffusion tube measurements are run at three AURN sites with co-located automatic instruments (Yarner Wood, Harwell and Eskdalemuir). The annual average NO_2 concentration measured at the Eskdalemuir automatic monitoring site was 2 $\mu g\ m^{-3}$ in 2014 with a data capture rate of 99%.

Nitrogen dioxide is measured with diffusion tube samplers at 9 sites in Scotland. The annual average concentrations measured in 2014 are provided in Table 6.18.

Table 6.18 NO_2 annual average concentrations 2014 at rural monitoring sites

Site	NO_2 (ug m^{-3})	Data Capture (%)
Allt a'Mharcaidh	2.1	100
Balquhidder 2	3.0	100
Eskdalemuir	3.5	100
Forsinain 2	2.7	100
Glensaugh	4.1	100
Loch Dee	3.5	86
Polloch	1.6	100
Strathvaich	1.6	100
Whiteadder	4.0	100

Acid Gas and Aerosol Network (AGANET)

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

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

The 11 sites in this network located in Scotland are listed in Appendix 1.

National Ammonia Monitoring Network (NAMN)

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

The 23 sites in this network located in Scotland are listed in Appendix 1.

7 Air Quality Mapping for Scotland

As part of the Scottish Air Quality Database project, Ricardo-AEA provide mapped concentrations of modelled background air pollutant concentrations on a 1 km x 1 km basis for the whole of Scotland. Modelled roadside air pollutant concentrations are provided for road links in Scotland. The air pollution maps are derived from a combination of (1) measurements from Scotland's network of air quality monitoring stations, and (2) spatially disaggregated emissions information from the UK National Atmospheric Emissions Inventory (NAEI). They provide estimated pollutant concentrations for the whole of Scotland. The methodology for producing the Scottish maps is based on the UK Pollution Climate Mapping (PCM) approach, used for producing air pollution maps for the whole UK for the purposes of annual compliance reporting to the European Commission.

The PCM methodology has been applied to provide pollution maps of Scotland for the Scottish Government for 2013 (the most recent year available) using measurements exclusively from Scottish air quality monitoring sites and Scottish meteorology. The maps provide spatial representation of the annual mean concentrations of:

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

The air pollution measurements used to prepare the maps presented here consists of appropriately scaled PM_{10} monitoring data (FDMS, Partisol and VCM-corrected TEOM data) and automatic monitoring measurements for NO_X and NO_2 in 2013. The model also uses Scottish meteorology observations (from RAF Leuchars) to create the Scotland-specific maps.

In 2009 Ricardo-AEA undertook a short study[6] on behalf of the Scottish Government which demonstrated that air pollutant source apportionment data and forward-projected concentrations of air pollutants were required for the Scottish pollution maps. These parameters were calculated for 2009, using Scotland-specific data, for use by Scottish local authorities for their Local Air Quality Management Review and Assessment reports. Scotland-specific air pollutant source apportionment data and forward-projected concentrations of air pollutants are available at:

http://www.scottishairquality.co.uk/maps.php?n_action=data.

7.1 Air Quality Maps for Scotland 2013

The details of the methodology and full results of the mapping study are provided in a separate Scottish Air Quality Mapping report 2013[7]. In this report, we summarise the main findings of this work.

7.1.2 NO_2 maps for 2013

The 2013 annual mean NO_2 concentrations for Scotland were modelled for background and roadside locations. Figure 7.1 and Figure 7.2 show modelled annual mean NO_2 concentrations in Scotland, for background and roadside locations respectively.

[6] Stevenson, K., Kent, A.J., and Stedman, J. (2010). Investigation of the possible effect of the use of Scottish specific air quality maps in the LAQM process in four selected Local Authorities. AEA Report AEAT/ENV/R/2948. http://www.scottishairquality.co.uk/documents/reports2/258100203_LA_mapping_Report_Issue_1_FINAL.PDF

[7] Rose R.A. (2015). Scottish Air Quality Maps. Pollutant modelling for 2013: annual mean NO_X, NO_2, and PM_{10}. To be published.

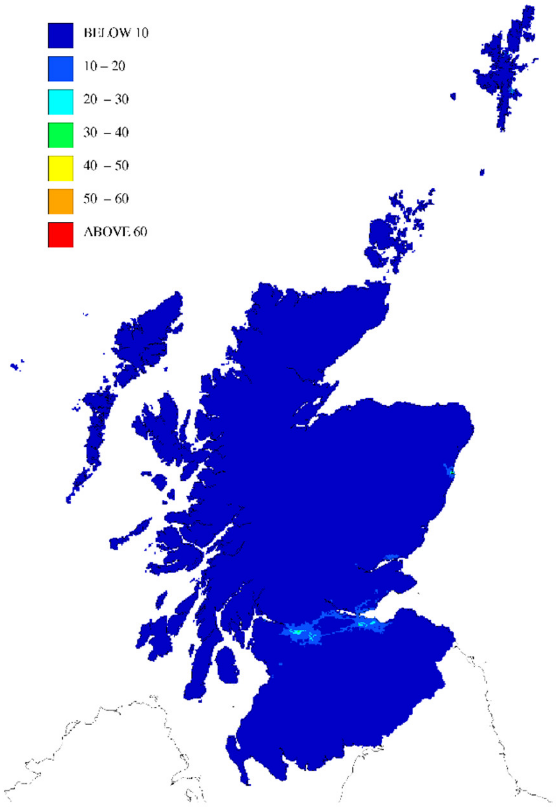
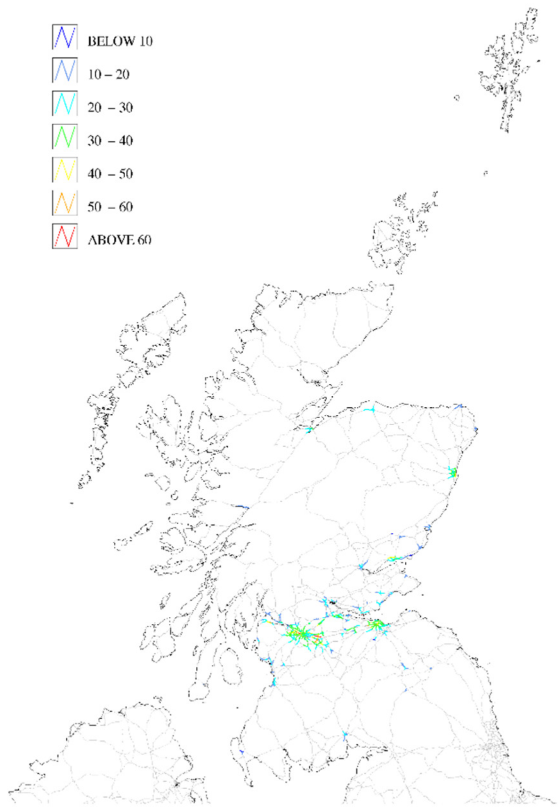
Figure 7.1 Background NO_2 map for 2013, µg m^{-3} (Scotland-specific model)	**Figure 7.2 Roadside NO_2 map for 2013, µg m^{-3} (Scotland-specific model)**
	

Table 7.1 shows that there were no modelled exceedances of the Scottish annual mean NO_2 objective of 40 µg m^{-3} at background locations. Table 7.2 shows that the Scotland-specific model predicted that the Scottish annual mean NO_2 air quality objective was exceeded along 99 road links (125 km of road). The majority of exceedances were predicted to occur in the Glasgow Urban area where exceedances were modelled for 68 road links (84 km of road). Overall exceedances of the Scottish annual mean NO_2 air quality objective were modelled in four of the six zones and agglomerations in Scotland. In each of the other three Scottish zones and agglomerations there were approximately 10 road links where exceedances of the Scottish annual mean NO_2 air quality objective were modelled, effecting 10-16 km of roads. No roadside exceedances of the Scottish annual mean NO_2 air quality objective were modelled in the more rural zones and agglomerations of Scotland, i.e. the Highlands and Scottish Borders. More detailed maps showing the roadside annual mean NO_2 concentrations can be found in the Scottish Air Quality Mapping report 2013[8]

[8] Rose R.A. (2015). Scottish Air Quality Maps. Pollutant modelling for 2013: annual mean NO_X, NO_2, and PM_{10}. To be published.

Table 7.1 Annual mean exceedance statistics for background NO_2 in Scotland based on the Scotland-specific model, 2013.

Zone or agglomeration	Total		>40 µg m^{-3}	
	Area (km^2)	Population	Area (km^2)	Population
Glasgow Urban Area	367	1105095	0	0
Edinburgh Urban Area	134	468399	0	0
Central Scotland	9984	1942272	0	0
North East Scotland	19024	1121019	0	0
Highland	43514	393586	0	0
Scottish Borders	11400	265466	0	0
Total	**84423**	**5295838**	**0**	**0**

Table 7.2 Annual mean exceedance statistics for roadside NO_2 in Scotland based on the Scotland-specific model, 2013.

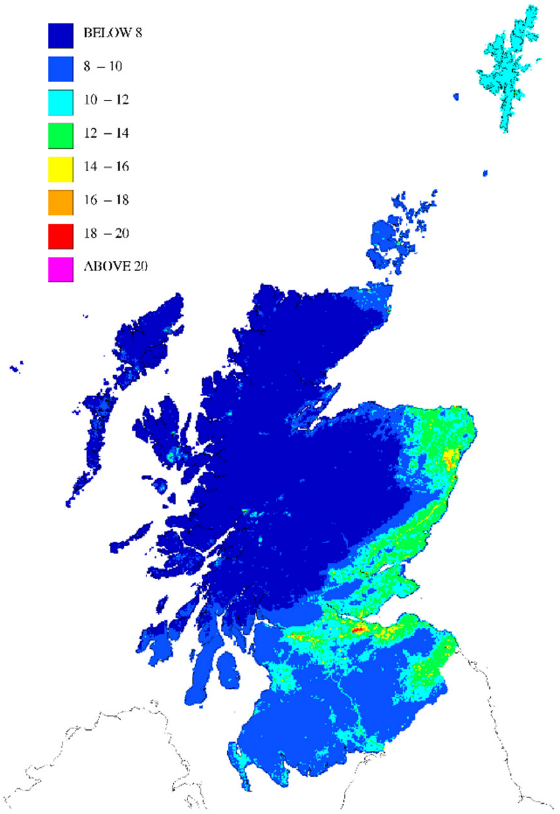
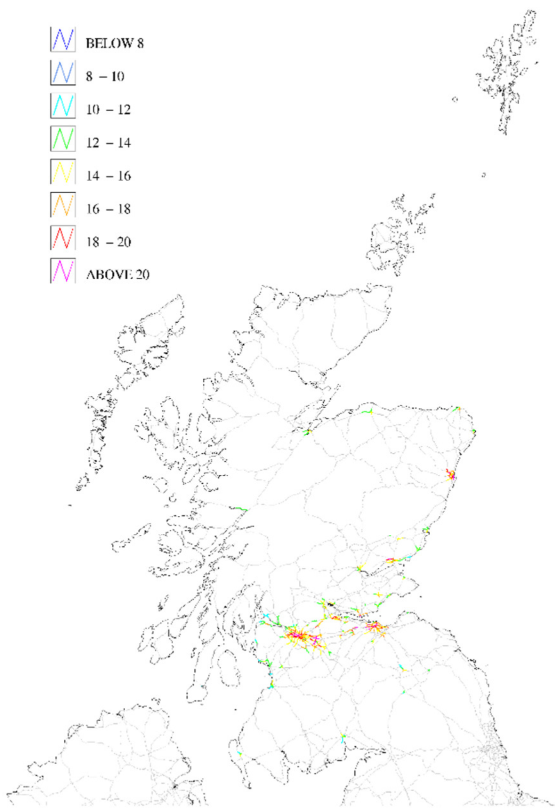
Zone or agglomeration	Total		>40 µg m^{-3}	
	Road links	Length (km)	Road links	Length (km)
Glasgow Urban Area	283	339.6	68	84.2
Edinburgh Urban Area	60	99.5	10	13.3
Central Scotland	238	353.0	12	12.1
North East Scotland	133	233.4	9	15.5
Highland	11	36.6	0	0.0
Scottish Borders	36	47.1	0	0.0
Total	**761**	**1109.3**	**99**	**125.0**

7.1.3 PM_{10} maps for 2013

2013 annual mean PM_{10} concentrations for Scotland were modelled for background and roadside locations. The modelling methodology used to calculate the annual mean PM_{10} concentration was similar to that used in previous years and used a mixture of appropriately scaled PM_{10} monitoring (FDMS, Partisol and VCM corrected TEOM) data. Many of the chemical components of the PM_{10} model are not affected by the Scotland-specific changes to the UK PCM model. This includes the contribution to the total PM_{10} mass from the following components:

- secondary inorganic aerosols (SIA, e.g., sulphate, nitrate, ammonium-based particles),
- secondary organic aerosols (SOA),
- primary particles from long-range transport (e.g., soot particles from biomass burning),
- sea salt aerosol, and
- iron and calcium-based dusts.

Maps of the modelled 2013 annual mean PM_{10} concentrations for Scotland's background and roadside locations are shown in Figures 7.3 and 7.4, respectively.

Figure 7.3 Background PM_{10} map for 2013, µg m^{-3} (Scotland-specific model)	**Figure 7.4 Roadside PM_{10} map for 2013, µg m^3 (Scotland-specific model)**
	

The 2013 Scotland-specific model identified 170 road links (187.2 km of road) exceeding the Scottish annual mean PM10 air quality objective, as shown in

Table 7.. 112 road links (113.0 km of road) were in the Glasgow Urban Area; 20 road links (24.9 km of road) in North East Scotland, 23 road links (24.9 km of road) in Central Scotland and 15 road links in the Edinburgh Urban Area (20.7 km of road). No roadside exceedances of the Scottish PM10 objective were modelled in the Highlands or Scottish Borders.

Table shows exceedances of the Scottish annual mean PM_{10} objective of 18 µg m^{-3} were modelled at nineteen, 1 km^2 grid squares in Scotland. Fifteen grid squares were located in Central Scotland within an area around the junction of M8 and M9 and M8 in the direction of Livingstone. The cause of the elevated modelled annual mean PM_{10} concentrations in these grid squares was difficult to apportion precisely due to the difficulties in resolving the source from a mix of modelled and measured air quality monitoring data. Examination of the grid squares revealed a complex situation with several potential contributory sources including emissions from road transport and industrial and agricultural emissions. The Scotland specific model has predicted similar exceedances in the annual mean PM_{10} concentration in this cluster of grid squares in previous years. Modelled concentrations in this area for 2012 were lower than the concentrations reported here for 2013, but modelled concentrations in 2011 were similar.

Further isolated exceedances were located in north-western side of Glasgow, Aberdeen, Wick and on the A6105 in the Scottish borders. The range of PM_{10} sources in these grid squares are quite diverse.

On the whole the extent of the exceedance of the Scottish PM_{10} air quality objective was typically of the order of 1 to 2 µg m^{-3}, but was as high as 4 µg m^{-3} in one grid square.

The 2013 Scotland-specific model identified 170 road links (187.2 km of road) exceeding the Scottish annual mean PM_{10} air quality objective, as shown in

Table 7.. 112 road links (113.0 km of road) were in the Glasgow Urban Area; 20 road links (24.9 km of road) in North East Scotland, 23 road links (24.9 km of road) in Central Scotland and 15 road links in the Edinburgh Urban Area (20.7 km of road). No roadside exceedances of the Scottish PM_{10} objective were modelled in the Highlands or Scottish Borders.

Table 7.3 Annual mean exceedance statistics for background PM_{10} in Scotland based on the Scotland-specific model, 2013.

Zone or agglomeration	Total		>18 µg m^{-3}	
	Area (km^2)	Population	Area (km^2)	Population
Glasgow Urban Area	367	1105095	1	2396
Edinburgh Urban Area	134	468399	0	0
Central Scotland	9984	1942272	15	6401
North East Scotland	19024	1121019	1	2070
Highland	43514	393586	1	1989
Scottish Borders	11400	265466	1	1187
Total	**84423**	**5295838**	**19**	**14043**

Table 7.4 Annual mean exceedance statistics for roadside PM_{10} in Scotland based on the Scotland-specific model, 2013.

Zone or agglomeration	Total		>18 µg m^{-3}	
	Road links	Length (km)	Road links	Length (km)
Glasgow Urban Area	283	339.6	112	113.0
Edinburgh Urban Area	60	99.5	15	20.7
Central Scotland	238	353.0	23	24.9
North East Scotland	133	233.4	20	28.7
Highland	11	36.6	0	0.0
Scottish Borders	36	47.1	0	0.0
Total	**761**	**1109.3**	**170**	**187.2**

8 Air Quality Trends for Scotland

This section of the report summarises how air quality in Scotland has changed in recent years. It focuses on those pollutants for which not all sites in Scotland currently meet the Air Quality Strategy Objectives. These pollutants are nitrogen dioxide, particulate matter and ozone.

Automatic monitoring of oxides of nitrogen and of ozone has been routinely carried out in Scotland since 1987, with automatic PM_{10} monitoring carried out since the 1990s. However, until 2000 there were relatively few automatic monitoring sites. Subsequent years have seen the number of monitoring sites in the Scottish Air Quality database increase from 20 sites (in 2000) to the current total of 91 sites (as of February 2015). The data produced by these monitoring sites have improved our understanding of Scotland's pollution climate. However, the increase in site numbers potentially complicates the investigation of trends in air quality. If trend investigation is based on all available data, the apparent trends we see may not reflect real changes in Scotland's air quality; instead, they may be due to the changes in the number of sites (and their distribution). Therefore, in reports in this series from 2010 onwards, investigation of trends has been based on subsets of long-running sites. This should lead to a more robust assessment. All the sites featured in this section have been in operation for a minimum of five consecutive years, as this is usually considered to be the minimum required in order to assess long-term trends at a monitoring site.

This section presents trend analysis carried out using Openair: a free, open-source software package of tools for analysis of air pollution data. Openair was developed by King's College London with the University of Leeds. A range of Openair tools are available on the "Air Quality in Scotland" website: for more information on the tools and how to use them, please see:

http://www.scottishairquality.co.uk/openair/openair.php

The trend analyses in this section were done using the Openair "TheilSen" tool. This uses the Theil-Sen statistical method to determine trends in pollutant concentrations over several years. The trend analysis is based on monthly mean pollutant concentrations. (At least 75% data capture is required for a valid monthly mean.) Openair includes an option to "de-seasonalise" the data (i.e. statistically modify the plotted data to remove the influence of seasonal cycles, thus providing a clearer indication of the overall trend over the relevant time). The "de-seasonalise" option has been used in all the Theil-Sen trend graphs presented here.

8.1 Oxides of Nitrogen and Nitrogen Dioxide

In Scotland (as elsewhere in the UK) the largest number of Air Quality Management Areas (AQMAs) has been declared in response to exceedances of objectives for nitrogen dioxide (NO_2). This is also reflected in the number of monitoring stations reporting exceedances for this pollutant (see Section 6 of this report). In particular, the objective of 40 µg m^{-3} for annual mean NO_2 concentration is the most widely exceeded.

It is therefore important to understand how concentrations of this pollutant are varying with time. When investigating trends, both NO_2 and total oxides of nitrogen (NO_x) should be considered. This is because most combustion sources (such as road vehicles, domestic heating and other fuel burning processes) emit a mixture of NO_2 (so-called "direct" NO_2) and NO: the latter is subsequently oxidised to NO_2 in the ambient air. A large proportion of NO_2 is formed from the oxidation of NO emitted from such sources.

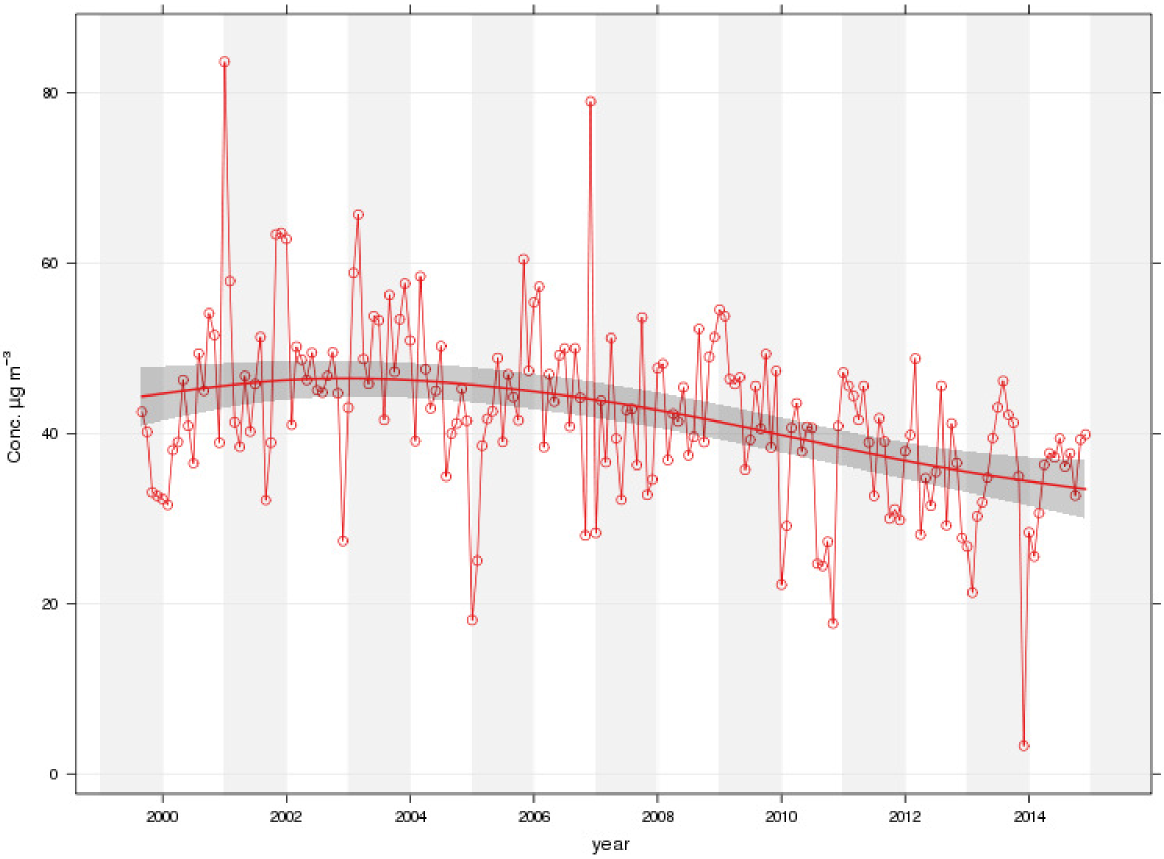
8.1.1 NO_x and NO_2 at Urban Background Sites

Historically, the longest-running urban background site in Scotland to have measured NOx concentrations was the former Glasgow City Chambers site (in operation from 1987 to 2012). This closed before the start of 2014 so is not discussed here. For information on trends at Glasgow City Chambers, please see earlier reports in this series, available from http://www.scottishairquality.co.uk/news/reports?view=technical .

At the time of writing, the longest-running urban background NOx monitoring site in Scotland is Aberdeen, Errol Place (in operation from late 1999 onwards). This site is also part of the UK's national air quality monitoring network (the Automatic Urban and Rural Network or AURN), in which it is referred to simply as "Aberdeen".

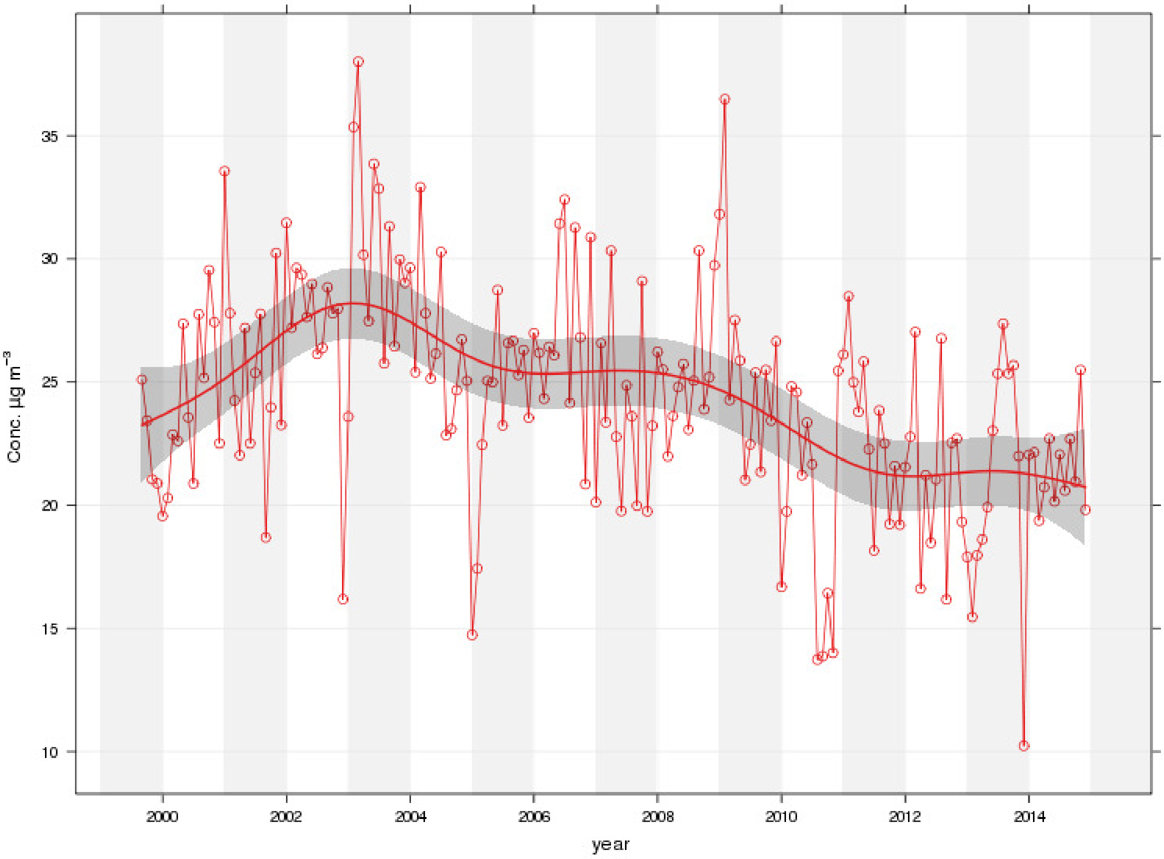
Error! Reference source not found. uses a smoothed trend plot to illustrate the variation in measured annual mean NO_x concentrations at Aberdeen Errol Place, from 1999 to 2014. **Error! Reference source not found.** shows that NOx concentrations at this site increased slightly in its earlier years of operation but have shown a general decrease since 2002.

Figure 8.1 Smoothed Trend Plot of NOx Concentration at Aberdeen, Errol Place: 1999 – 2014



Error! Reference source not found. shows a smoothed trend plot for nitrogen dioxide at the same site and over the same period. (Please note these graphs are plotted on different scales, because concentrations of total NOx are higher than those of NO_2.) The pattern for NO_2 is in some respects similar to that observed for NOx, in that it peaks around 2002 with a subsequent decrease: however, NO_2 appears to show more variation.

Figure 8.2 Smoothed Trend Plot of NO_2 Concentration at Aberdeen Errol Place 1999 – 2014



The Openair Theil-Sen function has been used to quantify trends in NO_x and NO_2 in more recent years, when a larger number of sites were operating. Three urban non-roadside sites have been monitoring NOx since 2004 or earlier; Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth. Aberdeen Errol Place and Edinburgh St Leonards are classified as 'urban background', while Grangemouth is an 'urban industrial' site.

Trends in NO_x and NO_2 are shown in **Error! Reference source not found.** and **Error! Reference source not found.** respectively, over the period from 2004 to 2014. In these plots the trend line is shown by a solid red line, with 95% confidence intervals for the trend shown by dotted red lines. The trend is given at the top of the plot in green, with confidence intervals shown in square brackets. The trend is given as units (i.e. µg m^{-3}) per year, over the period shown. This may be followed by a number of stars, with * indicating that the trend is statistically significant at the 0.05 level, ** indicating significance at the 0.01 level and *** indicating significance at the 0.001 level. The symbol + indicates that the trend is significant at the 0.1 level.

All three sites show a negative trend (i.e. decreasing NO_x) in **Error! Reference source not found.**. The actual decrease year-on-year is small; however, the trend is statistically highly significant (at the 0.001 level) at Aberdeen Errol Place and Edinburgh St Leonards (though not at Grangemouth).

In the case of NO_2 (**Error! Reference source not found.**), all sites again show a slight negative trend, though the year-on-year decrease is even smaller than for total NOx. Again, Aberdeen Errol Place and Edinburgh St Leonards show statistically significant negative trends, though they are weaker and, in the case of Edinburgh St Leonards, less significant for NO_2 than for NO_x.

Figure **8.3 Trends in NOx Concentration at Three Long-running Urban Non-Roadside Sites, 2004-2014**

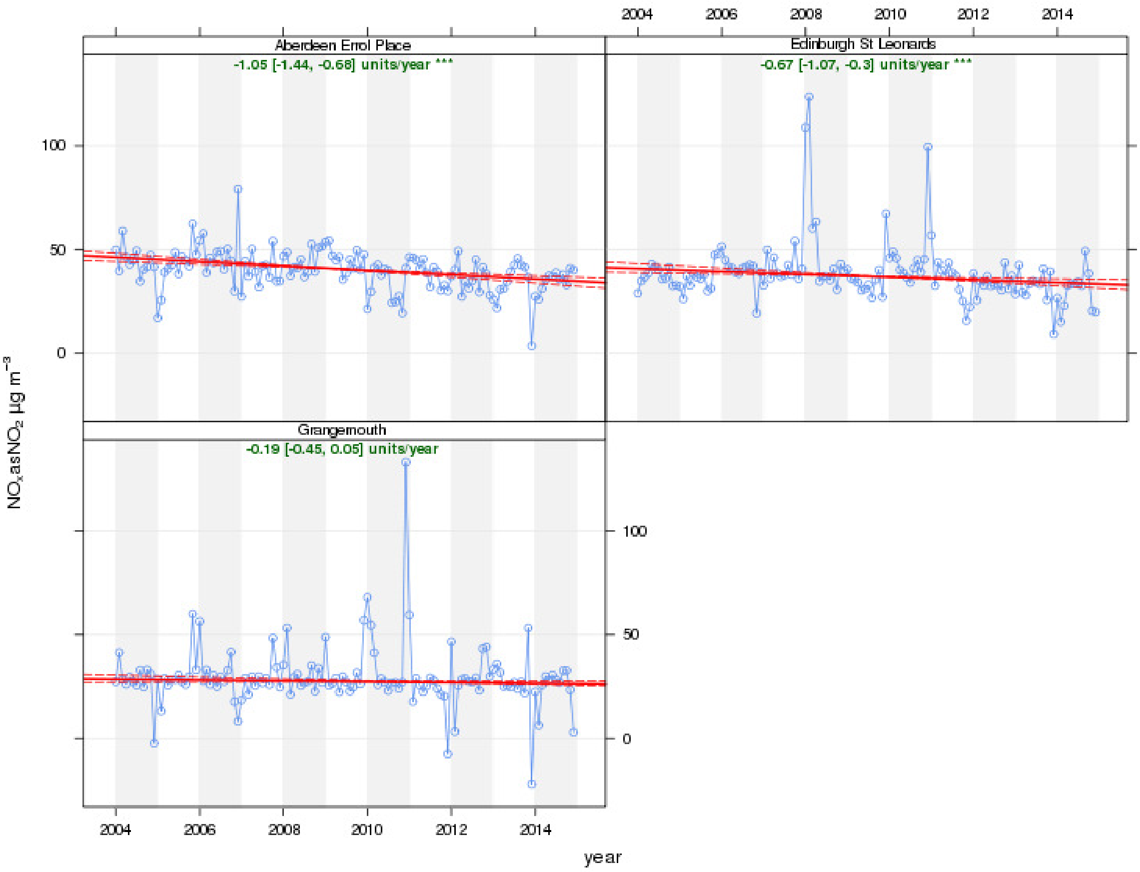
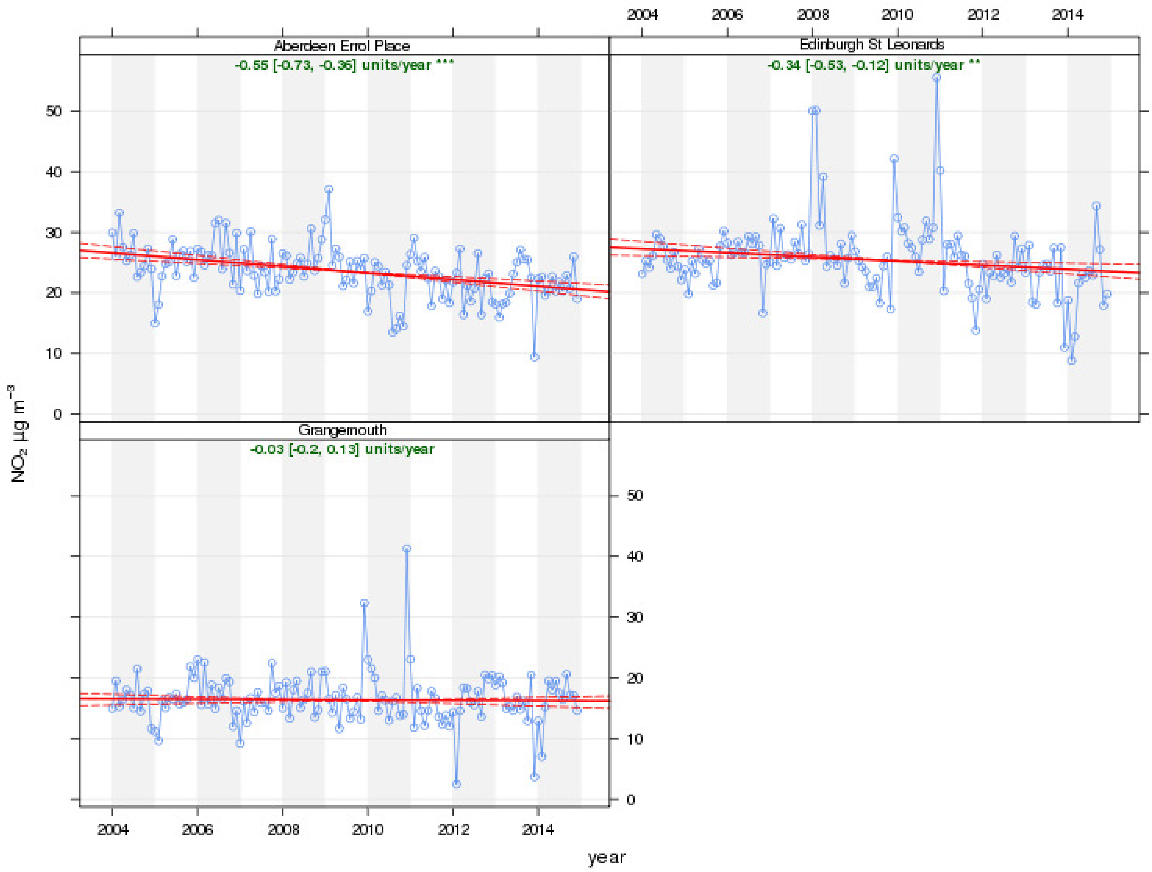


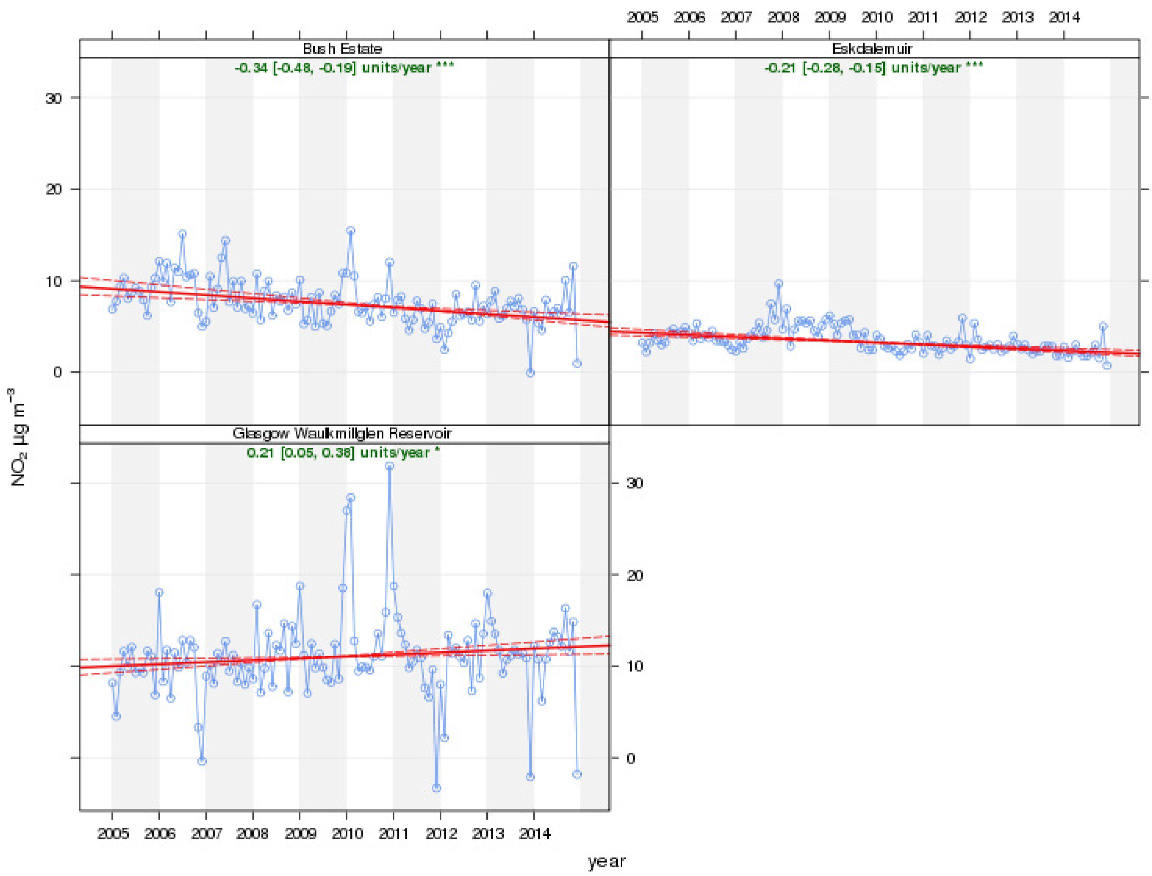
Figure 8.4 Trends in NO_2 Concentration at Three Long-running Urban Non-Roadside Sites, 2004-2014



8.1.2 NO_2 at Rural Sites

Three long-running rural sites have monitored oxides of nitrogen since 2005 or earlier: Bush Estate (to the south of Edinburgh close to the Pentland Hills Regional Park), Eskdalemuir and Glasgow Waulkmillglen Reservoir. **Error! Reference source not found.** shows trends in NO_2 concentration at these sites. (We have not plotted NOx in this case as these rural sites are well away from sources of NOx – therefore most of the NOx measured at these sites is likely to be NO_2). While the sites at Bush Estate and Eskdalemuir show small but highly significant downward trends, this is not the case for Glasgow Waulkmillglen Reservoir, where – by contrast - concentrations are increasing.

Figure 8.5 Trends in NO_2 Concentration at Three Rural Sites, 2005 – 2014



8.1.3 NO_x and NO_2 at Traffic-related Urban Sites

Error! Reference source not found. and **Error! Reference source not found.** show smoothed trend plots of NO_x and NO_2 concentration respectively, at Scotland's longest running traffic-related urban site, Glasgow Kerbside. This site began monitoring NOx in 1997 and is still doing so. There is considerable fluctuation in NO_x at this site, but some indication of an overall downward trend. By contrast, in the case of NO_2, there is no such apparent downward trend over this period.

Figure 8.6 Smoothed Trend Plot of NOx Concentration at Glasgow Kerbside: 1997 – 2014

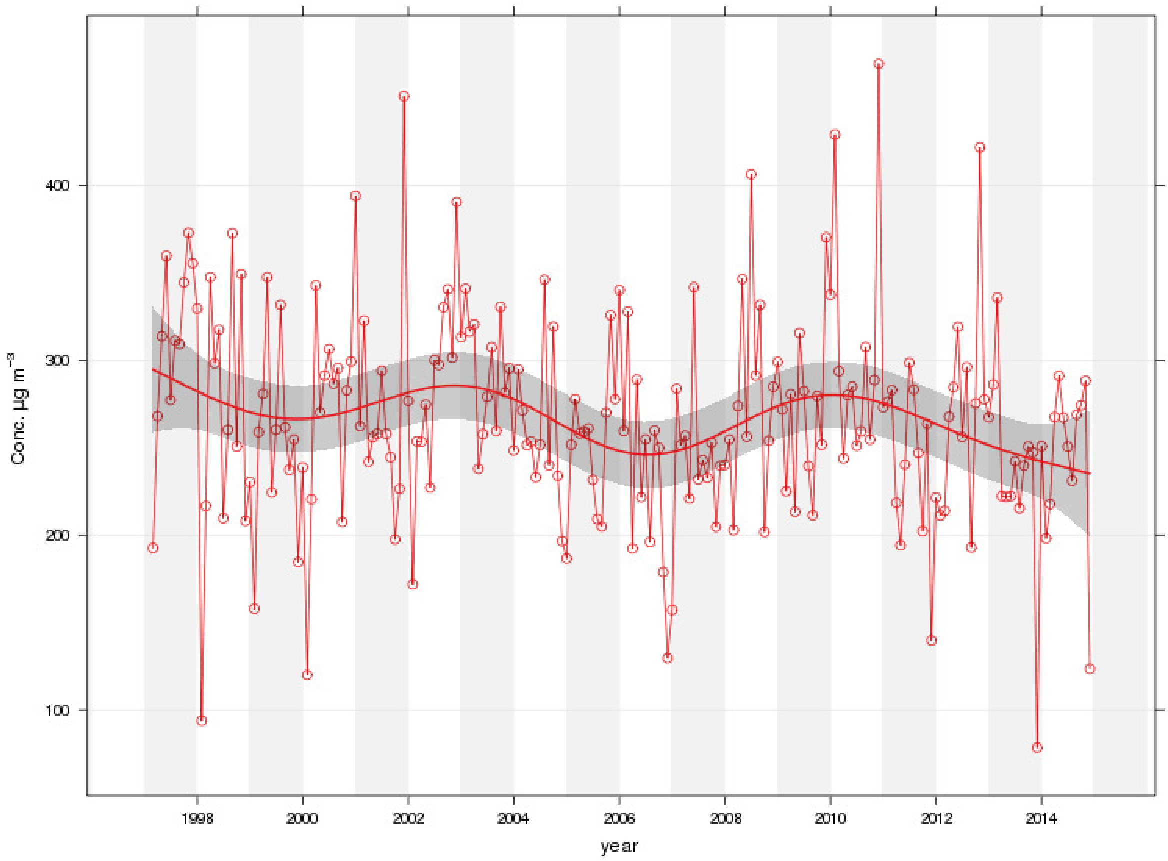
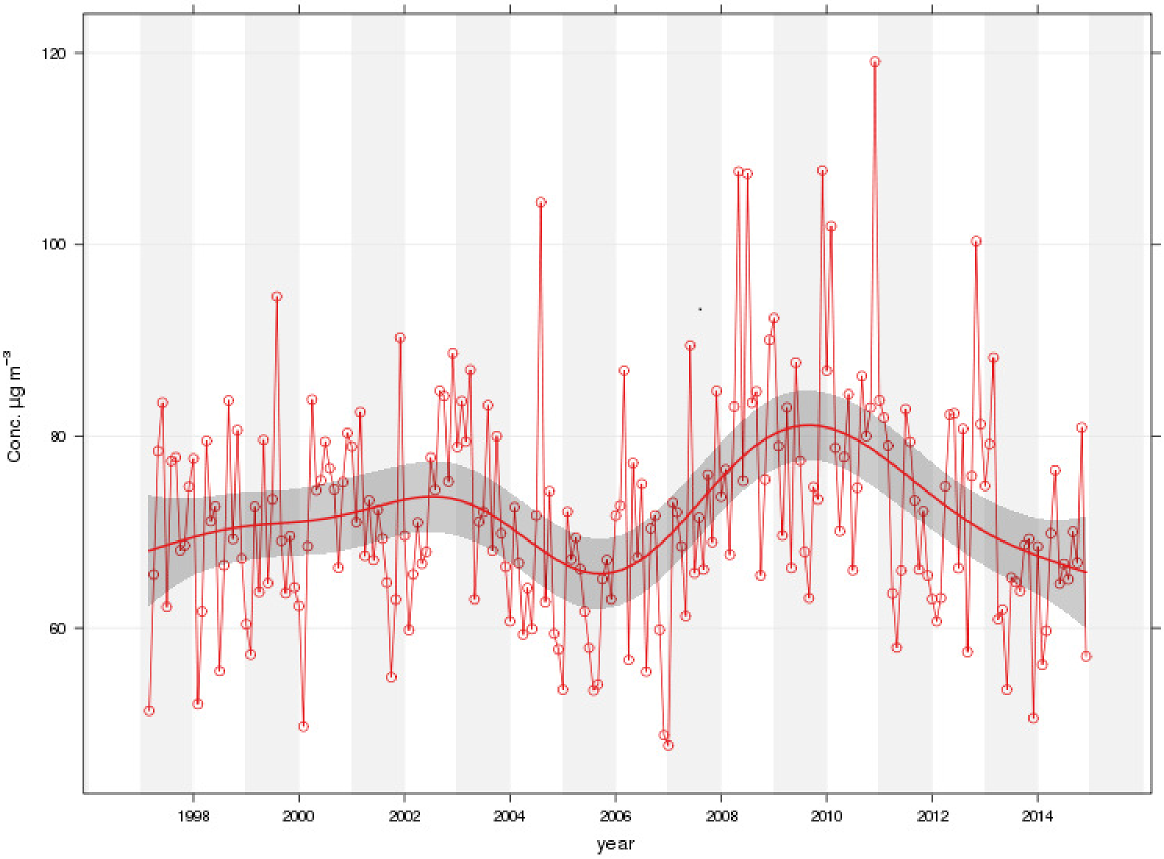


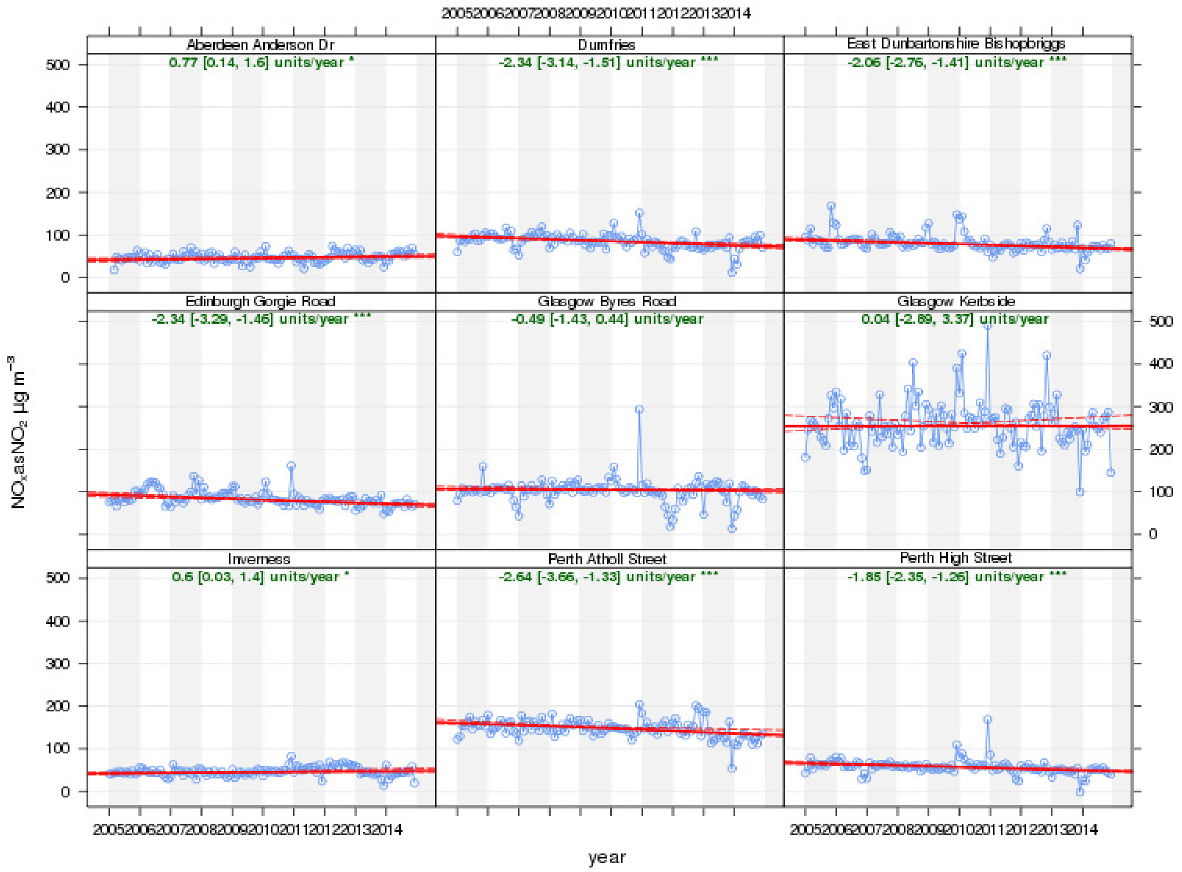
Figure 8.7 Smoothed Trend Plot of NO_2 Concentration at Glasgow Kerbside: 1997 – 2014



As in the case of the urban non-roadside sites, the Openair Theil-Sen function has been used quantify trends in NO_x and NO_2 in more recent years, when more sites were operating.

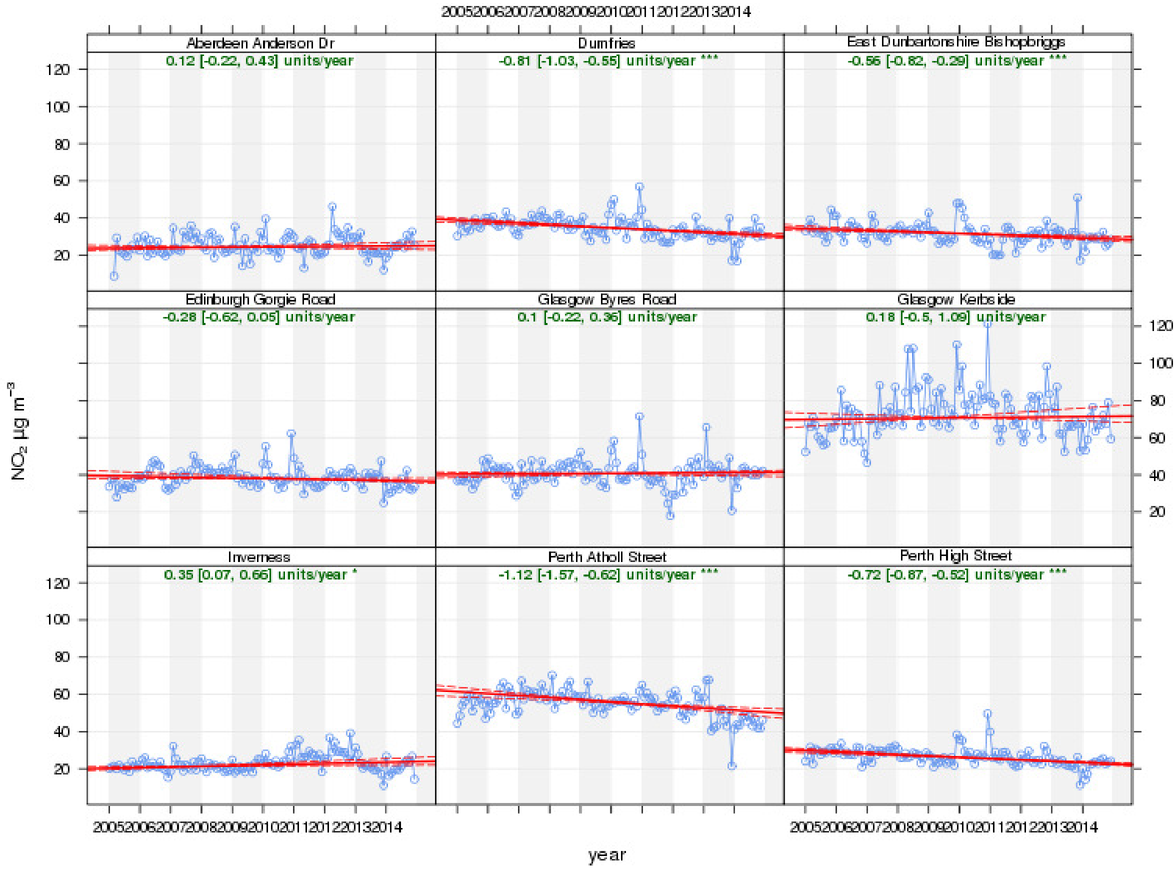
Error! Reference source not found. and **Error! Reference source not found.** show trends in NO_x and NO_2 respectively for a subset of nine long-running sites at urban traffic locations. These sites are: Aberdeen Anderson Drive, Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road, Glasgow Byres Road, Glasgow Kerbside, Inverness, Perth Atholl Street and Perth High Street), all of which have been in operation since 2004 or earlier. Five of the sites show a downward trend in NO_x (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road and both the Perth sites). However, Glasgow Byres Road and Glasgow Kerbside show no trend, and both Aberdeen Anderson Drive and Inverness show slight but significant upward trends.

Figure 8.8 Trends in NOx Concentration at Nine Long-Running Urban Traffic sites: 2005 – 2014



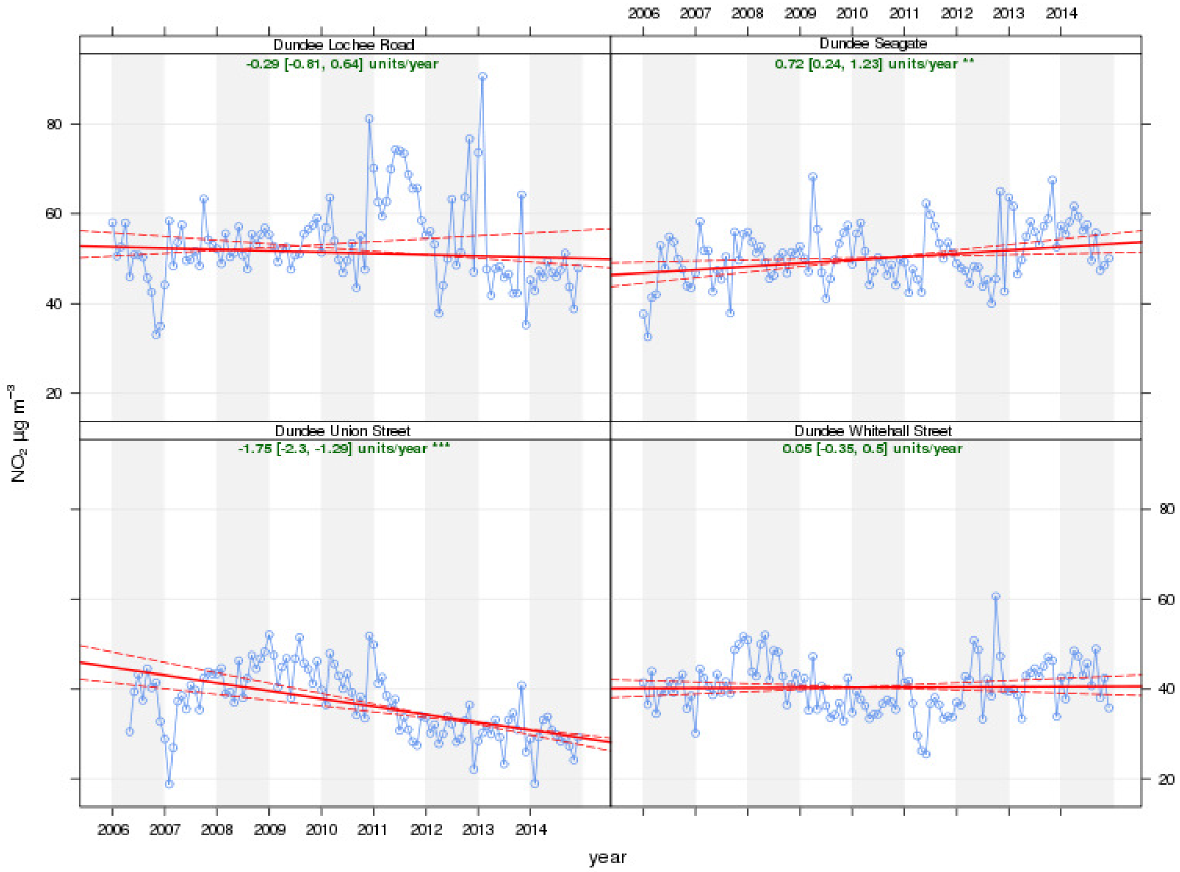
In the case of NO_2, there is more between-site variation in trends. Four of the sites (Dumfries, East Dunbartonshire Bishopbriggs, Perth Atholl Street and Perth High Street) show statistically significant downward trends. Inverness shows a small but statistically significant upward trend and the remaining four show no significant trend at all. This is similar to observations in the previous year's report: it may indicate that trends in concentrations of this pollutant depend greatly on conditions at the various sites.

Figure 8.9 Trends in NO_2 Concentration at Nine Long-Running Urban Traffic sites: 2005 – 2014



This may be illustrated by data from Dundee. Four urban traffic monitoring sites in Dundee have been measuring NO_2 since 2006. These are Dundee Lochee Road, Dundee Seagate, Dundee Union Street and Dundee Whitehall Street, all shown in **Error! Reference source not found.**. Even though all these sites are at roadside locations, and in the same city, they show different trends in NO_2 concentration over the period 2006 to 2014. There is a statistically significant upward trend at Dundee Seagate, a highly significant downward trend at Dundee Union Street, and no significant trend at the other two.

Figure 8.10 Example: Trends in NO_2 Concentration at Four Urban Traffic sites in Dundee, 2006 – 2014



8.2 Particulate Matter

This pollutant is of particular interest because:

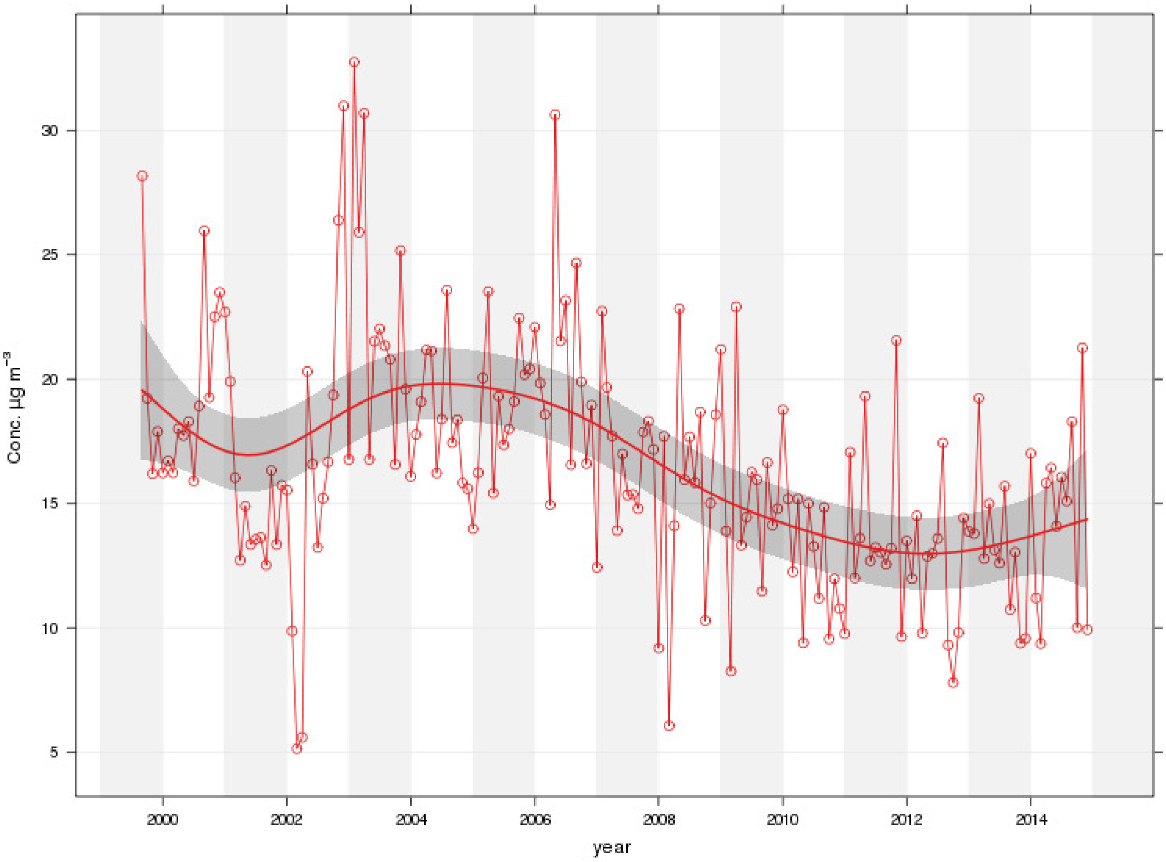
- Scotland has adopted an annual mean PM_{10} objective of 18 µg m^{-3}, which is more stringent than the objective of 40 µg m^{-3} adopted in the rest of the UK.
- Scientists do not believe that there is actually a safe level of this pollutant in terms of human health effects.

Many of Scotland's monitoring sites use the Tapered Element Oscillating Microbalance (TEOM) to monitor PM_{10}. For the reasons discussed in Section 4, it is necessary to correct TEOM data for possible evaporation of the volatile component (due to the high operating temperature of the TEOM, necessary to prevent condensation on the filter). For years up to and including 2008 the conventional way of doing this was to apply a factor of 1.3 to the data, and the data presented here for those years have been adjusted in this way. However, in 2009 a better correction method became available: the King's College Volatile Correction Model (VCM), which can be found at http://www.volatile-correction-model.info/ . This model uses measurements from nearby FDMS-TEOM instruments (which measure both the volatile and non-volatile fraction) to calculate and apply a correction to the daily or hourly dataset. This is now the recommended method, and has been used for the data presented here for years 2009 onwards, from sites where the TEOM is used.

8.2.1 PM_{10} at Urban Background Sites

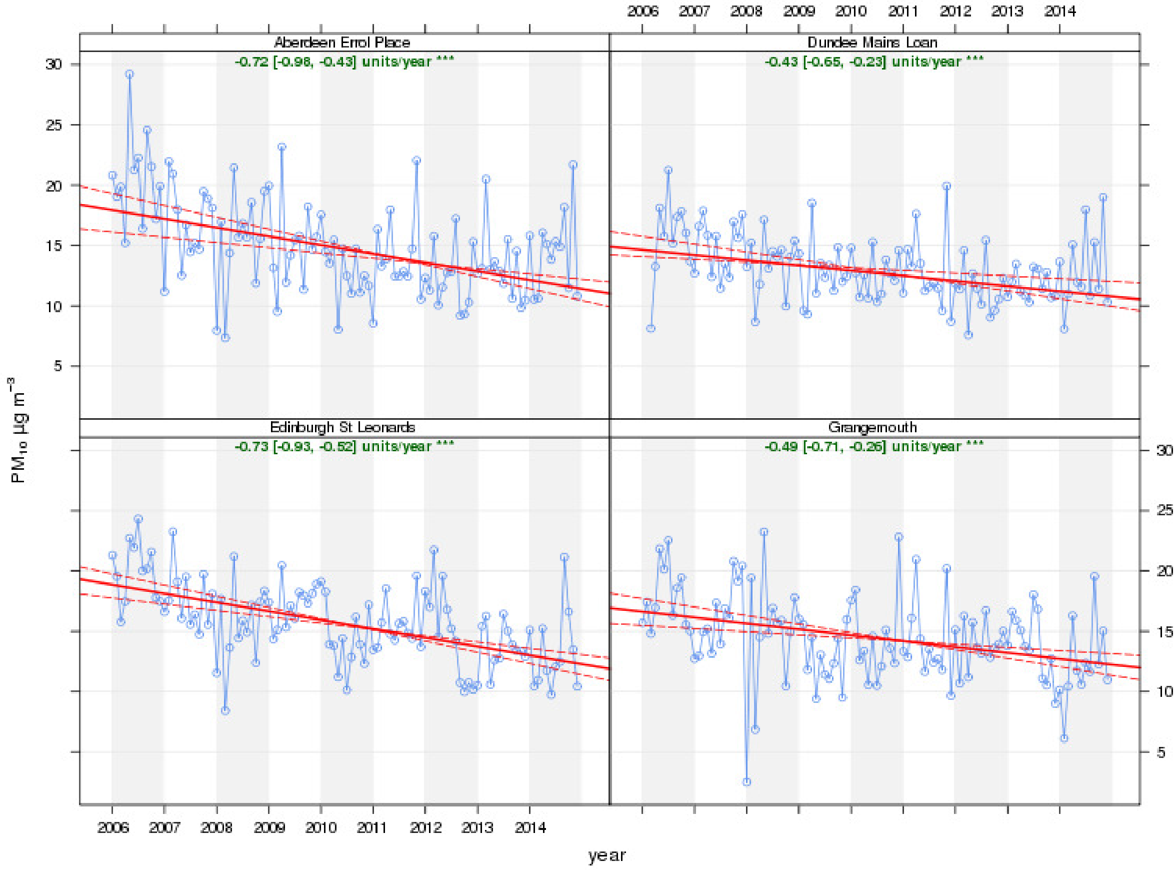
The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place, which has been measuring this parameter since late 1999. A smoothed trend plot of de-seasonalised monthly mean PM_{10} concentrations at this site is shown in **Error! Reference source not found.**. This shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013. There is some indication of a recent small up-turn.

Figure 8.11 Smoothed Trend Plot of PM_{10} Concentration at Aberdeen Errol Place: 1999 - 2014.



Four urban non-roadside sites in Scotland have been monitoring PM_{10} since 2006 or earlier. These are Aberdeen Errol Place (TEOM, converted to FDMS in 2009), Dundee Mains Loan (TEOM, data VCM corrected) Edinburgh St Leonards (FDMS since 2007), and the urban industrial site Grangemouth (FDMS since 2009). **Error! Reference source not found.** shows trends in de-seasonalised monthly mean PM_{10} at this subset of long-running sites. All four sites show a negative trend, significant at the 0.001 level (and strongest for Edinburgh St Leonard).

Figure 8.12 Trends in PM_{10} Concentration at Four Long-Running Urban Non-Roadside sites, 2006 – 2014



8.2.2 PM_{10} at Urban Traffic Sites

By far the longest-running traffic-related PM_{10} monitoring site in Scotland is Glasgow Kerbside, which has been monitoring PM_{10} since early 1997. **Error! Reference source not found.** shows a smoothed trend plot of de-seasonalised monthly mean PM_{10} at this site. Although concentrations are lower in recent years than in the late 1990s, the decrease has not been consistent.

Trends in de-seasonalised monthly mean PM_{10} concentrations for seven traffic-related sites in operation since 2005 or earlier are shown in **Error! Reference source not found.**. These are the long-running Aberdeen Anderson Drive, Aberdeen Union Street, East Dunbartonshire Bishopbriggs, Glasgow Byres Road, Glasgow Kerbside, Perth Atholl Street and Perth High Street. All sites show statistically significant downward trends, significant at the 0.001 level in all seven cases. The trends indicate that PM_{10} is decreasing year on year at these roadside sites.

The average PM_{10} concentration for all traffic-related sites in 2014 was 17 µg m^{-3}: this is within the Scottish AQS Objective of 18 µg m^{-3}. However, not all of the sites met the objective, as discussed in Section 6.

Figure 8.13 Smoothed Trend Plot of PM_{10} at Glasgow Kerbside, 1997 – 2014

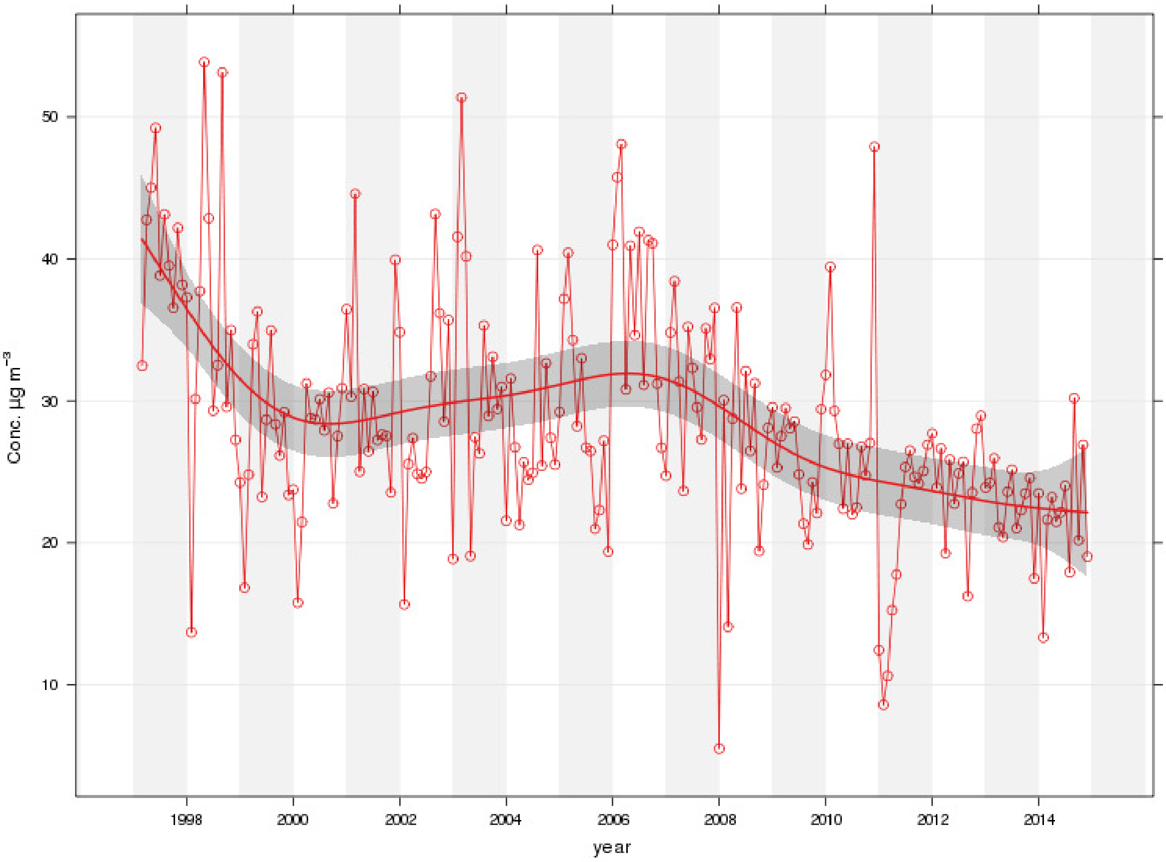
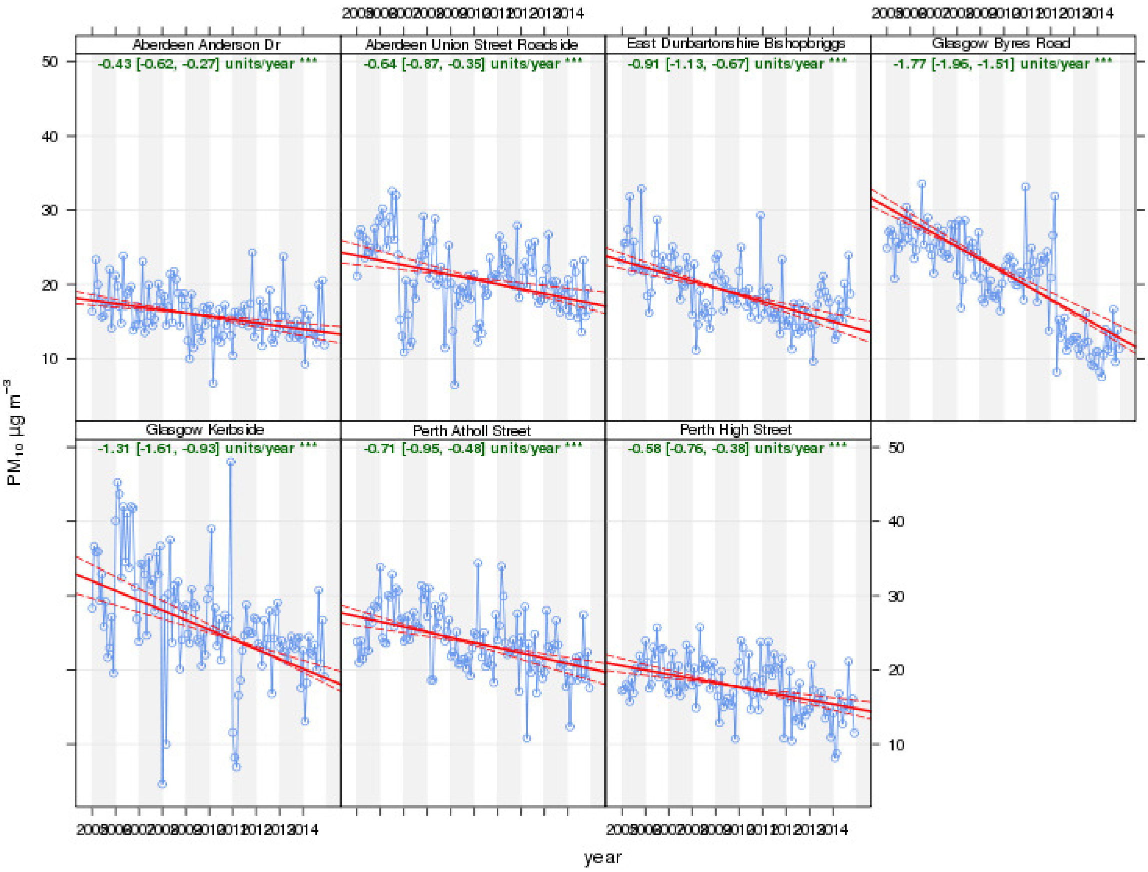


Figure 8.14 Trends in PM_{10} Concentration at Seven Long-Running Urban Traffic Sites, 2005 – 2014



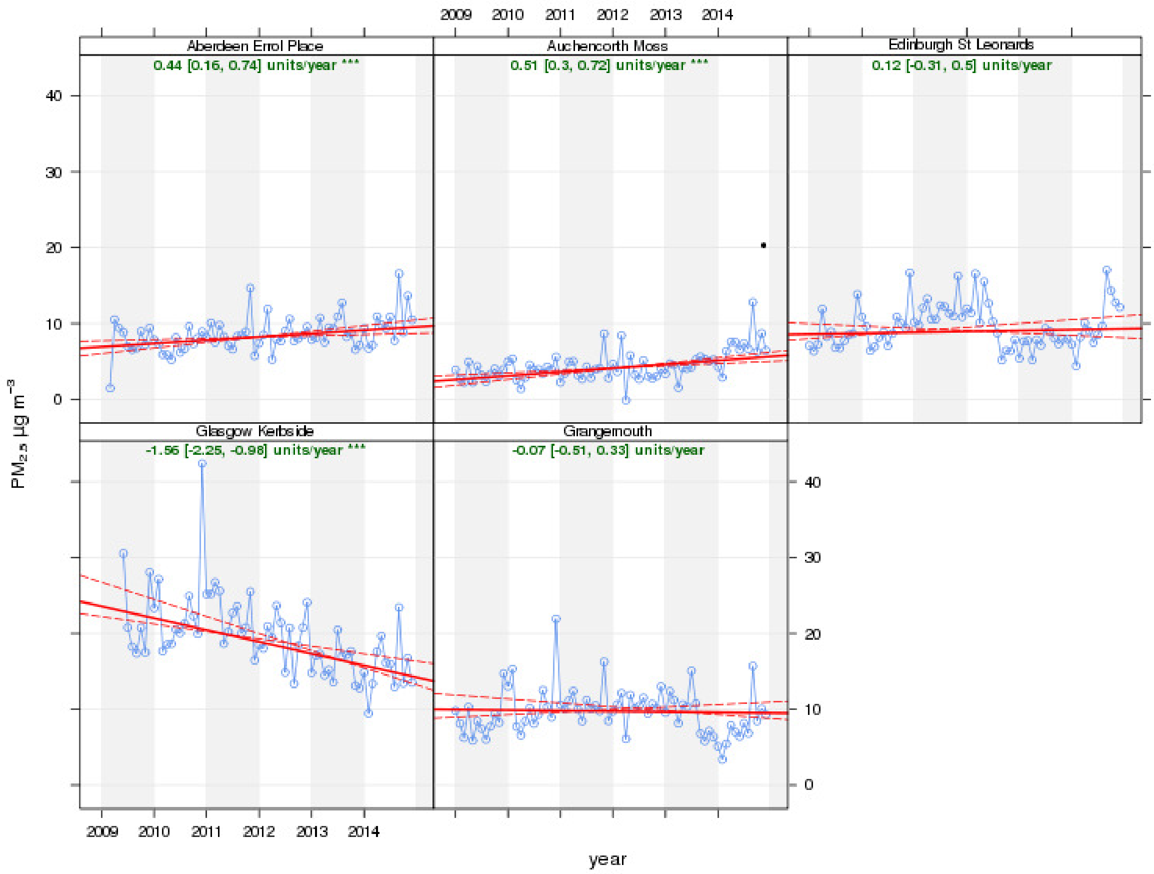
8.2.3 Particulate Matter as $PM_{2.5}$

In earlier years, most monitoring of particulate air pollution has been focused on the PM_{10} size fraction. However, the finer fractions such as $PM_{2.5}$ are becoming of increasing interest in terms of health effects. Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. They may also carry harmful compounds, absorbed on their surfaces, into the lungs.

There are still relatively few monitoring sites measuring $PM_{2.5}$ compared with the number monitoring PM_{10}. However, by 2014 there were five sites with at least five consecutive years of $PM_{2.5}$ data (the minimum considered necessary for assessment of long-term trends). These five sites are as follows: Aberdeen Errol Place (urban background), Auchencorth Moss (rural), Edinburgh St Leonards (urban background), Glasgow Kerbside (urban traffic) and Grangemouth (urban industrial). (A sixth site at Inverness uses the Partisol – a gravimetric sampler that takes daily measurements: the data cannot therefore be used in Openair trend plots in the same way.) The trend plots are shown in **Error! Reference source not found.**.

In contrast to PM_{10}, for which concentrations at most long-running sites show a downward trend, in the case of $PM_{2.5}$ the situation appears to vary more from site to site. In particular, two of the sites (Aberdeen Errol Place and the rural Auchencorth Moss site) show highly statistically significant upward trends in this particulate size fraction, since 2009.

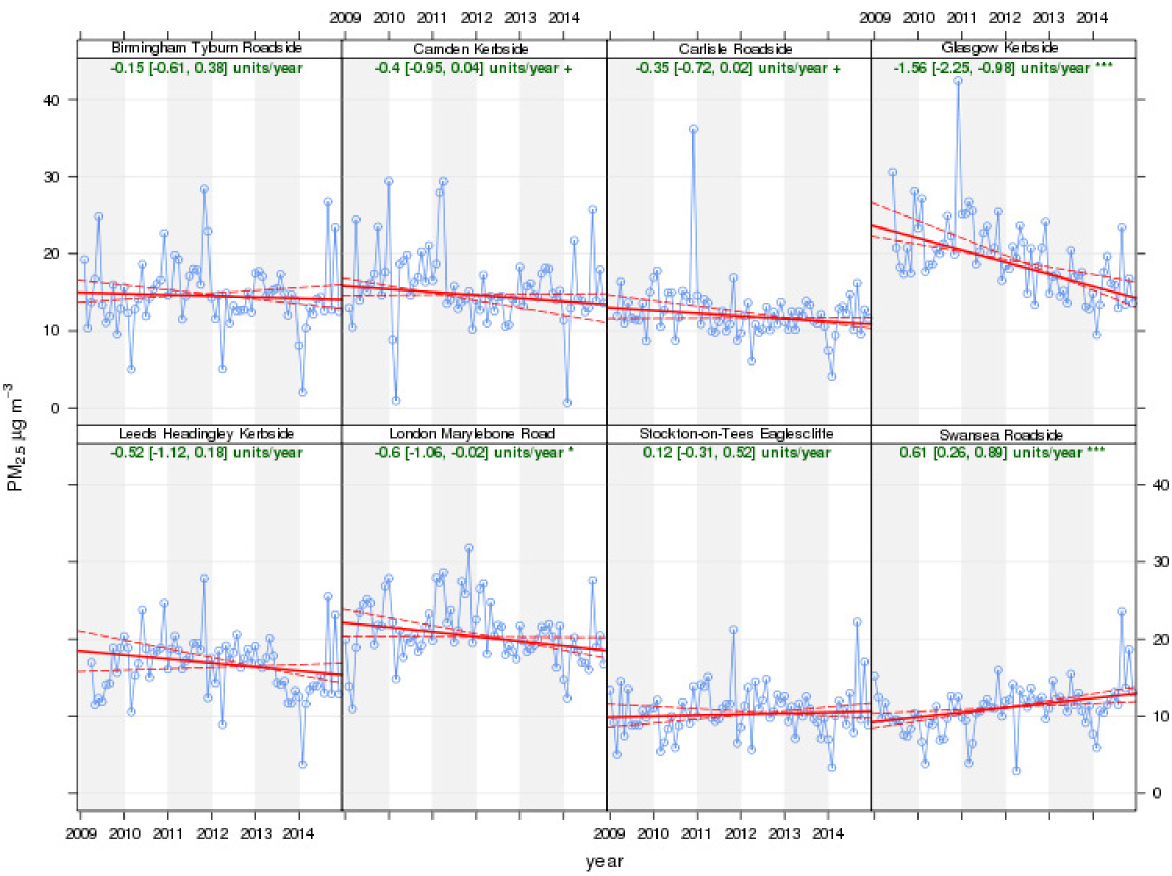
Figure 8.15 Trends in $PM_{2.5}$ Concentration at Five Long-Running Monitoring Sites, 2009 – 2014



Only Glasgow Kerbside shows a clear and statistically significant downward trend; as highlighted in the 2013 report, although the trend is significant at the 0.01 level, most of the decrease appears to have occurred since the start of 2011.

By comparing the trend at Glasgow Kerbside with that at other similar monitoring sites, it may be possible to tell if the downward trend is typical. Since Glasgow Kerbside is the only site of this classification that has monitored $PM_{2.5}$ in Scotland over this period, it is necessary to look elsewhere in the UK to find sites for comparison. **Error! Reference source not found.** compares the $PM_{2.5}$ trend at Glasgow Kerbside with those observed at seven other "urban traffic" air quality monitoring sites in cities in England and Wales. On this basis, it appears that the downward trend at Glasgow Kerbside is ***not*** typical. Most of the selected sites either show no significant trend in $PM_{2.5}$ concentration, or a trend significant only at the 0.1 level. There is also considerable variation from site to site. This may reflect differing trends in relevant factors influencing localised $PM_{2.5}$ concentration, such as traffic flow.

Figure 8.16 Comparison of Trends in $PM_{2.5}$ at Urban Traffic sites in Selected UK Cities, 2009-2014



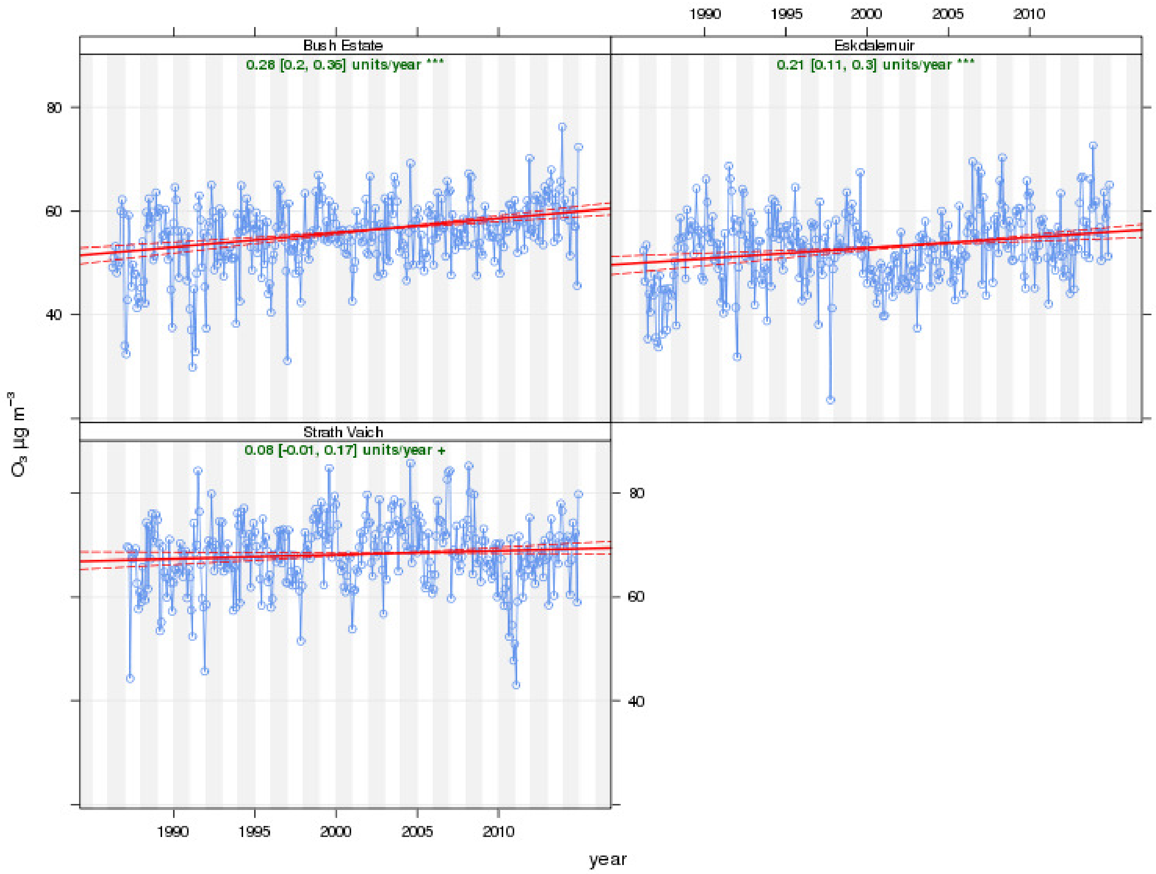
8.3 Ozone

8.3.1 Rural Ozone

Error! Reference source not found. shows trends in de-seasonalised monthly mean ozone (O_3) concentrations at the three long-running rural monitoring sites in Scotland. These sites have all been in operation since 1987: they are Bush Estate, Eskdalemuir and Strath Vaich. All three sites show a small but statistically significant upward trend in monthly mean rural ozone concentrations over this period. For Bush Estate and Eskdalemuir this trend is statistically significant at the 0.001 level. The charts also show considerable fluctuation; this may reflect the fact that ozone is formed by reactions involving other pollutant gases, in the presence of sunlight. Thus, ozone concentrations depend substantially on weather conditions. There is also evidence that the "hemispheric background" concentration of O_3 has increased since the 1950s due to the contribution from human activities.[9]

[9] See the APIS webpage "Ozone" at http://www.apis.ac.uk/overview/pollutants/overview_O3.htm

Figure 8-17 Trends in O_3 Concentrations at Long-Running Rural Sites, 1987 – 2014



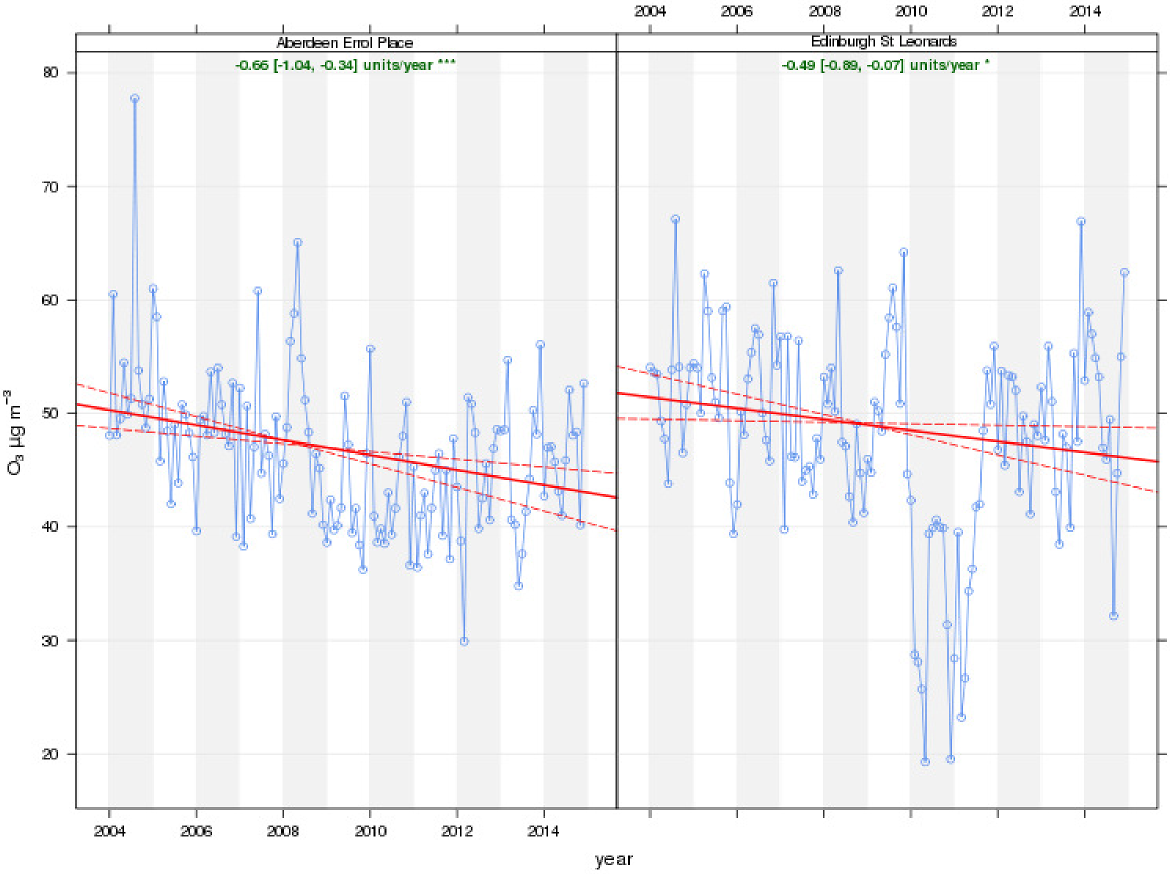
8.3.2 Urban Background Ozone

Error! Reference source not found. shows trends in de-seasonalised monthly mean ozone concentrations at the two Scottish urban background monitoring sites which currently monitor ozone, and have done so since 2004 or earlier: Edinburgh St Leonards and Aberdeen Errol Place.

In contrast to the pattern observed at rural sites, both these urban background sites show *decreasing* trends in ozone concentration in the years since 2004. The trends are statistically highly significant at both sites.

At Edinburgh St Leonards there is a noticeable dip in measured ozone concentrations throughout 2010 and into 2011. The reason for this is unknown and investigation of these low data has confirmed that the analysers were operating well throughout 2010 – 2011. Since no reason can be found to discard the data, they must be assumed to be genuine.

Figure 8.18 Trends in O_3 Concentration at Two Long-Running Urban Background Sites, 2004 – 2014



9 Emissions of Pollutant Species

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

Within Scotland, SEPA collate the detailed information on emissions from industrial sources into the Scottish Pollution Release Inventory (SPRI); this includes emissions to water and soil as well as to air. Full details are available on the SEPA SPRI database:

http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

There is also a link to the SEPA SPRI website on the home page of www.scottishairquality.co.uk . The data from the SPRI form the basis of the industrial emission data for Scotland which are incorporated into the NAEI.

Information provided in Section 9.2 of this report on the main industrial emissions of NOx and PM in Scotland have been compiled from the information presented on SEPA's Scottish Pollution Release Inventory, with permission from SEPA.

9.1 NAEI data for Scotland

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

9.1.1 Scotland NOx Inventory by NFR Sector, 1990-2012

Table 9.1 and Figure 9.1 provide a summary of the NO_X emissions in Scotland by broad NFR sector categories. The detailed data are available in the report and website cited in the introduction to this Chapter.

Table 9.1 Scotland emissions of NO_X by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004
1A1 - Energy Industries	97	65	52	50	56	52	50	47	46
1A2 - Industrial Combustion	32	28	25	24	24	24	21	20	20
1A3 - Transport Sources	117	96	81	77	70	67	64	60	58
1A4 - Commercial, Domestic and Agricultural Combustion	26	25	24	24	22	22	20	19	18
1A5,1B,2,4,5,6 - Other	8	4	4	4	4	4	4	4	4
Total:	**280**	**218**	**186**	**178**	**177**	**169**	**159**	**150**	**146**

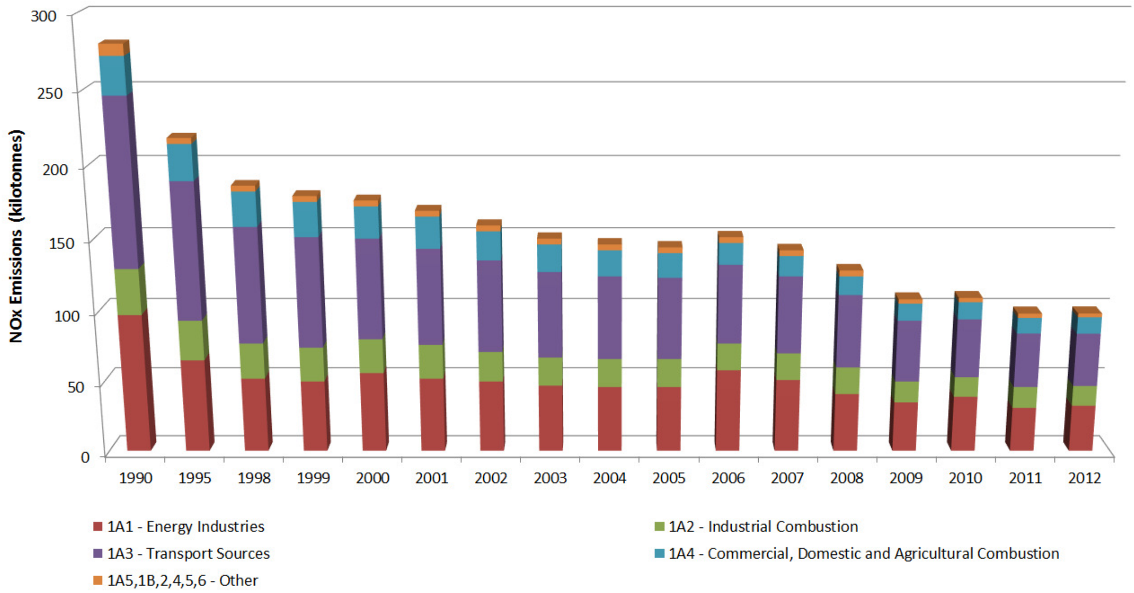
[10] Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2012 http://naei.defra.gov.uk/reports/reports?report_id=801

NFR Code	2005	2006	2007	2008	2009	2010	2011	2012	2012(%)
1A1 - Energy Industries	46	58	51	41	35	39	31	33	33%
1A2 - Industrial Combustion	20	19	19	19	15	14	15	14	14%
1A3 - Transport Sources	57	55	54	51	43	41	38	37	37%
1A4 - Commercial, Domestic and Agricultural Combustion	17	15	14	13	12	12	11	12	12%
1A5,1B,2,4,5,6 - Other	4	4	4	4	3	3	3	3	3%
Total:	**144**	**152**	**142**	**127**	**108**	**110**	**98**	**99**	**100%**

Units: kilotonnes

Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2012

Figure 9.1 Time series of Scotland NO_x emissions 1990-2012



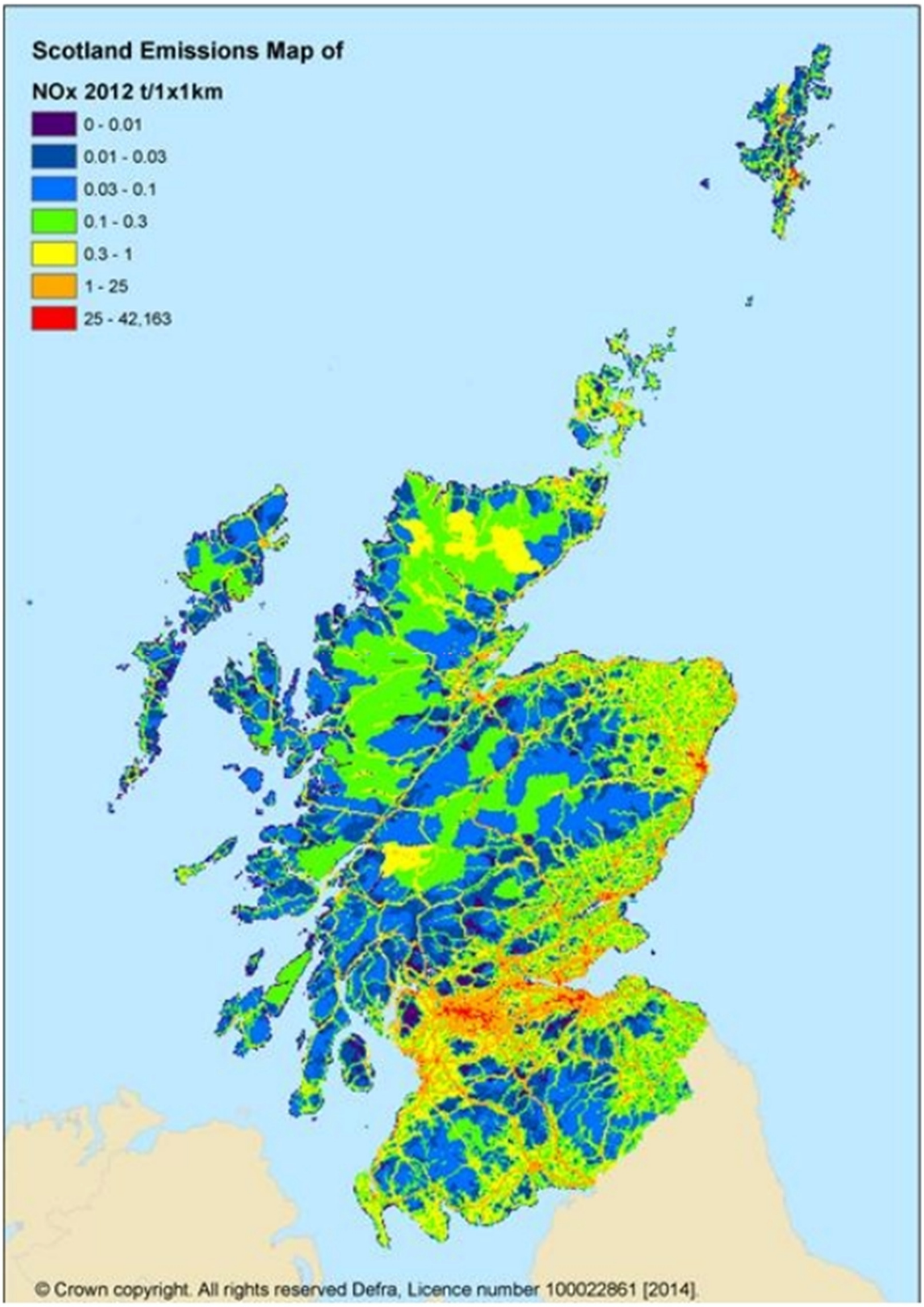
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2012

Scotland's NO_x emissions have declined by 65% since 1990 and in 2012 accounted for 9% of the UK total. 29% of these emissions stemmed from road transport combustion sources and 27% from power generation. These two sectors also represent the main sources of decline in NO_x emissions. The decline has mainly resulted from improvements in catalysts and the introduction of Euro Standards in vehicles, and the improvement in abatement technology and increase in renewables in power generation. *(Note that in the table and figure above, the sector 1A1 includes power generation, petroleum refining and other energy industries such as collieries and gas processing).*

Since 2009 the decreasing trend in NOx emissions appears to have slowed in all sectors with the exception of transport sources. As can be seen in figure 9.1 energy sources is shown to have increased in 2012 from 2011.

Figure 9.2 shows a map of Scotland's NO_X emissions in 2012.

Figure 9.2 Map of NO_X Emissions in Scotland, 2012



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2012

9.1.2 Scotland PM_{10} Inventory by NFR Sector, 1990 - 2012

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

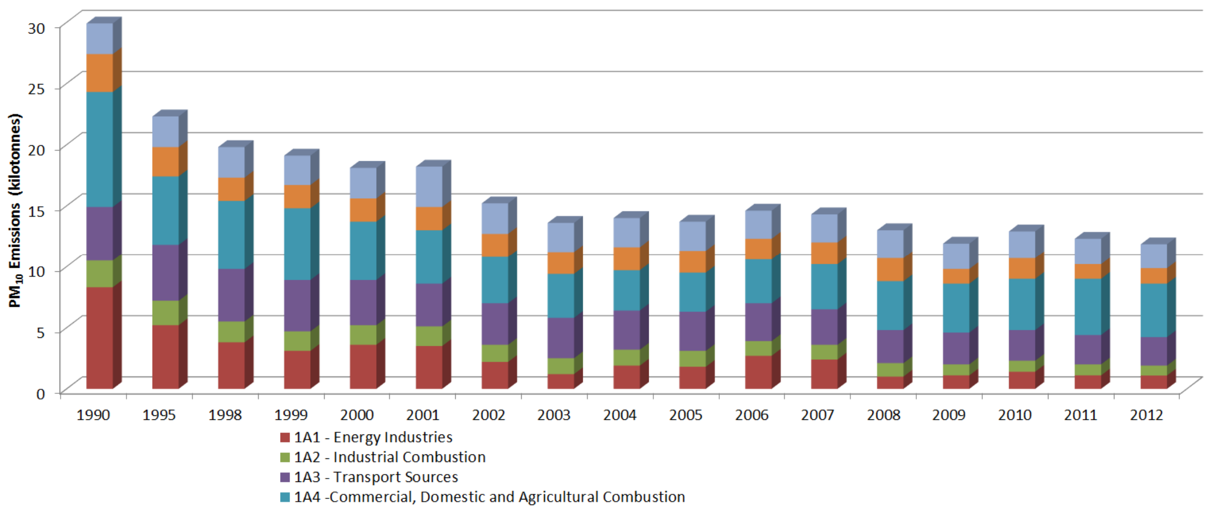
Table 9.2 Scotland's emissions of PM_{10} by NFR source sector

NFR Code	1990	1995	1998	1999	2000	2001	2002	2003	2004
1A1 - Energy Industries	8.3	5.2	3.8	3.1	3.6	3.5	2.2	1.2	1.9
1A2 - Industrial Combustion	2.2	2.0	1.7	1.6	1.6	1.6	1.4	1.3	1.3
1A3 - Transport Sources	4.4	4.6	4.3	4.2	3.7	3.5	3.4	3.3	3.2
1A4 -Commercial, Domestic and Agricultural Combustion	9.4	5.6	5.6	5.9	4.8	4.4	3.8	3.6	3.3
1B & 2 - Industrial Processes	3.1	2.4	1.9	1.9	1.9	1.9	1.9	1.8	1.9
1A5,3,4,6,7 - Other	2.5	2.5	2.5	2.4	2.5	3.3	2.5	2.4	2.4
Total:	**29.9**	**22.2**	**19.8**	**19.0**	**18.0**	**18.2**	**15.2**	**13.6**	**14.0**

NFR Code	2005	2006	2007	2008	2009	2010	2011	2012	2012 (%)
1A1 - Energy Industries	1.8	2.7	2.4	1.0	1.1	1.4	1.1	1.1	9%
1A2 - Industrial Combustion	1.3	1.2	1.2	1.1	0.9	0.9	0.9	0.8	7%
1A3 - Transport Sources	3.2	3.1	2.9	2.7	2.6	2.5	2.4	2.3	19%
1A4 -Commercial, Domestic and Agricultural Combustion	3.2	3.6	3.7	4.0	4.0	4.2	4.6	4.4	37%
1B & 2 - Industrial Processes	1.8	1.7	1.8	1.9	1.2	1.7	1.2	1.3	11%
1A5,3,4,6,7 - Other	2.4	2.3	2.3	2.3	2.1	2.2	2.1	2.0	17%
Total:	**13.6**	**14.5**	**14.2**	**13.0**	**11.9**	**12.9**	**12.3**	**11.8**	**100%**

Units: kilotonnes
Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2012

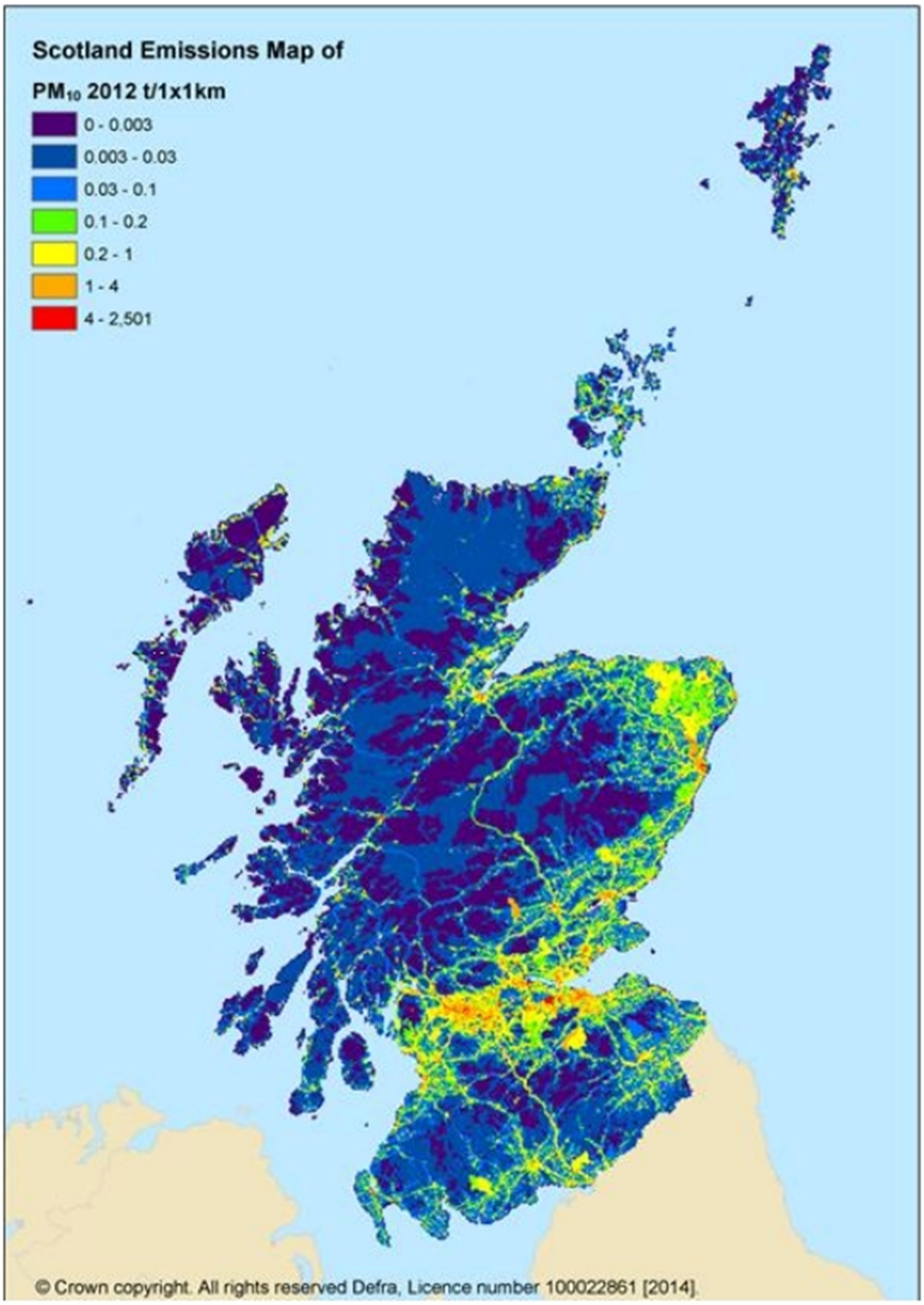
Figure 9.3 Time series of Scotland's PM_{10} emissions 1990-2012



Emissions of PM_{10} have declined by 59% since 1990 and in 2012 accounted for 10% of the UK total. At 37%, emissions from commercial, domestic and agricultural combustion were the main source of PM_{10} in 2012. Emissions from power generation account for 25% of total emissions in 1990 but have significantly reduced to 8% in 2012. This has been primarily attributed to the move from coal fired to gas energy generation, which has negligible particulate matter emissions.

Figure 9.4 shows a map of PM10 emission in Scotland for 2012.

Figure 9.4 Map of PM_{10} Emissions in Scotland, 2012



Source - Air Quality Pollutant Inventories, for England, Scotland, Wales and Northern Ireland: 1990 – 2011

10 Conclusions

Website

Since the new website launched on 26th March 2014 it has been developed further with new features to enhance the information it provides. These enhancements were launched at the annual air quality seminar on the 26th March 2015.

Education webpages and Packages

Interactive education packages have been developed through the creation of two sections which form part of Air Quality in Scotland. The first education webpage 'Air Pollution Detectives' was created for primary school pupils in the primary 5-7 age range. The second webpage "Clear the Air" ()launch in 2014) was developed in partnership with a number of schools for secondary school pupils in the S1-S3 age range.

The Clear the Air monitoring pack has been designed to give pupils hands on experience with air quality monitoring equipment together with a better understanding of the underlying science. The package encourages pupils to discuss the results and the factors influencing the air quality measured within the area. The Clear the Air package is supported by a teachers pack including notes to supplement the monitoring equipment and webinars to help introduce the concept of local air quality and conduct the monitoring.

Website and App Updates

New air pollution forecasts have been developed for Scotland allowing a greater level of detail than previously available. The key enhanced features are:

- New air pollution forecasts for individual local authorities
- New 5 day forecasts now available
- Additional text commentaries from the Ricardo-AEA duty forecaster for today, tomorrow and a general outlook added to the website

The existing Know & Respond alert service has been updated alongside the enhanced air pollution forecasts shown on the website to move from regional to local authority based pollution forecast alerts.

The Air Quality in Scotland app launched has also been updated to include the updated local authority forecasts and Know & Respond alerts.

The website site graphing functionality has been upgraded and enhanced. This enables the user to customise the date range selection, provides them with additional data and also more download options.

Additional to this the data section has been enhanced with a new date selector providing users with the ability to view the maximum levels measured at each monitoring site for previous days from the Google map.

Automatic Monitoring Data 2014

Air pollution data for 88 automatic monitoring sites throughout Scotland are available in the database for all or part of 2014. 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 traceable to UK national calibration standards for the various pollutants.

The pattern of measured concentrations is similar to previous years in that where exceedances of the Scottish Air Quality Objectives occur, these are in areas where the relevant Local Authority has already declared, or is in the process of declaring an Air Quality Management Area (AQMA). At present, 14 local authorities in Scotland have declared a total of 32 AQMAs.

Nitrogen Dioxide

Nitrogen Dioxide (NO_2) data were collected from 82 sites utilising automatic monitoring during 2014. Data for 13 of these are only available for part of the year with the overall data capture less than 75%. These include sites which opened or closed during the year, sites which were closed for part of the year due to roadworks etc and sites with instrument problems.

Of the remaining 69 sites with more than 75% data capture, 10 of these (kerbside or roadside sites) exceeded the AQS Objective for the NO_2 annual mean (40 µg m^{-3}). The AQS Objective of not more than 18 exceedances of 200 µg m^{-3} for the hourly mean was not exceeded at any site.

Three sites with less than 75% data capture recorded average NO_2 concentrations in excess of the NO_2 annual average objective: Glasgow Byres Road with a data capture rate of 72%, South Lanarkshire Raith Interchange with a data capture rate of 28%, and South Lanarkshire Rutherglen with a data capture rate of 71%

The highest annual average concentrations were measured at Glasgow Kerbside, with a measured annual mean concentration of 68 µg m^{-3}. The greatest number of exceedances of the hourly mean objective was measured at Paisley Central Road with 17 exceedances.

Particulate matter

Gravimetric equivalent particulate matter PM_{10} data from 77 sites utilising automatic monitoring and the Partisol daily sampler. Of these sites, 19 have less than 75% data capture during 2014.

Of the 59 sites with 75% or greater data capture, 10 sites exceeded the Annual Average PM_{10} Objective of 18 µg m^{-3} and a further 5 equaled this Objective. Of these sites, Aberdeen Market St 2 also exceeded the Daily Objective of 50 µg m^{-3} not to be exceeded more than 7 times in a year.

The maximum PM_{10} annual mean concentration was measured at Aberdeen Market St 2 with a measured annual mean concentration of 26 µg m^{-3} and 21 exceedances of the daily mean objective.

Of the 18 sites with less than 75% data capture Glasgow Anderston equalled the objective, while Paisley Gordon St, Glasgow Kerbside, Edinburgh Queensferry, South Lanarkshire Raith Interchange, and South Lanarkshire Rutherglen measured average PM_{10} concentrations greater than the Annual Average PM_{10} Objective of 18 µg m^{-3}No site exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10} and the daily mean objective of no more than 35 exceedances of 50 µg m^{-3}.

For compliance with the EU Directive, three $PM_{2.5}$ urban background monitoring sites are required in Scotland. These have been established as part of the AURN in Edinburgh, Glasgow and Aberdeen. In addition, for research purposes, additional monitors have been installed at the kerbside site in Glasgow and at the rural site at Auchencorth Moss. Also, with support from the Scottish Government, the daily gravimetric monitoring of $PM_{2.5}$ continues at Inverness and Aberdeen City Council now monitors $PM_{2.5}$ at Aberdeen Union St. Data from nine sites in Scotland are therefore available for all or part of 2014.

Data capture rates of less than 75% were measured at Aberdeen Union St, Edinburgh St Leonards and Glasgow Kerbside. $PM_{2.5}$ concentrations in excess of the Scottish AQS Objective of 12 µg m^{-3} as an annual mean was measured at Glasgow Kerbside with a data capture rate of 61%.

The $PM_{2.5}/PM_{10}$ ratios calculated for each site for the years 2009 to 2014. The highest $PM_{2.5}/PM_{10}$ ratios during 2014 for sites with greater than 75% data capture was calculated at Aberdeen Errol Place and Glasgow Kerbside with calculated ratios of 0.69 and 0.70, respectively.

At the rural Auchencorth Moss site south of Edinburgh, both FDMS and Partisol analysers are operated for PM_{10} (and $PM_{2.5}$). Both methods measured similar annual average PM_{10} concentrations of 7 µg m^{-3} and 8 µg m^{-3}, respectively. No exceedances of the daily objective were measured at the two sites.

Carbon Monoxide

Carbon monoxide was monitored using automatic techniques at 2 sites (Edinburgh St Leonards and N Lanarkshire Croy) during 2014. All monitoring sites achieved the Air Quality Strategy Objective for this pollutant.

Sulphur Dioxide

Sulphur dioxide (SO_2) was monitored using automatic techniques at 12 sites during 2104. N Lanarkshire Cumbernauld was decommissioned on 01/05/2014 and N Lanarkshire Kirkshaws was commissioned on 28/06/14 and so data are only available for part of the year. Monitoring at Shetland Lerwick was suspended during 2014 due to building works and the commissioning of a new monitoring hut. All sites in Scotland met the requirements of the Air Quality Strategy for the 15 minute, 1-hour and 24-hour mean objectives SO_2 in 2014.

Ozone

Ozone (O_3) was monitored at 11 sites utilising automatic monitoring for 2014. 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 2014, the air quality objective of not more than 10 days with a maximum 8 hr running mean greater than 100 µg m^{-3} was exceeded at Strath Vaich. No sites with a data capture rate of less than 75% exceeded the Air Quality Objective. Monitoring at Shetland Lerwick was suspended during 2014 due to building works and the commissioning of a new monitoring hut.

Air Quality Mapping

NO_2 Maps for 2013

Maps show that there were no modelled exceedances of the Scottish annual mean NO_2 objective of 40 µg m^{-3} at background locations.

The Scotland-specific model predicted that the Scottish annual mean NO_2 air quality objective was exceeded along 99 road links (125 km of road). The majority of exceedances were predicted to occur in the Glasgow Urban area where exceedances were modelled for 68 road links (84 km of road). Overall exceedances of the Scottish annual mean NO_2 air quality objective were modelled in four of the six zones and agglomerations in Scotland. In each of the other three Scottish zones and agglomerations there were approximately 10 road links where exceedances of the Scottish annual mean NO_2 air quality objective were modelled, effecting 10-16 km of roads.

PM_{10} Maps for 2013

Exceedances of the Scottish annual mean PM_{10} objective of 18 µg m^{-3} were modelled at 19, 1 km^2 grid squares in Scotland. Fifteen grid squares were located in Central Scotland within an area around the junction of M8 and M9 and M8 in the direction of Livingstone.

The Scotland specific model has predicted similar exceedances in the annual mean PM_{10} concentration in this cluster of grid squares in previous years. Modelled concentrations in this area for 2012 were lower than the concentrations reported here for 2013, but modelled concentrations in 2011 were similar.

Further isolated exceedances were located in north-western side of Glasgow, Aberdeen, Wick and on the A6105 in the Scottish borders. The range of PM_{10} sources in these grid squares are quite diverse. On the whole the extent of the exceedance of the Scottish PM_{10} air quality objective was typically of the order of 1 to 2 µg m^{-3}, but was as high as 4 µg m^{-3} in one grid square.

Air Quality Trends

NO_2

In terms of concentrations of NOx the longest-running urban background monitoring site in Scotland is Aberdeen, Errol Place (in operation from late 1999 onwards). NOx concentrations at this site increased slightly in its earlier years of operation but have shown a general decrease since 2002. The pattern for NO_2 is in some respects similar to that observed for NOx, in that it peaks around 2002 with a subsequent decrease: however, NO_2 appears to show more variation.

Three urban non-roadside sites have been monitoring NOx since 2004 or earlier; Aberdeen Errol Place, Edinburgh St Leonards, and Grangemouth. Over the period from 2004 to 2014, all three sites show a negative trend (i.e. decreasing NOx). The actual decrease year-on-year is small; however, the trend is statistically highly significant (at the 0.001 level) at Aberdeen Errol Place and Edinburgh St Leonards (though not Grangemouth).

In the case of NO_2, all sites again show a slight negative trend, though the year-on-year decrease is even smaller than for total NOx.

Three long-running rural sites have monitored oxides of nitrogen since 2005 or earlier: Bush Estate (to the south of Edinburgh close to the Pentland Hills National Park), Eskdalemuir and Glasgow Waulkmillglen Reservoir. While the sites at Bush Estate and Eskdalemuir show small but highly significant downward trends, this is not the case for Glasgow Waulkmillglen Reservoir, where – by contrast - concentrations are increasing.

At Scotland's longest running traffic-related urban site, Glasgow Kerbside (since 1997), there is considerable fluctuation in NOx at this site, but some indication of an overall downward trend. By contrast, in the case of NO_2, there is no such apparent downward trend over this period.

Looking at a subset of nine long-running sites at urban traffic locations (Aberdeen Anderson Drive, Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road, Glasgow Byres Road, Glasgow Kerbside, Inverness, Perth Atholl Street and Perth High Street) five of the sites show a downward trend in NOx (highly statistically significant at Dumfries, East Dunbartonshire Bishopbriggs, Edinburgh Gorgie Road and both the Perth sites). However, Glasgow Byres Road and Glasgow Kerbside show no trend, and both Aberdeen Anderson Drive and Inverness show slight but significant upward trends.

In the case of NO_2, there is more between-site variation in trends. Four of the sites (Dumfries, East Dunbartonshire Bishopbriggs, Perth Atholl Street and Perth High Street) show statistically significant downward trends. Inverness shows a small but statistically significant upward trend and the remaining four show no significant trend at all. This is similar to observations in the previous year's report: it may indicate that trends in concentrations of this pollutant depend greatly on conditions at the various sites.

PM_{10}

The longest-running Scottish urban background PM_{10} monitoring site is Aberdeen Errol Place (since 1999). This shows no clear trend in the early years, followed by a general decrease from around 2004 until 2013. There is some indication of a recent up-turn.

Looking at a subset of longest running urban non roadside sites, all sites show a negative trend significant at 0.001.

In terms of long term traffic related sites. All sites also show statistically significant downward trend, indicating a year on year decrease.

The longest-running traffic-related PM_{10} monitoring site in Scotland is Glasgow Kerbside (since 1997). Although concentrations are lower in recent years than in the late 1990s, the decrease has not been consistent.

$PM_{2.5}$

In contrast to PM_{10}, for which concentrations at most long-running sites show a downward trend, in the case of $PM_{2.5}$ the situation appears to vary more from site to site. In particular, two of the sites (Aberdeen Errol Place Auchencorth Moss site) show highly statistically significant upward trends in this particulate size fraction, since 2009.

Only Glasgow Kerbside shows a clear and statistically significant downward trend, although the trend is significant at the 0.01 level, most of the decrease appears to have occurred since the start of 2011. When compared to other similar sites in the UK, Glasgow Kerbside trend is not typical. Other similar UK sites show no significant trend and there is also considerable variation from site to site.

Ozone

For all long running ozone sites (Bush estate, Eskdalemuir and Strath Vaich), though fluctuating considerably, plots show a small but statistically significant upward trend.

Emissions of Pollutants

Scotland's NO_x emissions have declined by 65% since 1990 and in 2012 accounted for 9% of the UK total. 29% of these emissions stemmed from road transport combustion sources and 27% from power generation. These two sectors also represent the main sources of decline in NO_x emissions.

Since 2009, the decreasing trend in NO_x emissions appears to have slowed in all sectors with the exception of transport. Energy sources of NO_x emissions has shown to have increased from 2011 to 2012.

Emissions of PM_{10} have declined by 59% since 1990 and account for 10% of the UK total. At 37%, emissions from commercial, domestic and agricultural combustion were the main source of PM_{10} in 2012. Emissions from power generation account for 25% of total emissions in 1990 but have significantly reduced to 8% in 2012.

Appendices

Appendix 1 – National Monitoring Networks in Scotland 2014

Table A1.1. AURN Measurement Sites in Scotland 2014

Site Name	Site Type	Species Measured	Grid Reference
Aberdeen	URBAN BACKGROUND	NO NO_2 NO_X O_3 PM_{10}, $PM_{2.5}$	394416,807408
Aberdeen Union St Roadside	ROADSIDE	NO NO_2 NO_X	396345,805947
Auchencorth Moss	RURAL	O_3 PM_{10}(grav) $PM_{2.5}$(grav)	322167, 656123
Bush Estate	RURAL	NO NO_2 NO_X O_3	324626,663880
Dumbarton Roadside	ROADSIDE	NO NO_2 NO_X	240234,675193
Dumfries	ROADSIDE	NO NO_2 NO_X	297012,576278
Edinburgh St Leonards	URBAN BACKGROUND	CO NO NO_2 NO_X O_3 PM_{10} $PM_{2.5}$ SO_2	326265, 673136
Eskdalemuir	RURAL	NO NO_2 NO_X O_3	323552,603018
Fort William	RURAL	NO NO_2 NO_X O_3	210830,774410
Glasgow Kerbside	KERBSIDE	NO NO_2 NO_X PM_{10}, $PM_{2.5}$	258708,665200
Glasgow Townhead	KERBSIDE	NO NO_2 NO_X PM_{10}, $PM_{2.5}$	259692, 665899
Grangemouth	URBAN INDUSTRIAL	NO NO_2 NO_X PM_{10}, $PM_{2.5}$, SO_2	293840,681032
Grangemouth Moray	URBAN BACKGROUND	NO NO_2 NO_X	296436,681344
Inverness	ROADSIDE	PM_{10}(grav), $PM_{2.5}$(grav), NO NO_2 NO_X	265720,845680
Lerwick	RURAL	O_3	445337,113968
Peebles	SUBURBAN	NO NO_2 NO_X O_3	324812,641083
Strath Vaich	REMOTE	O_3	234787,875022

Table A1.2 Automatic Hydrocarbon Network Sites in Scotland 2014

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	RURAL	Benzene and 1,3-butadiene and 24 other ozone precursor hydrocarbon species*	322167, 656123

Table A1.3 Non-Automatic Hydrocarbon Network Sites in Scotland 2014

Site Name	Site Type	Species Measured	Grid Reference
Glasgow Kerbside[α]	KERBSIDE	Benzene	258708, 665200
Grangemouth	URBAN INDUSTRIAL	Benzene	293840,681032

EU requirement and part of the EMEP long-range transboundary air pollution monitoring programme.
[α]Non-Automatic Monitoring of Benzene started at this site on 01/09/10.

Table A1.3 PAH Monitoring Sites in Scotland 2014

Site	Address	Grid Reference
Auchencorth Moss	Rural site in Scotland, South of Edinburgh	322167, 656123
Edinburgh	145 Pleasance Edinburgh EH8 9RU	326265, 673136
Glasgow Townhead	Townhead Glasgow G4 0PH	259692, 665899
Kinlochleven 2	Electrical Substation Kinlochleven	219280, 761986

Table A1.4 Heavy Metals Monitoring Network Sites in Scotland 2014

Site Name	Site Type	Species Measured	Grid Reference
Auchencorth Moss	Rural	As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Se, V, Zn	322167, 656123
Eskdalemuir	Rural	As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Se, V, Zn	323552,603018

Table A1.6 Rural Metal Deposition Monitoring sites in Scotland 2014

Site	Location Grid Ref.	Heavy metals			Mercury	
		In Particles	In Rain	In Cloud	In Air	In Rain
Inverpolly	218776,908833		✓			
Banchory	367694,798519	✓	✓		✓	✓
Bowbeat	328289,647302		✓	✓		
Auchencorth Moss	322167, 656123	✓	✓		✓	✓

United Kingdom Eutrophying & Acidifying Network (UKEAP)

Table A1.7 The Precipitation Network (PrecipNet) Sites in Scotland 2014

Site Name	Grid Ref	Species included
Shetland	445449,113965	Na^{+}, Ca^{2+}, Mg^{2+}, K^{+}, PO_4^{3-}, NH_4^{+}, NO_3, SO_4^{2-}, Cl^{-}
Rum	140865,799220	
Halladale	290285,948838	
Strathvaich Dam	234787,875022	
Lagganlia	285684,803720	
Glensaugh	366329,780027	
Edinburgh St Leonards	326265, 673136	
Bush	324626,663880	
Auchencorth Moss	322167, 656123	
Carradale	179870,637801	
Eskdalemuir	323552,603018	

Table A1.8 Acid Gas and Aerosol Network (AGANet) and Ammonia Network (NAMN) Sites in Scotland 2014

Name	Grid Ref	Ammonia	Nitric Acid
Shetland	445449,113965	✓	✓
Halladale	290285,948838	✓	✓
Inverpolly B	218776,908733	✓	
Strathvaich Dam	234787,875022	✓	✓
Ellon Ythan	394500,830400	✓	
Oldmeldrum	383297,827323	✓	
Pitmedden	388300,827800	✓	
Lagganlia	285684,803720	✓	✓
Allt a Mharcaidh	289184,804320	✓	
Rum	140865,799220	✓	✓
Glensaugh	366329,780027	✓	✓
Glenshee Hotel	311187,769916	✓	
Glen Shee	312187,769016	✓	
Tummel	274483,761116	✓	
Rannoch	260380,753315	✓	
Loch Awe	196673,711509	✓	

Name	Grid Ref	Ammonia	Nitric Acid
Edinburgh Johnston Terrace	325389,673404	✓	
Edinburgh Medical School	326388,672605	✓	
Edinburgh St Leonards	326265, 673136	✓	
Bush 2	324789,663804	✓	
Bush 1	324671,663524	✓	✓
Auchencorth Moss	322188,656202	✓	✓
Carradale	179870,637801	✓	✓
Auchincruive B	238478,622899	✓	
Auchincruive 3	237977,623399	✓	
Sourhope	386796,621798	✓	
Eskdalemuir	323588,602997	✓	✓
Dumfries	254679,565792	✓	
Sourhope	386796,621798	✓	

Appendix 2 - Ratification Procedures

A2.1 Intercalibration and Audit procedures

The audit and intercalibration procedures adopted by Ricardo-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 Ricardo-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 Ricardo-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

Ricardo-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 (PM_{10}) 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.

Ricardo-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 air source is held at the Ricardo-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.

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.

RICARDO-AEA

2nd Floor
18 Blythswood Square
Glasgow
G2 4BG
United Kingdom

t: +44 (0)1235 753000
e: enquiry@ricardo-aea.com

www.ricardo-aea.com