The Scottish Government

Air Pollution in Scotland 2017

RICARDO
Ricardo Energy & Environment

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Introduction

This brochure has been produced as part of the Scottish Air Quality Database (SAQD) project on behalf of the Scottish Government. The 2017 brochure is the 11th in an annual series. It aims to provide a summary of the local air quality monitoring and associated work carried out by and on behalf of the Scottish Government and local authorities during 2017.

The SAQD project was developed as a comprehensive centralised resource to provide high-quality harmonised data and information. The quality assurance of the data generated by the Scottish network serves to improve research and analysis, and supports the evaluation of air quality policy in Scotland. Since the initial development of the SAQD in 2006, it has grown year on year. The total number of automatic air quality monitoring sites in the SAQD during 2017 was 96. The increase in the number of monitoring sites included in the SAQD since 2006 and locations of these sites are shown in Figure 1.1. While air quality in most of Scotland is generally good, levels of some pollutants still exceed air quality objectives, particularly in urban areas. Therefore, continued efforts to reduce air pollution are vital, coupled with appropriate monitoring to assess progress. For more information on air quality in Scotland and, more specifically, your area, please visit the Air Quality in Scotland website (www.airqualityinscotland.co.uk).

Section 2 of this brochure reviews the air quality legislation and policy applicable to Scotland. **Section 3** summarises the air quality monitoring carried out in Scotland and presents an overview of the data from 2016, including exceedances of air quality objectives. **Section 4** deals with trends in air pollution in Scotland and **Section 5** covers spatial patterns of pollution. **Section 6** provides information on educational activities that have taken place and **Section 7** is a summary of developments that occurred during 2017 with the SAQD. **Section 8** highlights all the different ways to obtain information on air quality in Scotland.

A more detailed Annual Report on the SAQD project is available on the Air Quality in Scotland website.

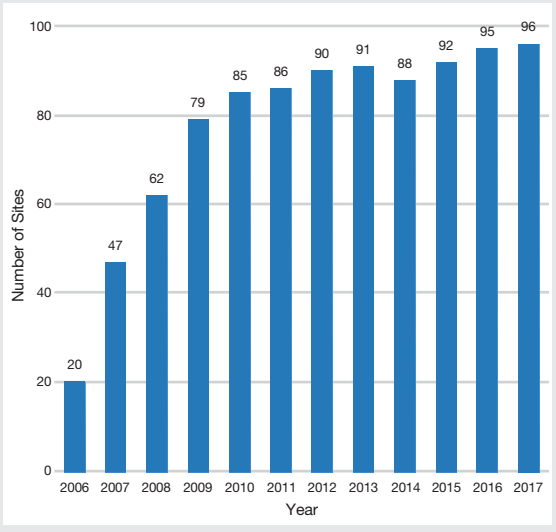

Figure 1.1

Growth in the number of monitoring sites included in the SAQD since 2006

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Legislation and Policy

Air quality management is shaped by statutory requirements transposed from EU and UK legislation and policies that have been adopted by Scotland. The foundations of Scotland's air quality management system are based on the following air quality directives adopted by all EU Member States:

- Directive 2008/50/EC – on ambient air quality and cleaner air for Europe (the Air Quality Directive)
- Directive 2010/75/EC – on industrial emissions (integrated pollution prevention and control) (the Industrial Emissions Directive)

The Scottish Government has duly transposed these Directives into national law through the Air Quality Strategy (AQS) and Air Quality Scotland Regulations. A substantial review of the EU's air quality policy, including the Air Quality Directive, was undertaken in 2013 with the European Commission adopting a new Clean Air Policy Package, including a new Clean Air for Europe programme with measures to ensure that existing targets are met in the short term and new air quality objectives for the period up to 2030. The Package also includes support measures to help cut air pollution, with a focus on improving air quality in cities, supporting research and innovation, and promoting international cooperation.

2.1 Air Quality Standards and Objectives

A set of air quality standards and objectives has been developed for several pollutants of concern for human health. The objectives are derived from the standards and are a compromise between what is desirable purely on health grounds and what is practicable in terms of feasibility and costs. Each objective has a date by when it must be achieved. The objectives adopted in Scotland for the purpose of local air quality management (LAQM) are set out in the Air Quality (Scotland) Regulations 2000, the Air Quality (Scotland) Amendment Regulations 2002 and the Air Quality (Scotland) Amendment Regulations 2016. Similar targets are set at EU level, where they are called limit and target values.

These limit and target values are set out in the Air Quality Directive and transposed into Scottish legislation. It is the responsibility of EU Member States to achieve these values. Scotland has adopted a more stringent objective for particulate matter up to 10µm and 2.5µm in diameter (PM_{10} and $PM_{2.5}$ respectively). A summary of the current Scottish air quality objectives is provided in Table 2.1.

Table 2.1 Summary of air quality in Scotland

Air Quality objective & pollutant	Concentration	Measured as	Date to be achieved by
Nitrogen dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg m^{-3}	Annual mean	31.12.2005
Particulate matter (PM_{10})	50 µg m^{-3}, not to be exceeded more than 7 times a year	24-hour mean	31.12.2010
	18 µg m^{-3}	Annual mean	31.12.2010
Particulate matter ($PM_{2.5}$)	10 µg m^{-3}	Annual mean	31.12.2020
	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
Sulphur dioxide (SO_2)	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005
Benzene (C_6H_6)	3.25 µg m^{-3}	Running annual mean	31.12.2010
1,3 Butadiene (C_4H_6)	2.25 µg m^{-3}	Running annual mean	31.12.2003
Carbon monoxide (CO)	10.0 mg m^{-3}	Running 8-Hour mean	31.12.2003
Lead (Pb)	0.25 µg m^{-3}	Annual Mean	31.12.2008

2.2 Cleaner Air for Scotland – The Road to a Healthier Future

The 'Cleaner Air for Scotland – The Road to a Healthier Future' (CAFS) strategy was published by the Scottish Government in November 2015. The purpose of CAFS is to provide a national framework that sets out how the Scottish Government and its partner organisations propose to achieve further reductions in air pollution and fulfil their legal responsibilities to achieve the air quality objectives. It is acknowledged in the CAFS strategy that, although progress has been made in Scotland, areas of poorer air quality still exist in towns and cities.

CAFS considers the impact of air quality on health, and looks at the estimated costs and predicted premature deaths associated with poor air quality. It has been estimated that 2,000 premature deaths and around 22,500 lost life-years across the Scottish population are associated with fine particulate air pollution [1].

2.2.1 Cleaner Air for Scotland Objectives

The CAFS strategy sets out six main objectives and the actions required to achieve improvements in air quality. A summary of these objectives and the 40 actions stated in CAFS are set out below.

1. Transport

A Scotland that reduces transport emissions by supporting the uptake of low and zero emission fuels and technologies, promoting a modal shift away from the car through active travel (walking and cycling) and reducing the need to travel.

This will be achieved by:

- Ensuring that all local authorities have a corporate travel plan that is consistent with any local air quality action plan
- Delivering the National Walking Strategy and Cycling Action Plan
- Working collaboratively with partners to deliver our shared vision in the Cycling Action Plan for Scotland
- Reviewing supporting green buses including the scope for supporting retrofitting existing vehicles, taking account of technology, market developments and climate change
- Evaluating the Bus Investment Fund
- Reviewing the Bus Service Operators' Grant to incentivise the use of low emission buses
- Reviewing guidance and legislation on the powers of local transport authorities regarding bus services
- Delivering 'Switched On Scotland: A roadmap to widespread adoption of plug-in vehicles'
- Reviewing the roadmap and developing a post 2015 plug-in vehicle action plan
- With key partners, investigating the use of hydrogen as a transport fuel and energy applications
- Reviewing the role less carbon-intensive fuels (such as liquefied petroleum gas (LPG), compressed natural gas (CNG) and biofuels) can play in achieving a near-zero-emission road transport sector by 2050
- Encouraging freight quality partnerships to consider their environmental impact
- Encouraging local authorities with Air Quality Management Areas (AQMAs) to establish a freight quality partnership to achieve improved air quality
- Reviewing ministerial guidance on regional and local transport strategies considering air quality management, and supporting a modal shift towards sustainable and active travel
- Reviewing the impacts of trunk roads on AQMAs and implementing mitigation measures where trunk roads are the primary contributor

2. Health

A Scotland that protects its citizens from the harmful effects of air pollution and reduces health inequalities.

This will be achieved by:

- NHS boards and their local authority partners including references to air quality and health in joint health protection plans
- Including World Health Organization (WHO) guideline values for PM_{10} and $PM_{2.5}$ in legislation as Scottish objectives

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PHE_CRCE_010.pdf

3. Legislation and policy

A Scotland where all European and Scottish legal requirements relating to air quality are, as a minimum, complied with.

This will be achieved by:

- Refocusing the LAQM system
- Establishing a $PM_{2.5}$ monitoring network
- Producing revised and updated Scottish action plans to demonstrate how compliance with the Air Quality Directive will be achieved
- Designing, developing and implementing a two-level modelling system for regional and local scales to support potential transport and planning solutions to air quality issues
- Developing guidance and promoting a support network for all practitioners in reviewing and assessing air quality
- Undertaking detailed modelling of all four major cities in Scotland (National Modelling Framework)
- Identifying requirements and undertaking data collection for additional urban areas within 3 years
- Implementing the national databases for traffic data collection and local modelling outputs associated with CAFS
- Ensuring that the National Low Emission Factor (NLEF) criteria, tests and processes are developed, agreed and finalised
- Designing and implementing a standard appraisal process for assessing local air quality measures
- Developing software tools and guidance for the NLEF including funding options and technical reports

4. Placemaking

A Scotland where air quality is not compromised by new or existing development and where places are designed to minimise air pollution and its effects.

This will be achieved by:

- Ensuring Scottish Planning Policy and the National Planning Framework take account of CAFS
- Ensuring Local Development Plans and policies are consistent with the objectives of CAFS and any local authority Air Quality Action Plans
- Working with Environmental Protection Scotland (EPS) to produce updated guidance on air quality and planning
- Working with the Scottish Environment Protection Agency (SEPA) to introduce air quality training for local authority planners
- Supporting SEPA in revising its guidance on Strategic Environmental Assessment to bring it into line with CAFS

5. Communication

A Scotland where all are well informed, engaged and empowered to improve our air quality.

This will be achieved by:

- Developing a Scottish air quality indicator to assist in assessing compliance with air quality legislation and delivering the objectives of CAFS
- Developing a national air quality public awareness campaign
- Supporting the ongoing Greener Scotland communication campaigns and encouraging individuals to use their car less to improve their health and their local environment

6. Climate change

Reducing greenhouse gas (GHG) emissions and achieving renewable energy targets while delivering co-benefits for air quality.

This will be achieved by:

- Ensuring 'Low Carbon Scotland: Meeting Our Emissions Reduction Targets' publication takes into account air quality impacts
- Expecting Scottish local authorities to ensure a Sustainable Energy Action Plan includes air quality considerations
- Working with Forestry Commission Scotland to publish updated guidance on the impact of biomass on air quality to help local authorities fulfil their statutory responsibilities

2.2.2 Cleaner Air for Scotland – $PM_{2.5}$

CAFS outlines further changes, such as the adoption of the WHO guideline values for $PM_{2.5}$. This was transposed by the Air Quality Scotland Amendment Regulations 2016 when the annual mean objective for $PM_{2.5}$ was set at 10 µg m^{-3}. For the latest progress on CAFS, please visit www.scottishairquality.co.uk/air-quality/CAFS

2.3 Local Air Quality Management

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas to determine if the air quality objectives are likely to be achieved. Where an exceedance is considered likely, the local authority must:

- Declare an AQMA
- Assess and identify the reasons for the problem and develop an Air Quality Action Plan (AQAP) to help address the problem

In 2016, the Scottish Government produced and updated the technical guidance and policy guidance for the LAQM regime in the UK. One of the main changes was to the LAQM reporting process. An Annual Progress Report (APR) has replaced the previous 3-year cyclical process. The LAQM policy and technical guidance documents are available online (www.scottishairquality.co.uk/air-quality/legislation).

2.4 Air Quality Management Areas

In Scotland, there are 38 AQMA declared across 14 of the Scottish local authorities. The AQMAs in Scotland are declared for either nitrogen dioxide (NO_2) and/or PM_{10} concentrations, with the exception of the Grangemouth AQMA for sulphur dioxide (SO_2). The adoption of the $PM_{2.5}$ objective of 10 µg m^{-3} has not resulted in any additional AQMAs being declared. However, $PM_{2.5}$ monitoring continues to increase. The AQMAs declared in Scotland are presented in Table 2.2.

Table 2.2 Current AQMAs in Scotland

Local authority	Pollutant (no of AQMAs)	Main Source	AQMAs
Aberdeen	NO_2 and PM_{10}	Roads	3
City of Edinburgh	NO_2 (5) and PM_{10} (1)	Roads	6
Dundee City	NO_2 and PM_{10}	Roads	1
East Dunbartonshire	NO_2 and PM_{10}	Roads	2
East Lothian	NO_2	Roads	1
Falkirk	SO_2 (1), NO_2 (1), PM_{10} (1), NO_2 and PM_{10} (1)	Industry and roads	4
Fife	NO_2 and PM_{10}	Roads	2
Glasgow City	NO_2 and PM_{10} (1), NO_2 (2)	Roads	3
Highland	NO_2	Roads	1
North Lanarkshire	PM_{10}	Industry and roads	4
Perth and Kinross	NO_2 and PM_{10}	Roads	2
Renfrewshire	NO_2 (2), NO_2 and PM_{10} (1)	Roads	3
South Lanarkshire	NO_2 (1) and PM_{10} (2)	Roads	3
West Lothian	NO_2 (2) and PM_{10} (1)	Roads	3

3

Networks and Data

3.1 Monitoring in Scotland

Extensive air quality monitoring is carried out across Scotland. Some monitoring sites are run as part of UK-wide monitoring networks and others are operated by local authorities for LAQM purposes. The following AQS pollutants were monitored in Scotland during 2017:

- Benzene (C_6H_6)
- 1,3-butadiene (C_4H_6)
- Carbon monoxide (CO)
- Lead (Pb)
- Oxides of nitrogen (NOx), comprising nitric oxide (NO) and nitrogen dioxide (NO_2)
- Ozone (O_3)
- Particles (as PM_{10}, $PM_{2.5}$ and black carbon)
- Polycyclic aromatic hydrocarbons (PAH)
- Sulphur dioxide (SO_2)

The locations of automatic monitoring stations are shown in Figure 3.1. These stations provide high-resolution, hourly information on a wide range of pollutants. Data from national network monitoring sites are updated hourly in near real time on the SAQD. Data from local authority operated monitoring sites are updated hourly or daily depending on the station configuration. A typical automatic monitoring site is shown in Figure 3.2.

Scotland's automatic monitoring is supplemented by non-automatic monitoring techniques, for example the pumped-tube samplers used to monitor benzene, the high-volume samplers used to measure PAH and the non-automatic techniques used to monitor nitrogen dioxide and metals (such as lead).

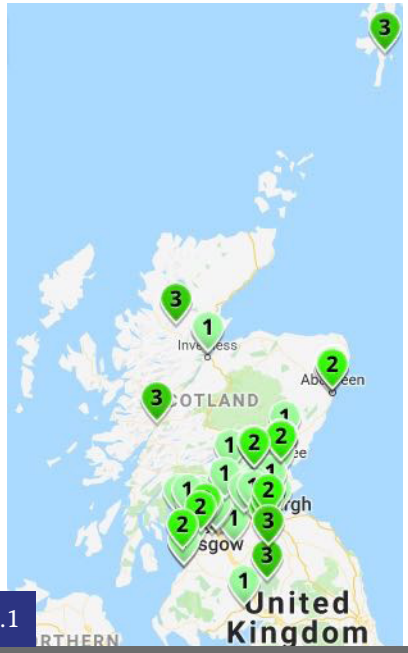


Figure 3.1

Location of automatic monitoring stations

Figure 3.2

Automatic monitoring stations (East Dunbartonshire Milngavie/South Lanarkshire Lanark))

3.2 Key Results for 2017

This section provides a summary of results from automatic and non-automatic monitoring in Scotland in 2016 – including compliance with AQS objectives. Further information is provided on the Air Quality in Scotland website (www.scottishairquality.co.uk). This will be supplemented by further information and data to be published in the full Annual Report later this year. Data from individual local authorities' NO_2 diffusion tube networks are not included.

Benzene

This hydrocarbon is a constituent of vehicle exhaust emissions. Benzene was monitored using a non-automatic pumped-tube sampler at two sites (Glasgow Kerbside and Grangemouth) as part of the UK Non-Automatic Hydrocarbon Network. Both sites had annual mean concentrations below the AQS objective for the running annual mean.

1, 3-Butadiene

1,3-butadiene is also a constituent of vehicle exhaust emissions. This pollutant was monitored at one rural site (Auchencorth Moss in Midlothian) as part of the UK Automatic Hydrocarbon Network. There were no exceedences of the 1,3 butadiene objective in 2017.

Carbon monoxide

This gas is a product of incomplete combustion, with vehicle exhaust emissions being an important source. It was monitored at two sites in Scotland in 2017 (Edinburgh St Leonards and North Lanarkshire Croy). Outdoor concentrations of CO were well within the AQS objective, as they have been for many years.

Lead

This toxic metal is emitted from some industrial processes (although emissions are now strictly controlled). Lead is monitored at two non-automatic sites in Scotland (Auchencorth Moss and Eskdalemuir). The 2017 annual mean from both sites was well below the AQS objectives.

Nitrogen dioxide

This toxic gas is emitted from most combustion processes, including power generation, domestic heating and vehicle engines. It was monitored at 81 automatic sites in Scotland during 2017 (shown in Figure 3.3). Of these, 10 achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean. This was because of instrument/sampling issues or the site starting up or closing down part way through the year.

Seven sites had annual mean NO_2 concentrations greater than the AQS objective of 40µg m^{-3}. The highest annual mean concentrations were measured at Glasgow Kerbside, located close to a busy road, which had a measured concentration of 58.5µg m^{-3}. Figure 3.3 shows annual mean NO_2 concentrations at each site (with at least 75% data capture).

No site exceeded the hourly AQS objective of 200µg m^{-3} on more than the 18 permitted occasions.

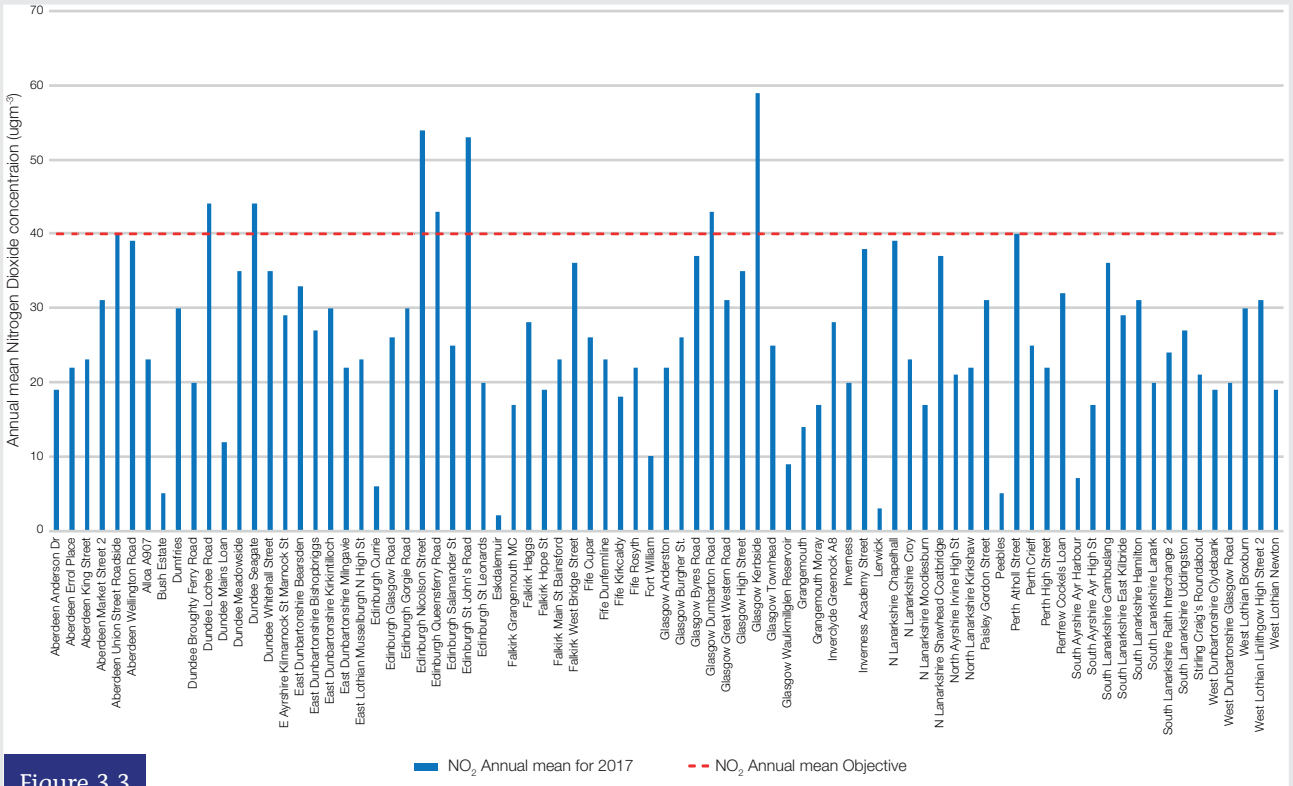


Figure 3.3

Annual mean NO_2 concentrations (2016)

Sulphur dioxide

This gas is emitted when fuels containing small amounts of sulphur (such as oil and coal) are burned. This pollutant was monitored at nine sites in 2017. No site recorded more than the permitted 35 exceedances of the AQS objective for the 15-minute mean (266µg m^{-3}) during 2017. This is illustrated in Figure 3.4. No exceedances of the 24-hour mean objective of no more than three exceedances of 125µg m^{-3} and 1-hour of no more than 24 exceedances of 350µg m^{-3} were measured at any site.

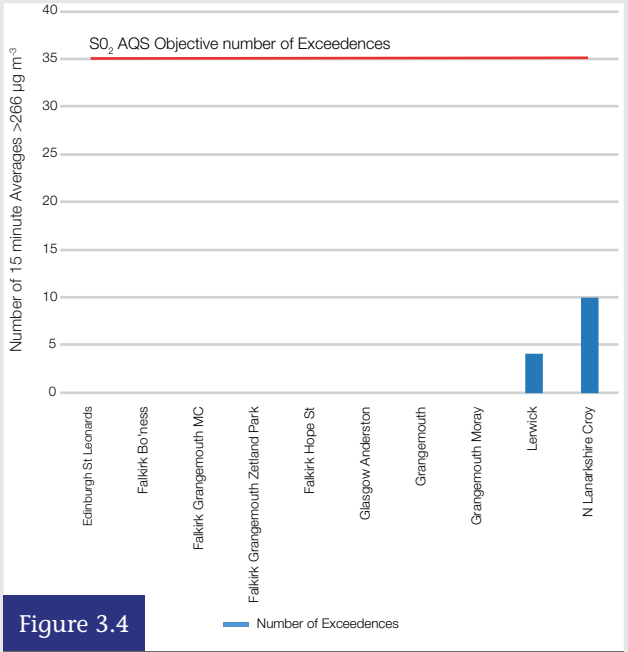


Figure 3.4

Exceedances of 15-min AQS objective for SO_2 (2017)

Particulate Matter as PM_{10}

Particulate matter arises from many sources. It can be directly emitted from combustion processes or formed from chemical reactions involving other pollutants. Natural sources (e.g. wind-blown dust and sea salt) also contribute. PM_{10} was monitored at 77 Scottish sites in 2017 sites using automatic monitoring and the Partisol™ daily sampler. Of these sites, nine have less than 75% data capture. No site exceeded the UK AQS objective of 40µg m^{-3} for the annual mean. However, Scotland has adopted a more stringent annual mean objective of 18µg m^{-3}.

This objective was exceeded at one site in 2017 – Edinburgh Queensferry Road with a measured annual mean concentration of 22.4µg m^{-3}. Figure 3.5 provides annual mean PM_{10} concentrations for all sites in Scotland with 75% or more data capture.

The UK AQS objective for the 24-hour mean PM_{10} concentration is 50µg m^{-3}, not to be exceeded on more than 35 days per calendar year. The more stringent Scottish objective requires that daily mean PM_{10} concentrations do not exceed 50µg m^{-3} on more than 7 days per year. One Scottish site measured more than seven exceedances – Edinburgh Queensferry Road (8 days).

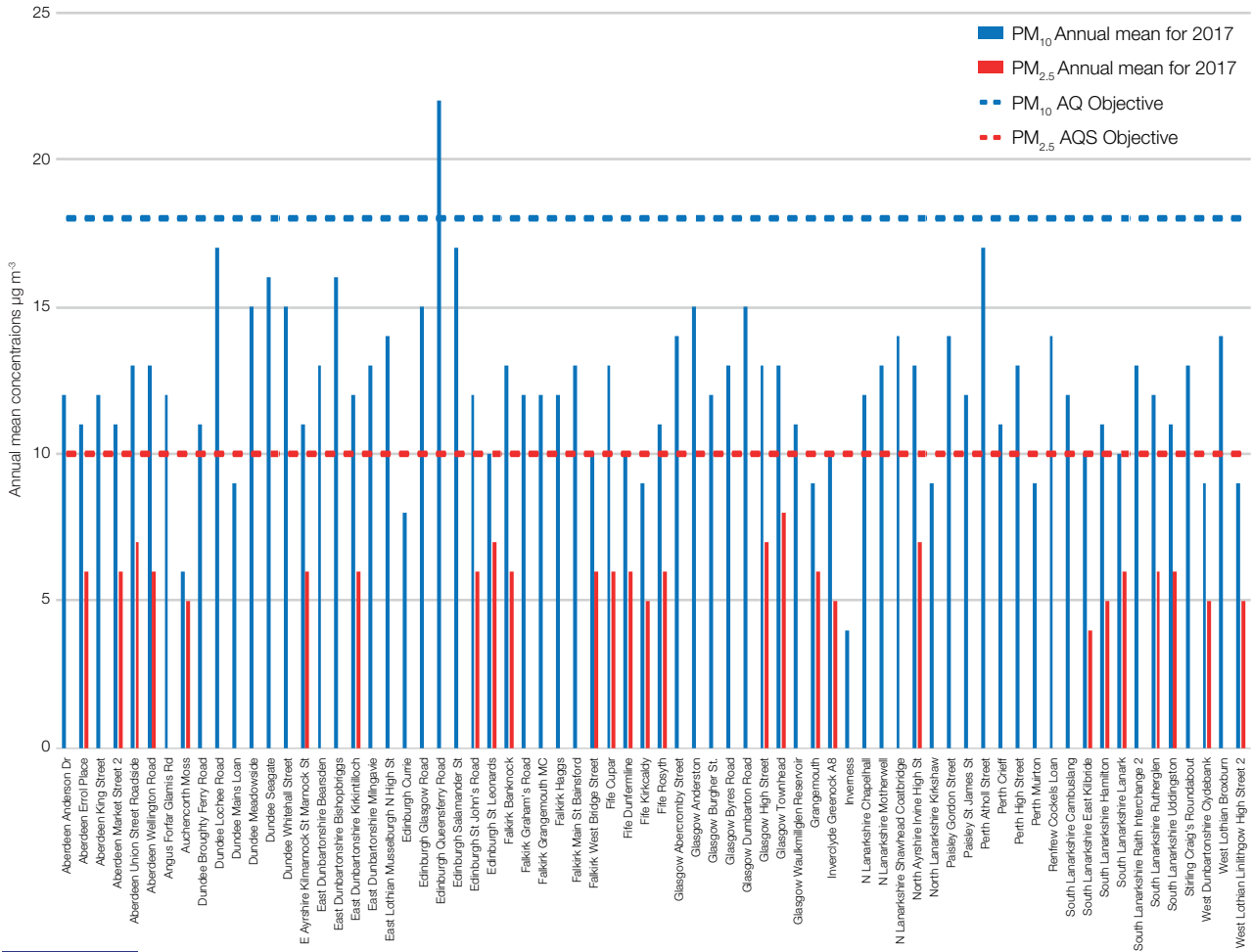


Figure 3.5

Annual average PM_{10} and $PM_{2.5}$ concentrations (µg m^{-3}) for all SAQD sites (2017)

Particulate Matter as $PM_{2.5}$

During 2017, the number of sites measuring the finer particle fraction, $PM_{2.5}$, increased from 27 to 41. Of these, 14 achieved less than the 75% data capture generally considered necessary to calculate a representative annual mean. This was because of instrument faults or instrument installations during the year.

On the 1 April 2016, the new Scottish annual average objective of 10µg m^{-3} was introduced.

This objective was not exceeded at any site. See Figure 3.5 for annual means at sites with a data capture of 75% or more.

Polycyclic Aromatic Hydrocarbons

This group of pollutants is monitored at four sites in Scotland. The AQS objective of 0.25ng m^{-3} for benzo[a]pyrene was not exceeded at any of the four sites during 2017.

Ozone

This is a secondary pollutant that is formed by reactions involving other pollutant gases in the presence of sunlight and over several hours. Once formed, it may persist for several days and be transported over long distances. This makes it difficult to control by local action. It was monitored at 11 sites in Scotland during 2017. Of these, the AQS objective of 100µg m^{-3} as an 8-hour running mean not to be exceeded more than 10 days was exceeded at Peebles (11 days) (see Figure 3.6).

The AQS objective is not included in regulations. This is in recognition of the fact that it is transboundary in nature and that local authorities have very little control over concentrations in their areas.

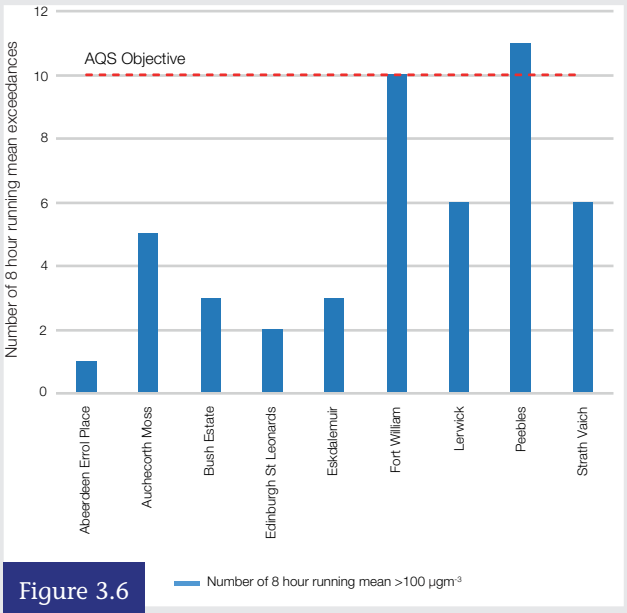


Figure 3.6

Exceedances of the 8-hour running AQS objective for ozone (2017)

4

Air Quality Trends for Scotland

This section summarises how air quality in Scotland has changed over recent years. In previous years, the focus was on particulate matter. This year, the pollutants of interest are NO_2 and$PM_{2.5}$.

Automatic monitoring of NOx has been routinely carried out in Scotland since 1987. However, until 2000, there were relatively few automatic monitoring sites. Subsequent years have seen the number of monitoring sites in the SAQD increase from 20 (in 2000) to the current total of 96. The data produced by these monitoring sites has 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 seen 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, for this report, investigation of trends has been based on subsets of long-running sites.

All the sites featured in this section have been in operation for a minimum of 5 consecutive years, as this is usually considered to be the minimum required to assess long-term trends at a monitoring site. In most cases, it is now possible to do trend analysis for longer periods (e.g. 10 years).

The trend analysis presented in this section has been carried out using the air pollution analytical tools available via the Air Quality in Scotland website. The main tool used was openair – a free, open-source software package of tools for analysing air pollution data [2].

The trend analyses 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. 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 in this section. When the de-seasonalise option is used, openair fills in any gaps in the data using a linear interpolation method.

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:

* indicating that the trend is statistically significant at the 0.05 level

** indicating significance at the 0.01 level

*** indicating significance at the 0.001 level

The + symbol indicates that the trend is significant at the 0.1 level.

4.1 Nitrogen Dioxide

In Scotland (as elsewhere in the UK), the largest number of AQMAs have been declared in response to exceedances of the NO_2 objectives. This is also reflected in the number of monitoring stations reporting exceedances for this pollutant (see Section 3.2 of this report). In particular, the objective of 40µg m^{-3} for annual mean NO_2 concentration is the most widely exceeded. Therefore, it is important to understand how concentrations of this pollutant vary with time.

[2] Visit http://analysistools.scottishairquality.co.uk/ for more information on the openair tools that are available and how to use them.

4.1.1 NO_2 at Urban Background Sites

There are relatively few long-running urban background monitoring stations in Scotland. Five urban non-roadside sites have been in operation for the past 10 years (2008-2017). These are Aberdeen Errol Place, Edinburgh St Leonards, Fort William, Glasgow Anderston and Grangemouth. Fort William is classified as a 'suburban' site, Grangemouth is an 'urban industrial' site and the other three are 'urban background'.

The openair Theil-Sen function has been used to quantify trends in NO_2 at these monitoring stations over the period 2008-2017 – the trend plots are shown in Figure 4.1. It should be noted that Edinburgh St Leonards and Glasgow Anderston have large gaps in their 2014 and 2015 datasets. As stated above, where there are gaps in the data, openair fills these in using an interpolation method. Aberdeen Errol Place, Edinburgh St Leonards and Glasgow Anderston showed highly significant negative trends (at the 0.001 level). For Fort William, there was no significant trend in NO_2 indicating the concentrations have stayed, on average, static for the last 10 years. At Grangemouth, there was a slight downward trend for NO_2, significant at the 0.5 level.

4.1.2 NO_2 at Rural Sites

There are three long-running rural sites that have monitored NO_2 for the past 10 years – Bush Estate, Eskdalemuir and Glasgow Waukmillglen Reservoir. Figure 4.2 shows trends in NO_2 concentration at these sites.

The sites at Bush Estate and Eskdalemuir showed small, but highly significant downward trends. However, this was not the case for Glasgow Waukmillglen Reservoir, where concentrations were decreasing very slightly year-on-year, though the trend was not significant.

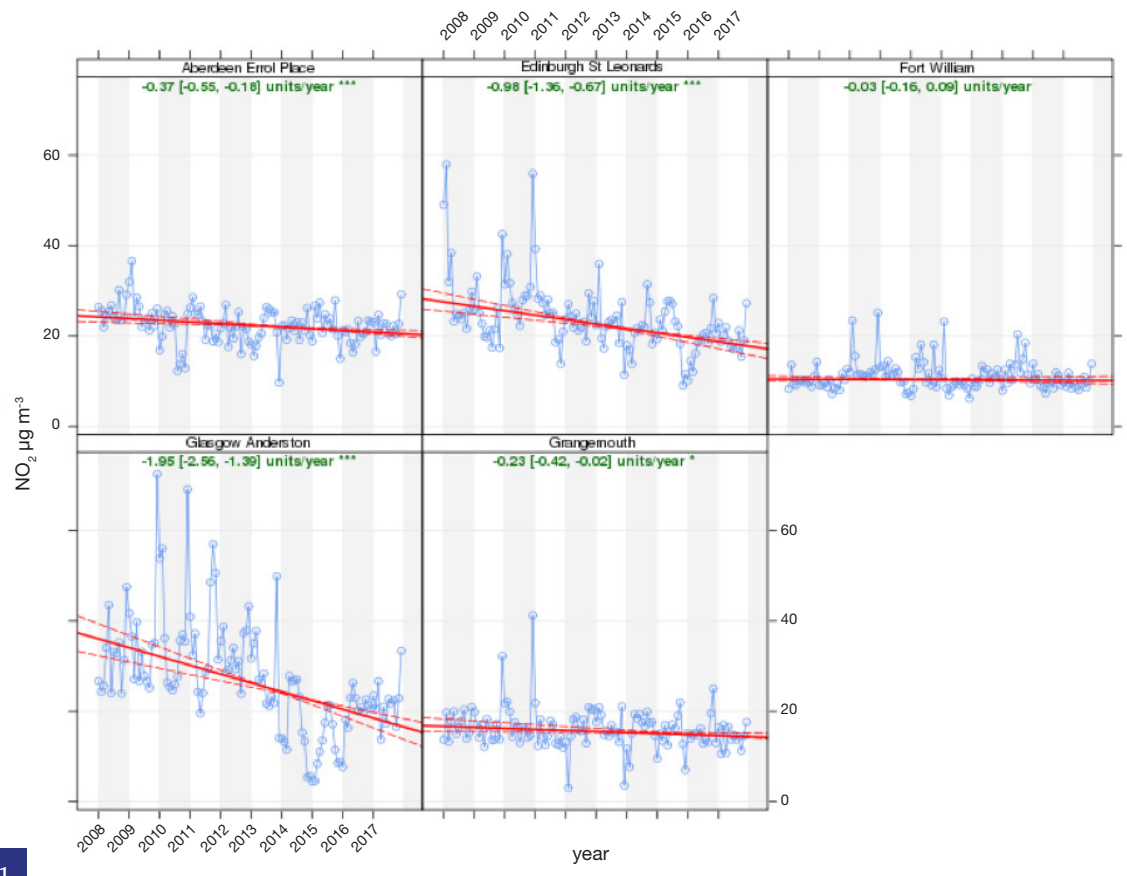


Figure 4.1

Trends in NO_2 concentrations non-roadside sites (2008-2017)

4.1.3 NO_2 at Traffic-related Urban Sites

Recent years have seen a substantial increase in the number of monitoring stations at urban traffic-related sites in Scotland. There are now 29 roadside or kerbside monitoring stations that have been in operation for 10 years or more (since the start of 2008 or earlier), and are still in operation. These are:

- Aberdeen Anderson Drive
- Aberdeen Union Street
- Aberdeen Wellington Road
- Dumfries
- Dundee Lochee Road
- Dundee Seagate
- Dundee Whitehall Road
- East Dunbartonshire Bearsden
- East Dunbartonshire Bishopbriggs
- East Dunbartonshire Kirkintilloch
- Edinburgh Gorgie Road
- Edinburgh St John's Road
- Falkirk Hope Street
- Falkirk West Bridge Street
- Fife Cupar

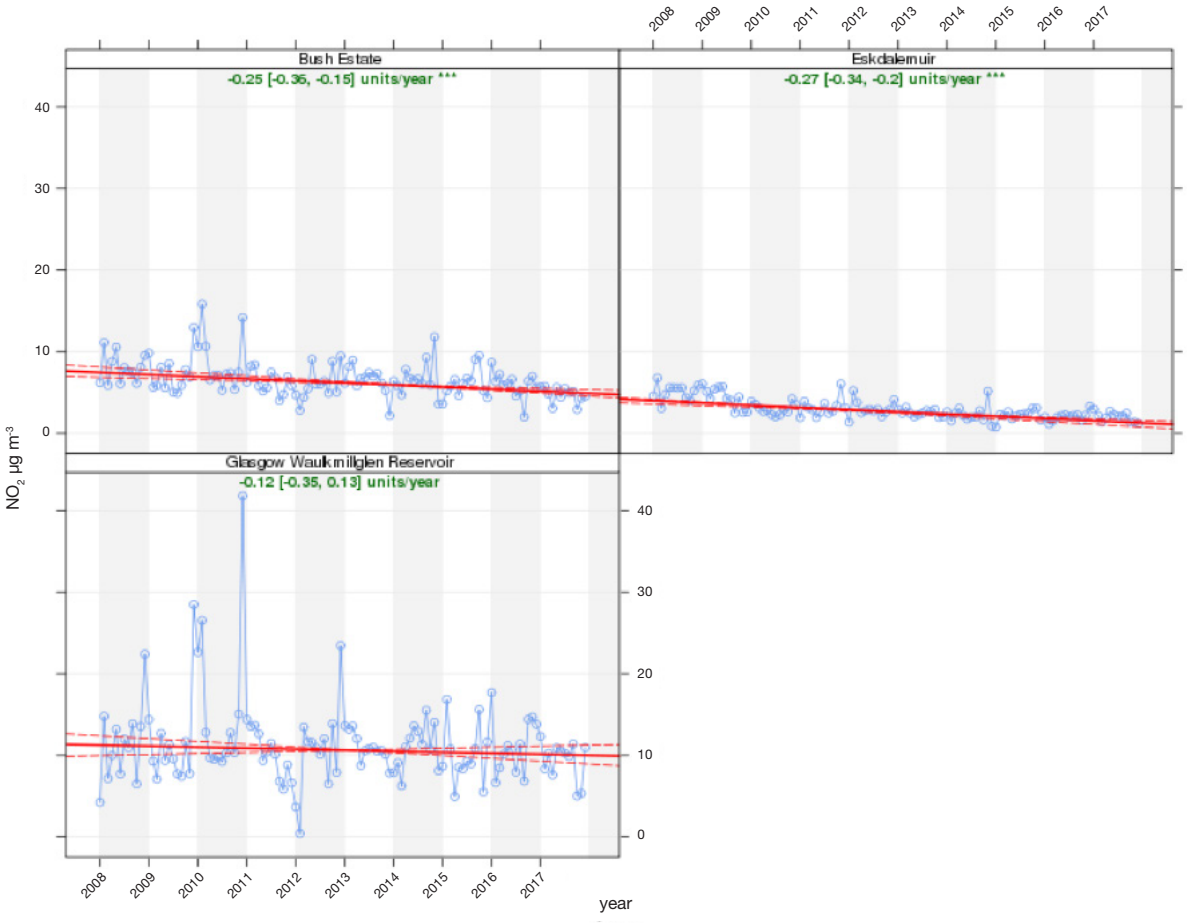


Figure 4.2

Trends in NO_2 concentration at three rural sites (2008-2017)

- Fife Dunfermline
- Glasgow Byres Road
- Glasgow Kerbside
- Inverness
- N Lanarkshire Chapelhall
- N Lanarkshire Croy
- Paisley Gordon Street
- Perth Atholl Street
- Perth High Street
- South Ayrshire Ayr High St
- South Lanarkshire East Kilbride
- West Dunbartonshire Clydebank
- West Dunbartonshire Glasgow Road
- West Lothian Broxburn

This is a large number of sites so, for the purposes of this report, nine have been selected that have measured exceedances of the AQS objective for annual mean NO_2 (40µg m^{-3}) in recent years (though not necessarily 2017). These are:

- Aberdeen Union Street
- Dundee Lochee Road
- Dundee Seagate
- Edinburgh Gorgie Road
- Edinburgh St John's Road
- Glasgow Byres Road
- Glasgow Kerbside
- East Dunbartonshire Bearsden
- Perth Atholl Street

Figure 4.3

Trends in NO_2 concentrations at nine, long-running urban traffic sites with exceedances (2008-2017)

Figure 4.3 shows the trend plot. All nine sites showed significant downward trends in NO_2 concentration, eight of which were highly significant (at the 0.001 level). At East Dunbartonshire the trend was significant at the 0.01 level.

Trends over the most recent five complete years, 2013-2017, have also been examined for these sites. These are shown in Figure 4.4. Comparing the 10-year and five-year trends, the patterns are generally similar. East Dunbartonshire shows a small, but non-significant, downward trend over the most recent 5-year period. The downward trend at Dundee Seagate has become greater and more significant during the past five years. Therefore, NO_2 concentrations in 2017 were lower than that in previous years, leading to larger or more significant downward trends when analysed for the most recent 5 years.

Further information on air quality trends for a range of pollutants is reported in more detail within the SAQD Annual Report.

4.2 Particulate Matter ($PM_{2.5}$)

In earlier years, most monitoring of particulate air pollution was 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 the end of 2017, 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 sites are:

- Aberdeen Errol Place (urban background)
- Auchencorth Moss (rural)
- Edinburgh St Leonards (urban background)
- Grangemouth (urban industrial)
- Inverness (roadside)

Figure 4.4

Recent trends in NO_2 concentration at nine, long-running urban traffic sites (2013-2017)

The trend plot for the first four of these five sites is shown in Figure 4.5. The Inverness data has been plotted separately in Figure 4.6, because this site uses the Partisol gravimetric sampler so only takes daily measurements, not hourly like the other sites. For Inverness, the full period of $PM_{2.5}$ measurement, from 2008 onwards, is shown in Figure 4.6.

All five of the long-running PM2.5 monitoring sites showed a downward trend in this pollutant. However, it was only statistically significant at three of them – Edinburgh St Leonards, Grangemouth and the non-automatic Inverness site. In all three cases, the level of significance was high (0.001 level).

4.3 Regional Pollution Episodes 2017

During 2017, there was one countrywide pollution episode. On the 15 February 2017, air quality monitoring data from sites across much of Scotland measured elevated concentrations of PM_{10} and $PM_{2.5}$. Concentrations measured were generally in the daily air quality index banding 'moderate' (36-53µg m^{-3} for $PM_{2.5}$ and 51-75µg m^{-3} for PM_{10}). However, high (index 7, 84-91µg m^{-3} PM_{10}) was measured at roadside site Edinburgh Queensferry Road. It is not uncommon for countrywide pollution events to happen around the January to March period.

Figures 4.7 illustrates these elevated concentrations as seen on the Air Quality in Scotland website (www.scottishairquality.co.uk).

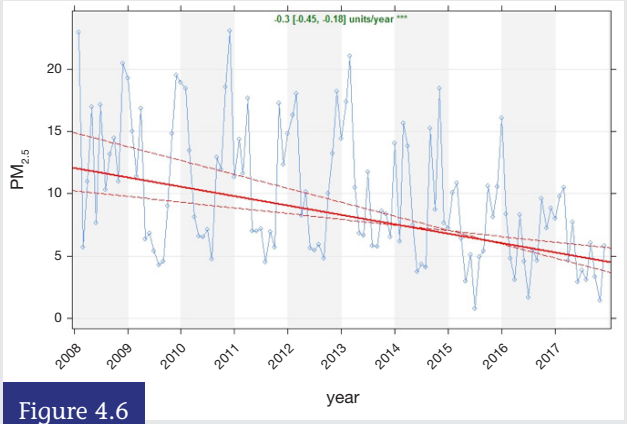


Figure 4.6

Trends in $PM_{2.5}$ concentration (de-seasonalised) at Inverness (Partisol site) (2008–2017)

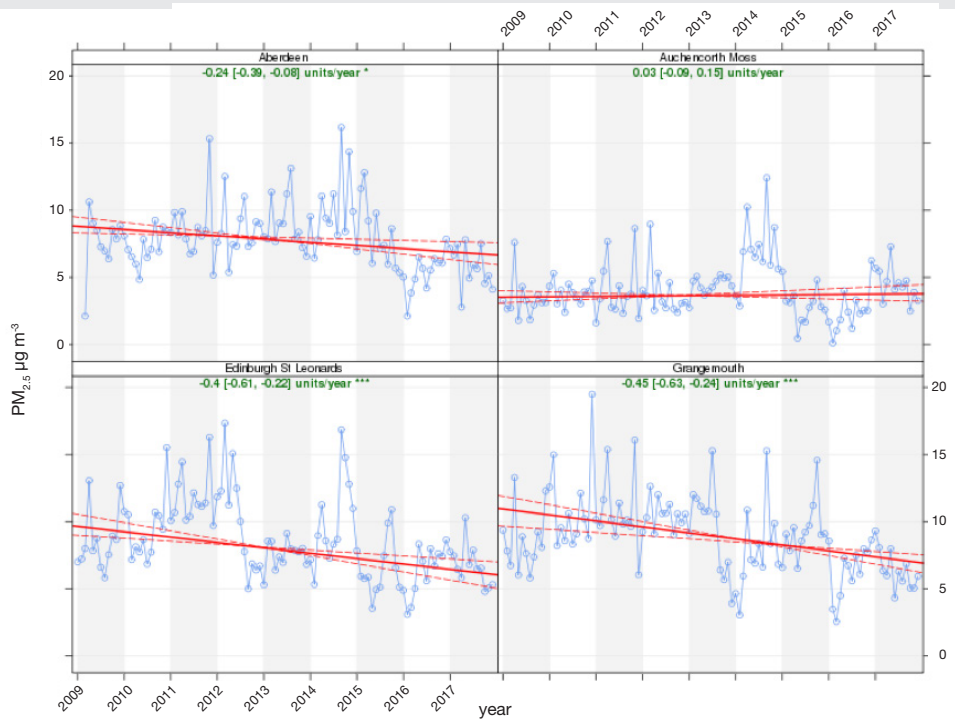


Figure 4.5

Trends in $PM_{2.5}$ concentration at four long-running monitoring sites (2009-2017)

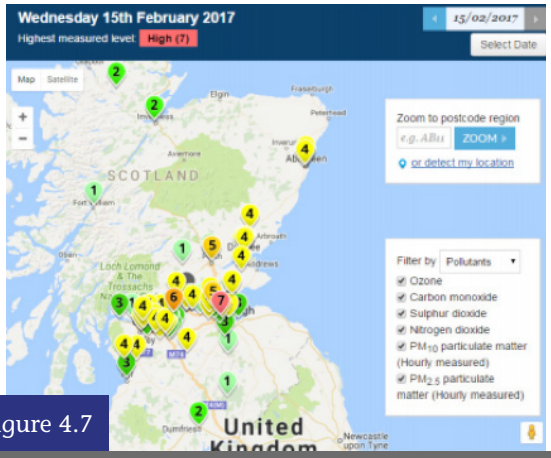


Figure 4.7

Air Quality in Scotland website 15 February 2017

The episode was attributed to a combination of factors which included weather conditions, air masses affecting the country, and the build-up of locally sourced pollutants. Dry, still and misty weather conditions experienced throughout much of Scotland caused poor pollution dispersion conditions. This resulted in locally sourced pollution building up. Air masses from the south and east also affected the country (as illustrated in Figure 4.8). Air masses from this direction often transport transboundary pollutants such as PM_{10} and $PM_{2.5}$ from the rest of the UK and continental Europe causing background levels to increase. The combination of these factors resulted in particulate concentrations reaching moderate to high levels in mainly urban locations.

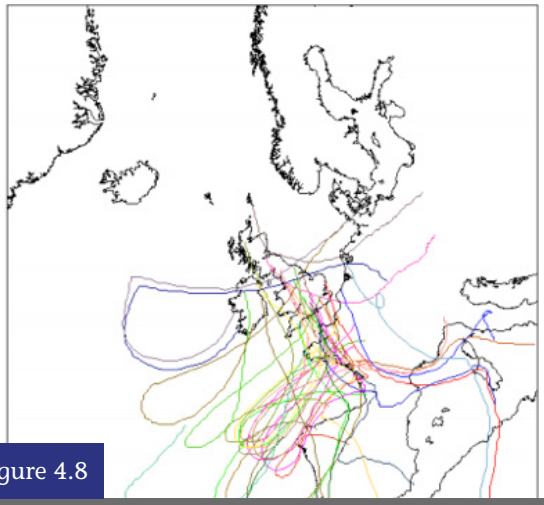


Figure 4.8

Daily air quality Index for $PM_{2.5}$ and PM_{10}

Figures 4.9 and 4.10 are polar plots for the pollutant PM_{10} and $PM_{2.5}$ for the past 7 years (the exception being Glasgow Townhead as it only started monitoring in 2013) from a selection of urban background and background monitoring sites across Scotland. They illustrate that increased particulate concentrations are experienced when southerly and easterly air masses affect the country.

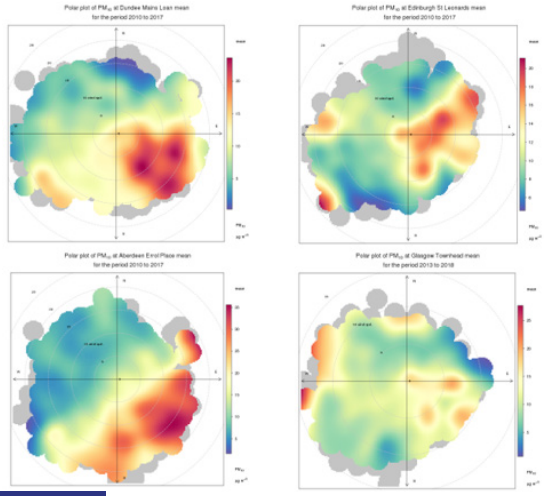


Figure 4.9

Scottish site PM_{10} polar plot

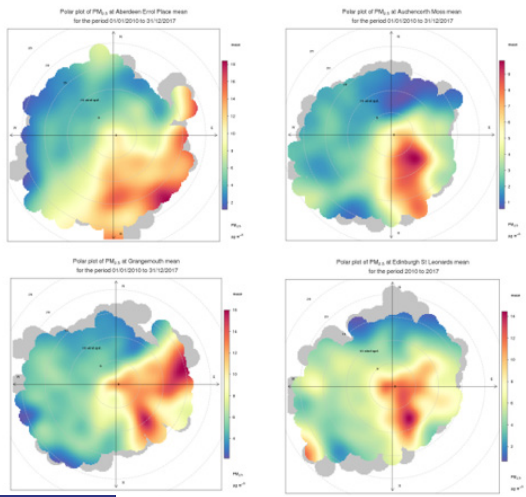


Figure 4.10

Scottish site $PM_{2.5}$ polar plot

5

Air Quality mapping for Scotland

As part of the SAQD project, Ricardo Energy & Environment provides mapped concentrations of modelled background air pollutant concentrations on a 1km x 1km 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
2. Spatially disaggregated emissions information from the UK National Atmospheric Emissions Inventory (NAEI)

The maps 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. This is 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 2016 (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)
- NOx and NO_2

The air pollution measurements used to prepare the maps consists of appropriately scaled PM_{10} monitoring data and automatic monitoring measurements for NOx and NO_2 in 2016. The model also uses Scottish meteorology observations (from Royal Air Force Station Leuchars) to create the Scotland-specific maps as shown in Figure 5.1.

This section discusses the maps of pollutant concentrations produced for the Scottish Government. The full range of maps, together with the most up-to-date interactive technical report, can be found here www.scottishairquality.co.uk/maps.php?n_action=data

This online, interactive reporting format makes reading the report a more dynamic experience. It does so by enabling the reader to interact with the maps and tables within the report itself allowing them to obtain usable data.

5.1 Air Quality Maps for Scotland

The 2016 annual mean NO_2 concentrations for Scotland were modelled for background and roadside locations. Figure 5.1 and Figure 5.2 show modelled annual mean NO_2 concentrations in Scotland for background and roadside locations respectively.

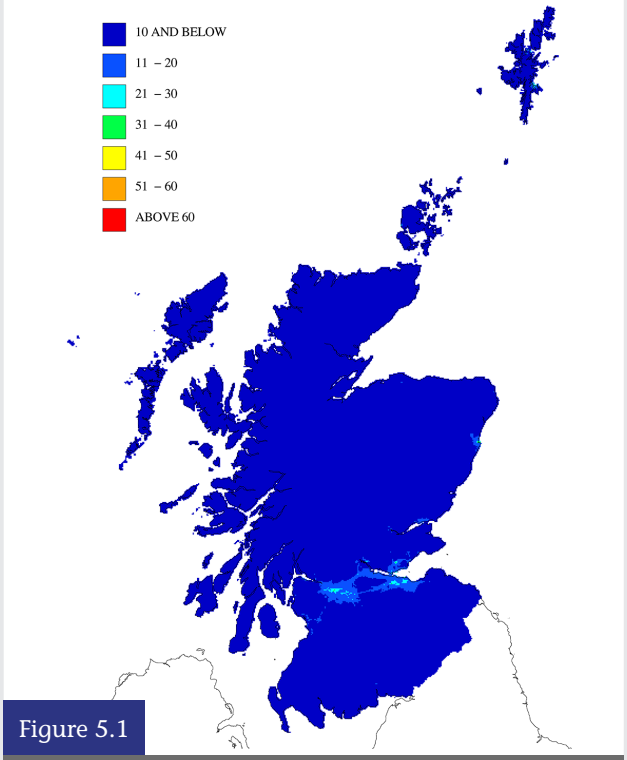


Figure 5.1

Background NO_2 map for 2016 (µg m^{-3}) (Scotland specific)

There were no modelled exceedances of the Scottish annual mean NO_2 objective of 40µg m^{-3} at background locations. Overall exceedances of the Scottish annual mean NO_2 air quality objective were modelled at roadside locations in four of the six zones and agglomerations in Scotland. Exceedances of the annual mean NO_2 objective at roadside locations were modelled at 57 road links (76.2km of road length) in Glasgow Urban Area and at 14 road links (19.6km of road length) in Central Scotland. In Edinburgh Urban Area and North East Scotland, there were fewer than 10 road links where exceedances of the Scottish annual mean NO_2 air quality objective were modelled (between 5km and 8km of road length). 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 for 2016.

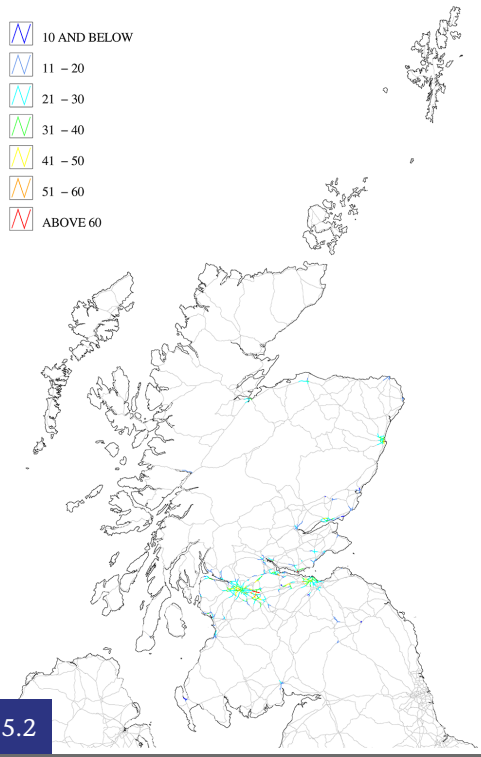


Figure 5.2

Roadside NO_2 map for 2016 (µg m^{-3}) (Scotland specific)

5.2 PM_{10} Maps for 2016

Maps of the modelled 2016 annual mean PM_{10} concentrations for Scotland's background and roadside locations are shown in Figures 5.3 and 5.4, respectively.

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 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 and ammonium-based particles)
- Secondary organic aerosols (SOA)
- Primary particles from long-range transport (e.g. soot particles from biomass burning)
- Sea-salt aerosol
- Iron- and calcium-based dusts

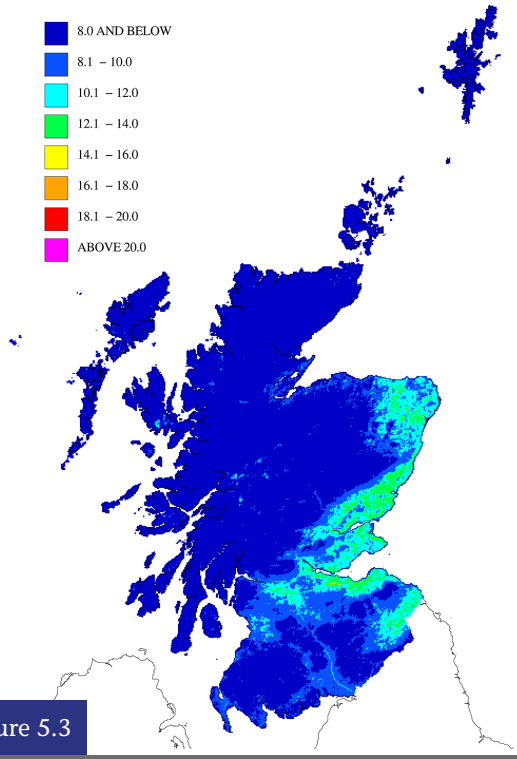


Figure 5.3

Background PM_{10} map for 2016 (µg m^{-3}) (Scotland specific)

The 2016 Scotland-specific model identified no exceedances of the Scottish annual mean PM_{10} objective of 18µg m^{-3} at background locations. Two road links (3.9km of road) in Glasgow Urban Area and one road link (0.9km) in Central Scotland were identified as exceeding the Scottish annual mean PM_{10} air quality objective. No roadside exceedances of the Scottish PM_{10} objective were modelled in other zones or agglomerations in Scotland.

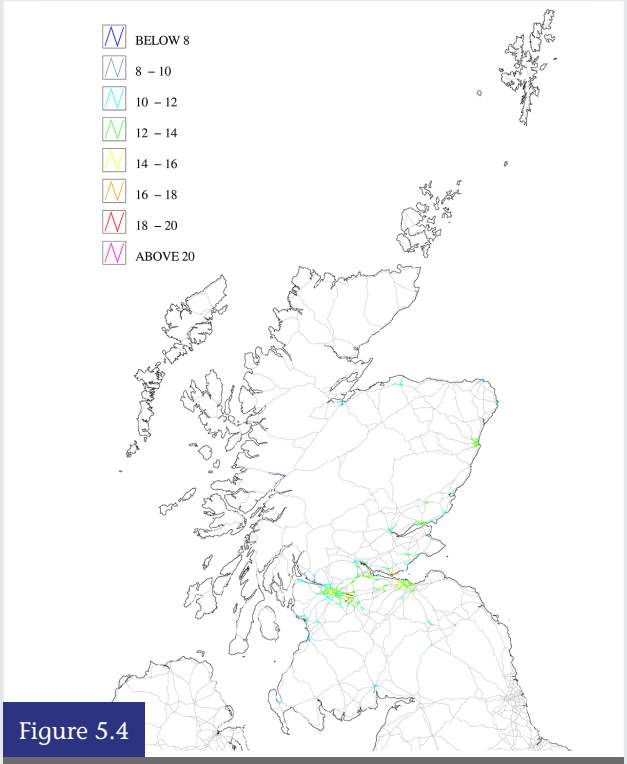


Figure 5.4

Roadside PM_{10} map for 2016 (µg m^{-3}) (Scotland specific)

6

Education

Education has been an ongoing development for air quality in Scotland. Interactive education packages have been developed through the creation of two sections that form part of the Air Quality in Scotland website. The first education website, 'Air Pollution Detectives', was created for schoolchildren in P5 to 7 (8-11 years old). The second website, 'Clear the Air', was developed in partnership with a number of secondary schools for pupils in S1 to S3 (12-15 years old). The education packages can be accessed from the Air Quality in Scotland website (www.scottishairquality.co.uk/education).

Figure 6.1

Air Pollution Detectives and Clear the Air

6.1 Air Pollution Detectives

Initially launched in 2011, the Air Pollution Detectives website has been continuously revised and updated. It was designed to introduce air quality issues to primary school pupils between the ages of 8 and 11. The animated, interactive webpages provide an introduction to air pollution sources and how pupils' actions can impact the air quality around them. Pupils can select individual pollutants to learn more and can take the quiz after each section to see what they have learned. The website is accompanied by a set of teachers' notes to enhance the learning experience and worksheets for pupils are provided. Figure 6.2 shows the worksheets that were updated during 2016. Figure 6.3 shows the additional educational information that accompanies the Air Pollution Detectives website.

Figure 6.2

Updated worksheets are available on the Air Pollution Detectives webpage

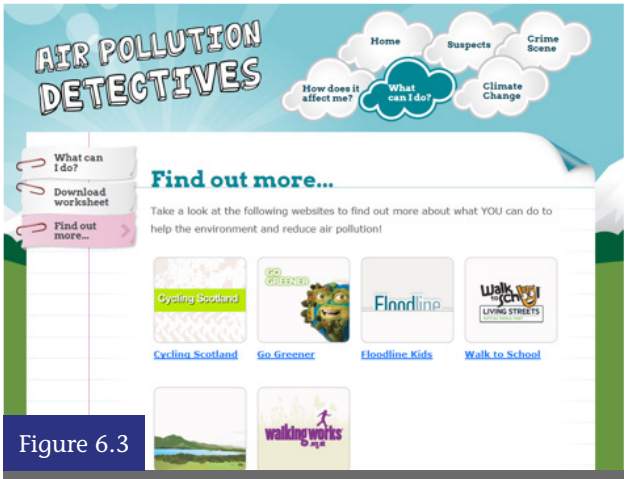


Figure 6.3

Additional information available on the Air Pollution Detectives webpages

Visit the Air Pollution Detectives website at: www.scottishairquality.co.uk/education/

'The online education resources were extremely useful for teaching about sustainability and the environment. The activities were interesting, easy to use and the children loved being Air Pollution Detectives!'

Chloé McCallion, Primary School teacher at West Dunbartonshire Council

Figure 6.4

Clear the Air webpage

6.2 Clear the Air

The Clear the Air website was developed following the success of Pollution Detectives. The webpage, as presented in Figure 6.4, provides an interactive learning experience for air quality and citizen science aimed at secondary school age and above.

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 a citizen science project that enables classes to monitor air quality around the school by using NO_2 diffusion tubes. Pupils are given an NO_2 diffusion tube to take home so they can monitor outside their house.

6.2.1 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 and 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 monitoring data (location and measured concentration) can be uploaded via the school's private user portal so that the results can be displayed on a map (see Figure 6.5). 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 how to conduct the monitoring.

Further information can be obtained at:
http://cleartheair.scottishairquality.co.uk

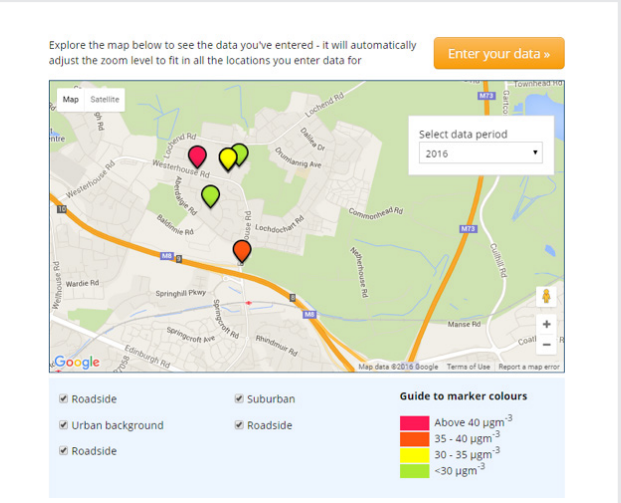


Figure 6.5

Data entry available for each school profile

7

Developments in 2017

7.1 Continued Expansion of the $PM_{2.5}$ Network

During 2017, the $PM_{2.5}$ monitoring network continued to grow to 50 sites from 41 in 2016. The growth in $PM_{2.5}$ monitoring sites (as illustrated in Figure 7.1) is a result on the introduction of the statutory $PM_{2.5}$ objective of 10µg m^{-3} in April 2016.

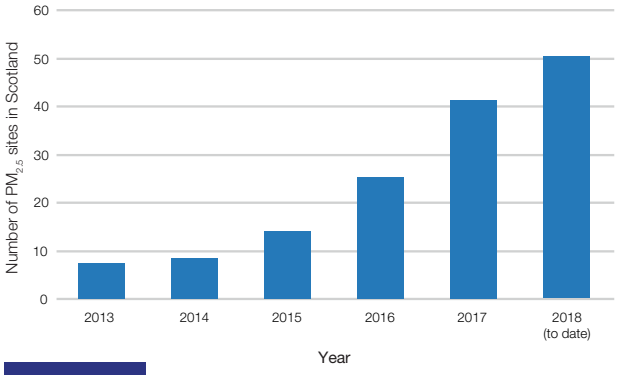


Figure 7.1 Figures stated as of September 2018

Number of $PM_{2.5}$ sites in Scotland since 2013

7.2 Enhanced Air Pollution Forecast Pages

In 2017, the Scottish Government commissioned the updating of the air quality forecasting facility on the Air Quality in Scotland website (www.scottishairquality.scot/latest/forecast). The main aims of the update were to improve the accuracy of the forecasting itself and making it more detailed to Scotland at a local level, revitalise the overall look, and provide the user with more information on weather data and how it related to air pollution forecasting.

To improve the accuracy of the forecast, a sense-checking system has been introduced into the daily forecast provided by the Met Office. This system includes:

- Daily review of the forecast by experienced Scottish-based forecasters
- Use of additional forecasting resources such as the Weather Research and Forecasting (WRF) and Community Multi-scale Air Quality Model (CMAQ) models, and Air Mass back trajectories to sense check the forecast
- Using localised knowledge and understanding of air pollution in Scotland

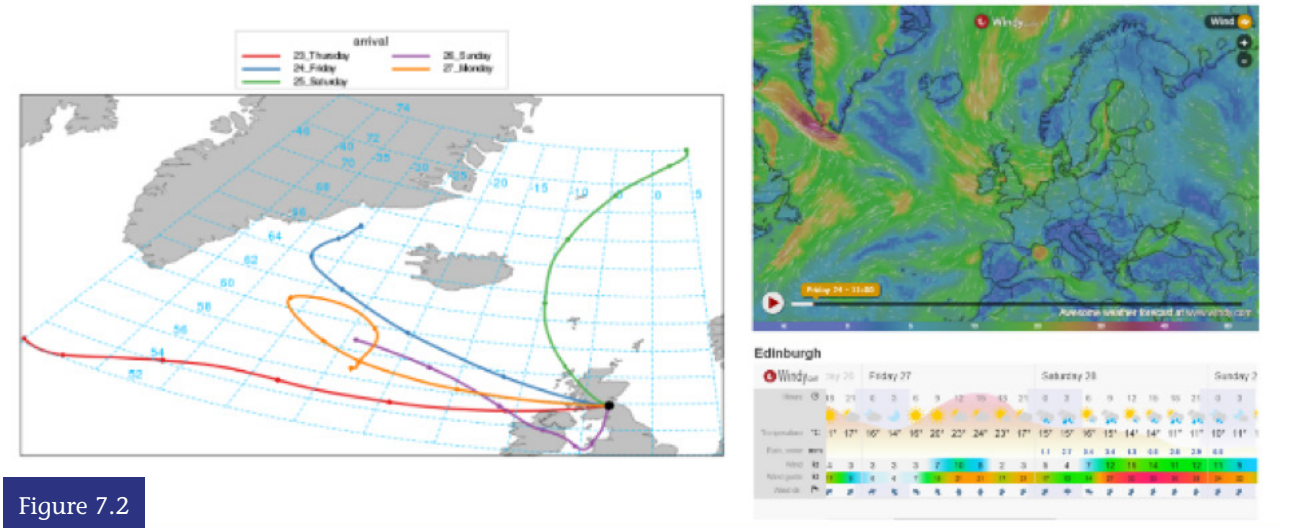


Figure 7.2

Scotland-specific forecasting – additional, informative and interactive graphics

To revitalise the look and enhance the information provided on the forecast facility, interactive graphics illustrating weather conditions and air-mass back trajectories (see Figure 7.2) have been introduced.

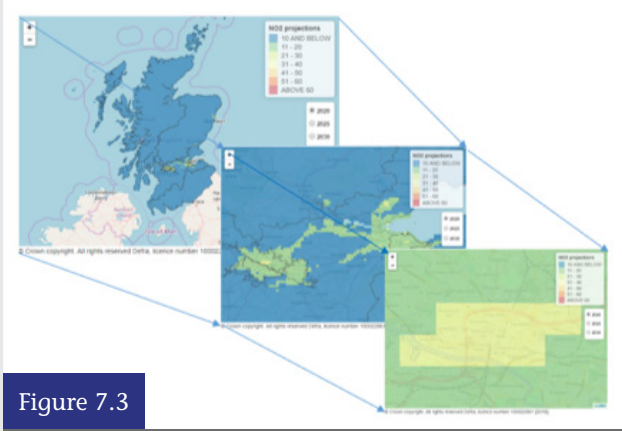


Figure 7.3

Example of Interactive concentration maps from the Scottish Air Quality Maps 2015 report

7.3 Interactive Scottish Air Quality Maps Report

The 'Scottish Air Quality Maps – Annual Mean NOx, NO_2 and PM_{10} modelling for 2015' report was published in January 2018 on the Air Quality in Scotland website. In 2017, the Scottish Government commissioned this report to be produced using an interactive format based on R Markdown. This online, interactive reporting format makes reading a report a more dynamic experience. It does so by enabling the reader to interact with the maps and tables within the report itself allowing them to obtain usable data.

Figure 7.3 illustrates a map provided in the new reporting format and shows how the once-static image can now be interacted with and high-resolution data obtained. The user is able to zoom into the map itself and view areas of interest and obtain data.

7.4 Online NO_2 adjustment for NOx Sector Removal Function

In November 2017, the Scottish Government commissioned a new, online NO_2 adjustment for NOx sector removal function for the Air Quality in Scotland website. The new function went live in April 2018. (www.scottishairquality.co.uk/data/mapping?view=data)

This function was developed in response to Scottish background maps not being compatible with the current excel spreadsheet-based 'NO_2 Adjustment for NOx Sector Removal Tool' (v6.0) hosted on the Department for Environment, Food and Rural Affairs' LAQM website.

The new, fully automated, online function sits within the current background mapping tool already provided on the website. Instead of a separate spreadsheet-based tool, the new function uses R (a language and environment for statistical computing and graphics) and sits as additional drop-down options.

7.5 Introduction of CAFS and LEZ pages

To provide people with easy access to information and the latest updates regarding the CAFS strategy and the implementation of Scotland's Low Emissions Zones (LEZs), dedicated pages have been created on the website (www.scottishairquality.co.uk/lez/). The information provided on these pages includes:

- General information
- Information on CAFS and the LEZs
- Organograms
- Latest updates on the delivery of CAFS and LEZs in Scotland
- The latest and historical CAFS Governance Group meeting minutes
- Latest update reports and meeting minutes from the Glasgow LEZ delivery group and LEZ delivery forum

8

Stay Informed

8.1 Scotland Air Pollution Forecast

A five-day forecast for each local authority in Scotland is available on the Air Quality in Scotland website. The forecasts provide a greater level of detail, which can benefit the public – particularly those with health issues. Forecasts are displayed through a summary table and a map. The five-day forecast map and summary table are available at www.scottishairquality.co.uk/latest/forecast

8.2 Know and Respond

Know & Respond is a free service providing alerts when pollution levels are forecast to increase. Users can subscribe to a specific local authority and will receive push notifications directly to their device if 'moderate' or higher air pollution is forecast each day. Users can choose to receive alerts by text, voicemail or email. Know & Respond alerts are also available via the Air Quality in Scotland app.

8.3 Air Quality in Scotland App

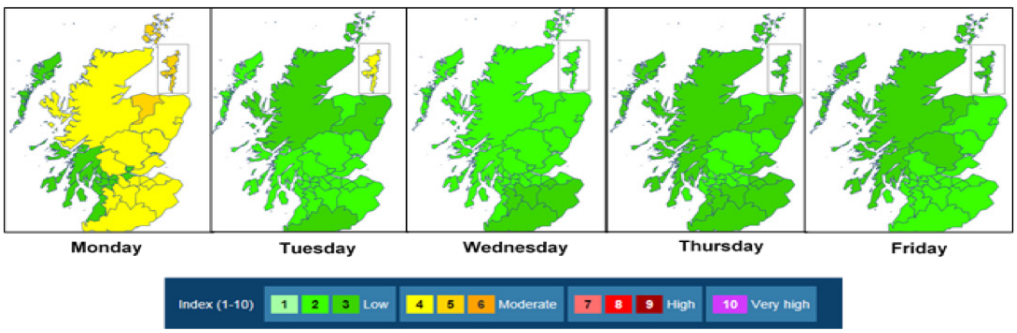
The Air Quality in Scotland app gives the latest air quality levels for each site, forecasts for the day ahead and alerts when air pollution levels increase via the Know & Respond health alerts service. The free Air Quality in Scotland app is available for most mobile devices.

8.4 Email Alerts

Sign up to our email bulletins and receive summaries directly to your inbox. You can choose how frequently you receive them and what type of summary you are interested in.

8.5 Interactive Mapping and Analytical Tools

New visualisation and data analysis tools are available on the Air Quality in Scotland website as beta test web pages. The tools pull data from the SAQD and present it in several pre-analysed formats. These tools enable the data to be customised and filtered to meet individual, requirements, such as viewing air quality in a particular area or for local authorities when preparing annual reports.



8.6 Twitter

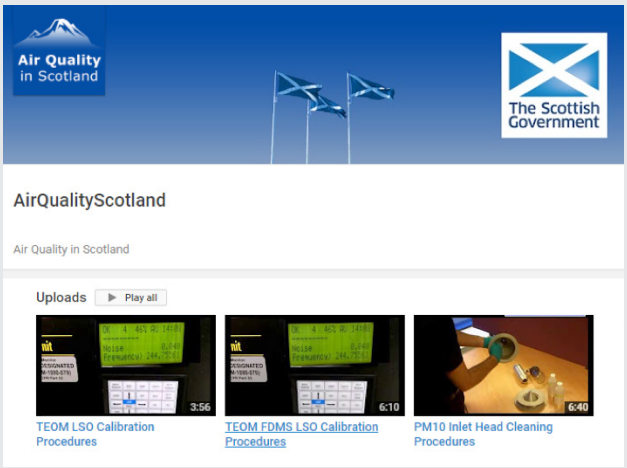
Follow Air Quality in Scotland on Twitter (@scotairquality) for air quality forecasts and summaries of measurements from Scotland.

The service enables you to stay informed about current and forecast air quality including the occurrence of air quality episodes. Health advice and information on the UK Air Quality Index should be considered in conjunction with the tweets, particularly when air pollution is elevated.

8.7 Youtube™

The Air Quality in Scotland YouTube account was initially launched to provide a platform for related videos and it hosts the 'How To' videos for the Local Site Operator manual.

Each video is available through the YouTube website itself, but can also be accessed directly within the Air Quality in Scotland website (www.youtube.com/user/AirQualityScotland).



The Scottish Government

Ricardo Energy & Environment

This report has been produced by Ricardo Energy and Environment on behalf of the Scottish Government.

Its main authors are Alison Loader, David Hector, Dr Colin Gillespie (SEPA), Ashleigh Norrie, Stephen Stratton, Stephen Gray, and Ellis Marshall Padkin

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