The Scottish Government

Air Pollution in Scotland 2010

AEA

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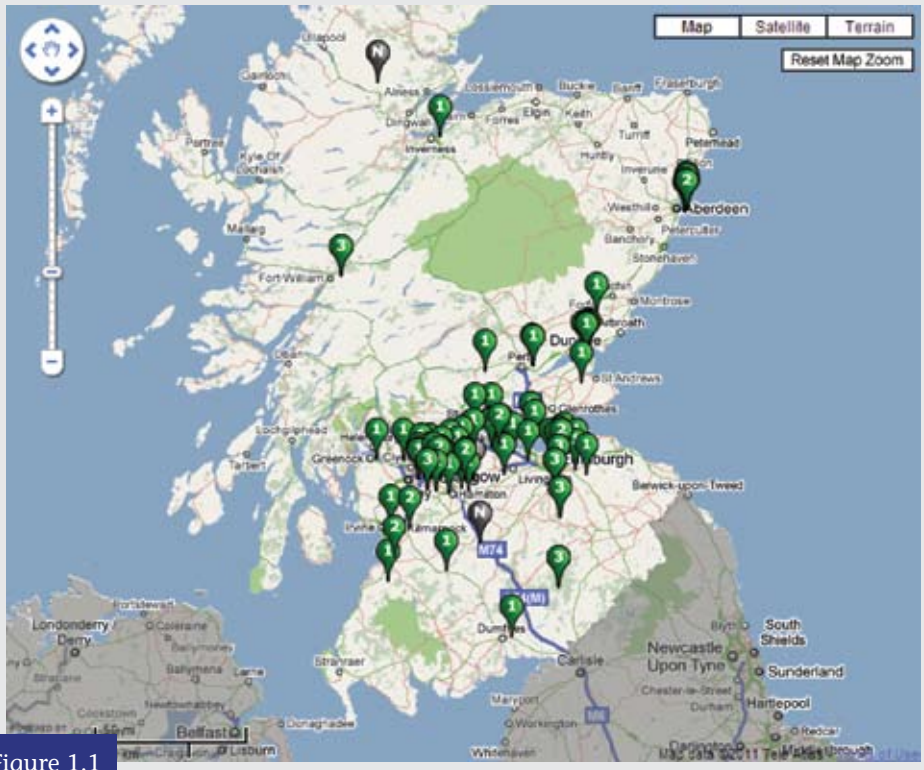
Introduction

This brochure is the fourth in an annual series on air quality in Scotland. Produced by AEA on behalf of the Scottish Government, it aims to provide the people of Scotland, and the wider air quality community, with a summary of air quality monitoring carried out on behalf of Government and Local Authorities during 2010.

Section 2 of this brochure reviews the air quality legislation and policy applicable to Scotland. **Section 3** summarises the main national air quality monitoring programmes, and provides an overview of the provisional data from 2010. **Section 4** provides an analysis of the events and air quality concerns surrounding the eruption of the Eyafjallajökull volcano in Iceland in April 2010. **Section 5** deals with long-term trends in air pollution in Scotland; this is followed by spatial patterns of pollution in **Section 6**. Finally, for readers wanting to find out more, additional web-based and published sources of information on Scotland's air quality are summarised in **Section 7**. A more detailed Annual Report on the Scottish Air Quality Database Project will also be available on the Air Quality in Scotland website (at www.scottishairquality.co.uk/index.php) in May 2011.

The total number of air quality monitoring sites operating in Scotland during part or all of 2010 was 93: eight new sites started up, and five closed down. The number of sites operating at the time of writing is 88. The locations of the monitoring sites are shown in Figure 1.1.



While air quality in much of Scotland is good, some pollutants in some parts of Scotland still exceed air quality objectives. Continued effort to reduce air pollution is therefore vital, together with careful monitoring to assess progress.

Figure 1.1

Locations of Automatic Air Quality Monitoring Sites in Scotland © Google Map Data ©2011 Tele Atlas. (Please note, the colour of the dot showing each site just refers to the air pollution level at the site at the time the screenshot used to generate this map was taken).

2

Legislation and Policy

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

2.1 The European Union Process

Much of the foundation of Scotland's air quality management has its roots within the Air Quality Directives adopted by all Member States of the European Union:

- The European Union's Directive 2008/50/EC on Ambient Air Quality and Cleaner Air For Europe (the Air Quality Directive); and
- Directive 2004/107/EC (the Fourth Daughter Directive) relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

The Scottish Government transposed the Air Quality Directive into Scotland's national law on 10th June 2010.

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

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

A major revision of the Strategy was published in July 2007. This included a detailed update of the effectiveness of the previously existing provisions and objectives, and proposed new regulatory measures and objectives to be adopted. All the existing objectives for pollutants were maintained. Additional objectives were adopted for the $PM_{2.5}$ particulate fraction, to protect human health (12 µg m^{-3} annual mean in Scotland), and for ozone, to protect ecosystems - based on accumulated ozone dose. In addition, a series of policy measures was considered for adoption, following detailed cost-benefit analysis. The full revised Air Quality Strategy and its extended series of associated technical annexes can be seen at: www.scotland.gov.uk/Topics/Environment/Pollution/16215/6116.

2.3 Local Air Quality Management

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

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

The Scottish Government Policy Guidance and Technical Guidance on LAQM are available online, from www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Pollution-1/16215/6116.

At the time of writing, 12 of Scotland's 32 Local Authorities have declared Air Quality Management Areas. Since last year's edition, three additional air quality management areas have been declared, all in Falkirk. These are: Banknock and Haggs (NO_2 annual mean), Falkirk Town Centre (NO_2 annual mean) and Falkirk Town Centre (NO_2 hourly mean). This makes a total of 24 management areas in the 12 Local Authority areas. Of these 12, three have declared an AQMA for PM_{10} alone, four have declared AQMAs for NO_2 and PM_{10} together, five have declared an AQMA for NO_2 only and one has declared for SO_2 and NO_2 (annual mean and hourly objective). A summary of the current AQMAs is presented in Table 2.1 together with the locations of these AQMAs, and the pollutants they deal with. All Authorities with AQMAs have either prepared, or are currently preparing, Air Quality Action Plans for their AQMAs.

Table 2.1 Air Quality Management Areas declared by Local Authorities in Scotland

Council	Pollutant	Source	Date Declared	AQMAs
Aberdeen	NO_2 & PM_{10}	Roads	July 2006, December 2008	3
Dundee City	NO_2	Roads	July 2006	1
East Dunbartonshire	NO_2 & PM_{10}	Roads	December 2005	1
Edinburgh	NO_2	Roads	Dec 2000, 2006 and March 2009	3
Falkirk	SO_2 (1) & NO_2 (3)	Industry (SO_2), Roads (NO_2)	November 2005, March 2010	4
Fife	NO_2 & PM_{10}	Roads	October 2008	1
Glasgow City	NO_2	Roads	January 2002, July 2007	3
Midlothian	PM_{10}	Domestic	April 2008	1
North Lanarkshire	PM_{10}	Roads	December 2005, June 2008	4
Perth & Kinross	NO_2 & PM_{10}	Roads	May 2006	1
Renfrewshire	NO_2	Roads	September 2005	1
South Lanarkshire	PM_{10}	Roads	November 2008	1

As part of the Scottish Air Quality Database project, AEA provide mapped concentrations of pollutants on a 1 x 1 km square grid basis. These pollution maps combine measurement data with emissions information from the National Atmospheric Emissions Inventory (NAEI) to provide estimated pollutant concentrations for the whole of Scotland.

The 2009 background maps, produced for the Scottish Government, used measurements from Scottish air quality monitoring sites and Scottish meteorology. The pollutant data used in the mapping work presented here uses automatic monitoring data for NO_x and NO_2, and appropriately scaled gravimetric PM_{10} monitoring data (FDMS, Partisol and VCM corrected TEOM data), from 2009, in conjunction with Scottish meteorology data (from RAF Leuchars) to create the Scotland-specific model. For the 2009 roadside maps, the use of Scotland-specific data permits derivation of a roadside pollutant calibration coefficient that is sensitive to the traffic flow on Scottish road links. Within the model this allows determination of the contribution of roadside emissions to the increase in local pollutant concentrations. Where possible the modelled pollutant concentrations have been verified against 2009 Scottish air pollutant measurements.

In addition to the 2009 background and roadside maps, background maps of NO_x and NO_2, and gravimetric PM_{10} have been prepared for 2010, 2015, and 2020. These maps are produced using current emissions projections. Sector emissions for each 1 x 1 km grid for each Local Authority area were calculated. The 2009 base year maps and the projections for 2010, 2015, and 2020 should be used for all new Local Authority assessments.

3

Networks and Data

3.1 Monitoring in Scotland

A wide range of air quality monitoring activities are carried out in Scotland. Some monitoring sites are run as part of UK-wide monitoring networks; others are operated by Local Authorities in order to meet local objectives. The following Air Quality Strategy pollutants were monitored in Scotland during 2010:

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO_x) and Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Particles (as PM_{10} and $PM_{2.5}$), also using the Black Carbon technique.
- Ozone (O_3)
- Benzene
- 1,3-Butadiene
- Polycyclic Aromatic Hydrocarbons (PAH)
- Lead

The locations of automatic monitoring sites are shown in Figure 1.1 (in section 1). These provide high-resolution hourly information on a wide range of pollutants. Data from national network monitoring sites are updated hourly in near-real time on the Scottish Air Quality Database, whilst data from Local Authority operated monitoring sites are updated either hourly or daily, depending on the station configuration. Photographs of the Perth Crieff and Kilmarnock John Finnie Street sites, which were added to the Network in 2010, are shown in Figure 3.1.

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 metals including lead.

In addition, many Local Authorities use NO_2 diffusion tubes as part of their Local Air Quality Management (LAQM). These are low cost single-use samplers that absorb specific pollutants directly from the air and need no power supply. They measure average concentrations over a specified sampling period (typically one month) and provide invaluable data for screening purposes, 'hot-spot' identification, local impact assessment and mapping overall levels of pollution across the country as a whole.

Figure 3.1

Perth Crieff (left) and Kilmarnock John Finnie Street (right) Monitoring Sites

Air quality data for Scotland are stored in a comprehensive database that is available on-line at www.scottishairquality.co.uk and provides comprehensive and rapid communication of air quality information to the public.

Monitoring of a range of important pollutants for which no specific UK Objective has been set is also routinely undertaken within national networks in Scotland. These include heavy metals (urban and rural), ammonia, black carbon and acid deposition.

3.2 King's College London Volatile Correction Model

Many monitoring sites use the Tapered Element Oscillating Microbalance (TEOM) to measure PM_{10}. The relatively high operating temperature of this instrument (necessary to prevent condensation on the filter) can result in the loss of volatile components of the particulate matter sampled, causing under-estimation of the PM_{10} concentration.

However, it is possible to correct for this, using the Volatile Correction Model (VCM) developed by King's College, London. The VCM uses data from Filter Dynamic Measurement Systems (FDMS) PM_{10} analysers in the region (which measure both the volatile and non-volatile fractions) to calculate an appropriate correction based on the location of the instrument and the period of the measurements. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent. The TEOM air quality data for 2009 submitted by the UK to the European Commission in 2010 was corrected by the Volatile Correction Model. To access the model and for more information, visit www.volatile-correction-model.info.

3.3 Key Results for 2010

This section provides a summary of results from both automatic and non-automatic monitoring in Scotland in 2010 including analysis of compliance with Air Quality Strategy Objectives. Further information is provided on the Scottish Air Quality website at www.scottishairquality.co.uk. This will be supplemented by further information and data to be published in the full Annual Report later this year.

Note that automatic data for 2010 summarised here are not yet fully ratified; there may therefore be subsequent changes to the data which may affect the results presented here.

Carbon monoxide was monitored using automatic techniques at six sites during 2010. Three of these were in Glasgow, one in Edinburgh, and two in North Lanarkshire (Croy and Harthill West). All achieved the Air Quality Strategy (AQS) Objective for this pollutant.

Nitrogen dioxide data from 73 sites utilising automatic monitoring are available for all or part of 2010. Seventeen of these sites had less than 75% data capture, either because of instrument faults or because the site started up or closed part-way through the year. Twenty sites had annual average concentrations exceeding the AQS Objective for the annual mean (40 µg m^{-3}). These were sites located in Aberdeen, Dundee, East Dunbartonshire, Edinburgh, Falkirk, Glasgow, North Lanarkshire, Paisley, Perth and West Lothian. A total of 10 sites also exceeded the AQS Objective of 200 µg m^{-3} for the hourly mean, more than the permitted 18 times (this includes two of the sites which had less than 75% data capture for the year).

Of the Local Authorities with monitoring sites exceeding the AQS Objectives for NO_2 during 2010, all except one (West Lothian) already have Air Quality Management Areas in place. The highest annual mean NO_2 concentrations, based on provisional data, were measured at Glasgow Kerbside and Edinburgh St John's. Both these sites – which are located close to very busy roads - recorded annual mean NO_2 concentrations in excess of 70 µg m^{-3}.

Sulphur dioxide data from 14 sites utilising automatic monitoring are available for all or part of 2010. At two sites (Falkirk's Grangemouth and Grangemouth Moray sites), the AQS Objective for the 15-minute average was exceeded more than the permitted 35 times. All other sites in Scotland met the requirements of the AQS for 15-minute, 1-hour and 24-hour mean SO_2 in 2010.

Particulate matter (as PM_{10}) was monitored at 71 sites in 2010. Of these, 51 achieved 75% data capture (the minimum required for a valid annual mean). All data from Tapered Element Oscillating Microbalance (TEOM) analysers have been adjusted using the Volatile Correction Model (VCM) to provide gravimetric equivalent data.

Overall, 29 sites exceeded the Scottish annual average PM_{10} Objective of 18 µg m^{-3} and a further five equalled this Objective. Fifteen also exceeded the Scottish daily

mean Objective of 50 µg m^{-3} on more than the seven days permitted during the year. No site, however, exceeded the UK AQS Objective of 40 µg m^{-3} for the annual mean PM_{10}, or the daily mean objective (50 µg m^{-3}), on more than the permitted 35 days per calendar year.

The finer $PM_{2.5}$ particulate fraction was monitored at seven sites in Scotland during 2010. This includes four sites in urban background areas and three in other types of environment. All are required for monitoring under the Ambient Air Quality Directive. The Scottish AQS Objective of 12 µg m^{-3} for $PM_{2.5}$ was met at 5 of these sites, equalled at Glasgow Centre and exceeded at Glasgow Kerbside.

The Ambient Air Quality Directive sets an exposure reduction target for $PM_{2.5}$, based on the Average Exposure Indicator (AEI). This statistic is the three-calendar year running annual mean concentration averaged over all urban background measurement stations for a "baseline" period of 2009, 2010 and 2011. The reduction to be achieved by 2020 depends upon the "baseline" AEI. Over the "baseline" period so far, the mean $PM_{2.5}$ concentration at Scotland's four urban background sites was 9.5 µg m^{-3}. Based on this value, it is likely that the reduction required in Scotland by 2020 will be 10%. For more information on the Ambient Air Quality Directive's provisions regarding $PM_{2.5}$, please see the 2009 report in this series[1].

Ozone data are available from 11 sites with automatic analysers in 2010. Ozone may persist for several days and be transported over long distances. This means that Local Authorities have little control over ozone levels in their area. The target value for the 8-hour running mean Objective of 100 µg m^{-3} was exceeded on more than the permitted ten days at one site: Peebles.

Benzene and 1,3-butadiene are monitored using automatic techniques at the rural Auchencorth Moss site (Midlothian) and at Glasgow Kerbside, as part of the Automatic Hydrocarbon Network. In 2010 neither site achieved the minimum data capture of 75% required for a valid annual mean, for either pollutant. However, the running annual means (based on available data) were well within the UK Air Quality Strategy objectives for benzene and 1,3-butadiene, and the Ambient Air Quality Directive limit value for benzene. Benzene is also measured using a non-automatic pumped tube sampler, in Grangemouth, as part of the UK Non-Automatic Hydrocarbon Network. This site also met the AQS Objective and EC Directive limit value in 2010.

PAH monitoring takes place at four sites: however, the full 2010 dataset is not yet available.

Lead is monitored at two sites in Scotland: the full dataset for 2010 is not yet available but previous years' data from both sites have established that ambient concentrations are well within the AQS Objective and EC limit value.

3.4 Summary

Provisional results from Scotland's network of automatic air quality monitoring stations in 2010 show that the Air Quality Strategy Objectives for carbon monoxide, benzene and 1,3-butadiene, which were met by the due dates, continue to be met, and air quality over much of the country is good.

However, there remained a number of sites close to busy roads in urban areas that did not meet AQS Objectives for nitrogen dioxide and/or particulate matter as PM_{10}. The Scottish Objective for $PM_{2.5}$ was met or equalled at urban background sites, but not Glasgow Kerbside, which is representative of locations close to busy roads. At two sites in the industrial Grangemouth area, the AQS Objective for the 15-minute average SO_2 was exceeded more than the permitted 35 times. One site (Peebles) recorded an exceedence of the Objective for ozone: given the nature of this pollutant, occasional ozone exceedences remain a possibility in future.

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

[1] Scottish Government "Air Pollution in Scotland 2009" [online].
Available at www.scottishairquality.co.uk/documents/reports2/281100426_Scottish_Newsletter_2009-vFF4_screenopt.pdf. [Accessed 10th Mar 2011].

4

Eyjafjallajökull

On 20th March 2010, Iceland's Eyjafjallajökull volcano began erupting for the first time in 190 years. The main summit eruption of Eyjafjallajökull started on 14th April, sending a plume of ash and gases including sulphur dioxide into the atmosphere. The size of the eruption itself was relatively weak, but the initial phase was extremely explosive due to meltwater from the glacier causing the magma to fragment into highly abrasive glass particles which were thrown upwards in a plume to 13 km.

Following advice from the UK Met Office (the north-west European Volcanic Ash Advisory Centre) UK airspace was closed for six days due to the risk of damage to aircraft flying through the plume. A significant reduction in NO_x was measured near some major airports during the period that air space was closed[2]. There was concern that Eyjafjallajökull's activity might trigger the eruption of a nearby and larger volcano, Katla - an occurrence last seen in 1821. However, this has not happened to date.

From 14th April the volcano continued to erupt intermittently for several weeks (Figure 4.1). Typically the dust plume from the volcano was between 4 km and 6 km above sea level as it passed over the UK, and under such conditions there would be no expected impact on air quality.

The NOAA HYSPLIT model forecast that the ash plume might be driven over Shetland on 15th April. Under certain meteorological conditions grounding of the plume could occur, increasing levels of air pollution (sulphur dioxide and particulate matter) at ground level (Figure 4.2) There were indeed reports of odour and falling ash in the Northern Isles, and a Scottish Environment Protection Agency (SEPA) news item of 16th April reported that ash had fallen in Lerwick, Shetland. An update later the same day reported that ash samples from Lerwick, and also ash samples from Aberdeen, appeared to have properties consistent with volcanic origin[3].

Figure 4.1

Images of the ash plume taken during April 2010
Source: Icelandic Met Office, http://en.vedur.is/

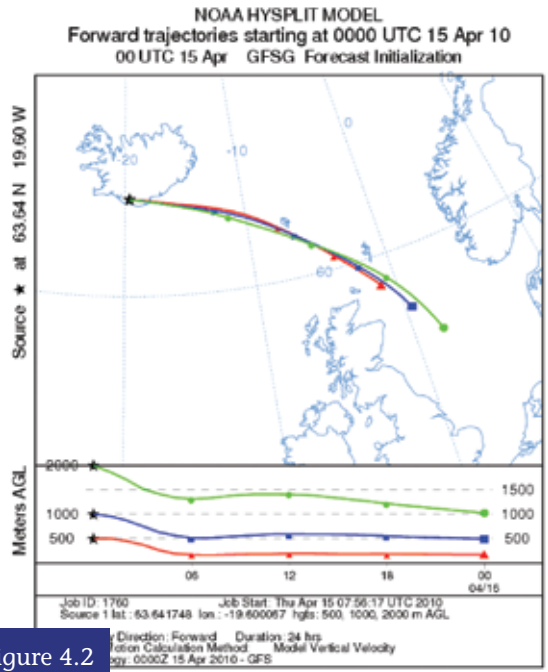


Figure 4.2

NOAA HYSPLIT output showing the forecast movement of air masses from Iceland over the Northern Isles (as provided by NOAA website, http://ready.arl.noaa.gov/HYSPLIT.php)

[2]Barratt, B and Fuller, G (2010) "Preliminary analysis of the impact of airport closures due to the 2010 Eyjafjallajökull volcanic eruptions on local air quality" [online]. Available at www.londonair.org.uk/london/reports/volcano_airport_closures.pdf [Accessed 4th Nov 2010].

[3]SEPA (2010) "Volcanic ash cloud – the latest news from SEPA - update 1" News update of 16th April 2010 [online]. Available at www.sepa.org.uk/about_us/news/2010/volcanic_ash_cloud_%e2%80%93_the_lates.aspx [Accessed 9th Feb 2011].

Despite this, ambient concentrations of sulphur dioxide (one of the gases emitted by volcanoes) at Scottish monitoring sites including the Lerwick Staney Hill site showed no elevation over this period. Nor did ambient concentrations of PM_{10} or $PM_{2.5}$ (not measured at Lerwick) rise above typical concentrations at other Scottish monitoring sites.

On April 19th the NOAA HYSPLIT model forecast that the ash plume might once again be driven over the UK. Air quality monitoring data from around the UK were examined for any evidence of this.

Updates were provided on the Scottish Air Quality Website, addressing public concern about possible air quality impacts during this dramatic event. However, throughout the eruption period, measured ambient concentrations of PM_{10} and SO_2 at Scottish sites remained within the usual range for the time of year. Although the volcano may have contributed to concentrations of particulate matter and sulphur dioxide at ground level, news items on the website stated that there was no significant increase in ambient concentrations measured by the Scottish air quality network[4].

There is still much to be learned from the vast amount of data collected, and many organisations continue to carry out research into the volcanic eruption and its effects.

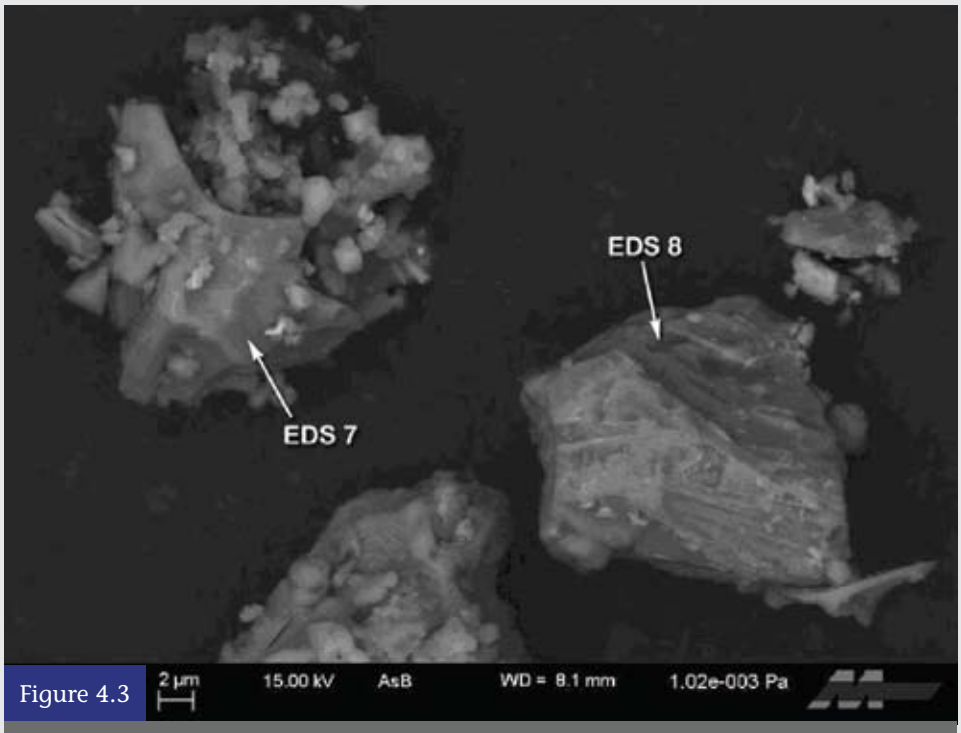


Figure 4.3 Ash Sample collected by SEPA: picture by Macaulay Institute[5]. Courtesy of SEPA.

[4]AEA (2010) "The Eyjafjallajokull Volcanic Ash Cloud and its Effects on Scottish Air Quality. Update 06 May 2010" [online].
Available at www.scottishairquality.co.uk/documents/news/Eyjafjallajokull_Volcanic_Ash_Cloud_06may2010_Scottish_update.pdf [Accessed 9th Feb 2011].

[5]SEPA (2010) "Volcanic ash cloud – the latest news from SEPA - update 2" [online].
Available at www.sepa.org.uk/about_us/news/2010/volcanic_ash_cloud_%e2%80%93_the_lat-1.aspx

5

Air Quality Trends

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

This section summarises how pollution levels in Scotland have changed over the last 20 years, concentrating on those pollutants for which Air Quality Strategy Objectives are currently not met in Scotland (i.e. nitrogen dioxide, particulate matter as PM_{10} and ozone). The annual mean is used here, as this is relevant to long-term exposure to pollution.

Current policy is to include all data in this analysis, but it should be noted that this may affect the robustness of the trends shown. This is because there have been substantial increases in the number of monitoring sites. There were relatively few background monitoring sites up until 2000, and relatively few roadside/kerbside sites until 2002. Therefore, trends in the earlier years should be regarded with caution. Recent research has indicated that for reasonably robust annual mean trends analysis, at least four monitoring sites with good annual data capture should be available[6].

5.1 Nitrogen Dioxide

Within Scotland (and throughout the UK) the most widely exceeded AQS objective applies to annual mean NO_2 concentration. It is therefore important to understand how trends in this pollutant are varying with time.

Trends in NO_2 cannot be considered without also taking into account the variations in total NO_x concentrations, since a large proportion of NO_2 is formed from the oxidation of NO emitted from source (vehicle tailpipe or chimney stack). At roadside locations, direct emissions of NO_2 are also important; the effect of these is discussed in more detail later in this section.

Figure 5.1 presents the annual mean variation in measured NO_x concentrations at roadside/kerbside and urban background monitoring stations since reliable measurements began in Scotland in 1987. (The graph is lighter in colour for the earlier years when there were less than four sites in operation, darker for subsequent years with at least four sites). Despite a limitation in the number of monitoring stations in the early years, there is a clear long-term improvement in NO_x concentrations, due to the reductions in emissions from combustion sources which UK and EC policies have delivered.

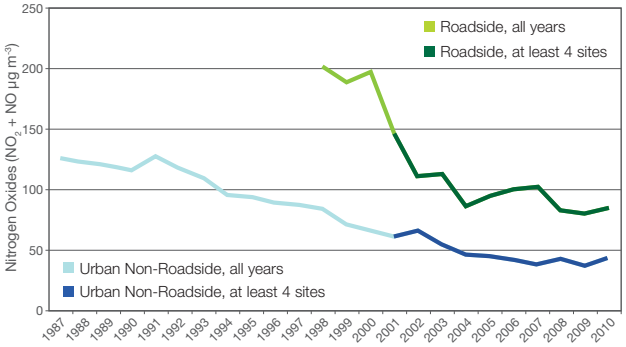


Figure 5.1

Trends in annual mean NO_x concentration at urban background and roadside sites in Scotland: 1987 - 2010.

Figure 5.2 below shows the corresponding trends for NO_2, and also demonstrates a long-term decline in concentrations of this pollutant. In this case, however, the progression is less smooth, principally due to the dependence of NO_2 concentrations on atmospheric ozone chemistry and hence the predominant weather conditions from year-to-year. Provisionally 2010 shows a slight increase on 2009: however, average roadside concentrations of NO_2 were just below 40 µg m^{-3} for the third consecutive year. This is despite accepted evidence of a levelling-off in the reduction in concentrations in recent years which UK experts (AQEG 2007)[7] believe may be due to:

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

[6]Draft report - University of Glasgow, School of Mathematics and Statistics.

[7]Air Quality Expert Group (2007) "Trends in primary nitrogen dioxide in the UK". [online].
Available at www.defra.gov.uk/environment/quality/air/airquality/publications/primaryno2-trends/index.htm [accessed 25th Feb 2011].

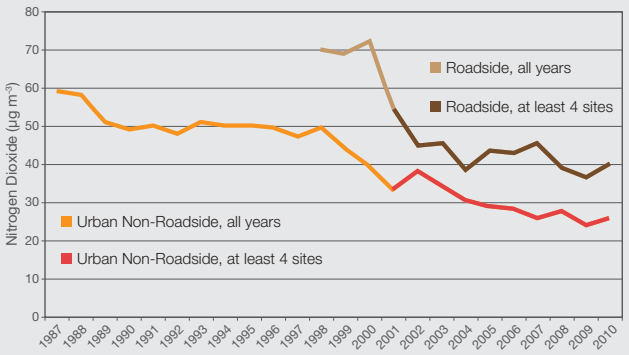


Figure 5.2

Trends in annual mean NO_2 concentration means at urban background and roadside sites in Scotland: 1987 - 2010

5.2 Ozone

Figure 5.3 illustrates the long-term trends in ozone concentration. There is a slight upward trend in ozone concentration at rural and remote sites, and a clear increase at urban background sites (although the latter appears to have levelled off in recent years).

At urban background sites the trend clearly increased at urban background locations until 2004 but has, perhaps, levelled off in recent years. 2010 appears to have been a low year compared to years 2004- 2009.

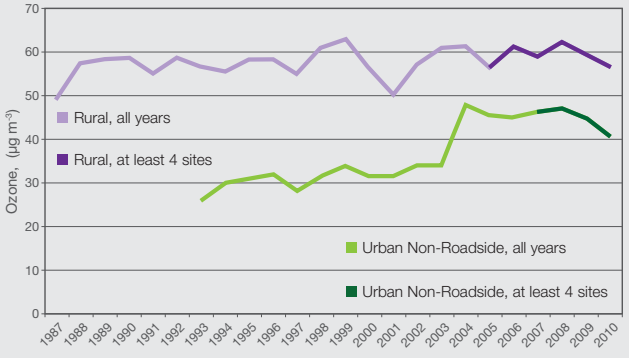


Figure 5.3

Trends in annual mean ground-level ozone concentration at sites in Scotland: 1987 - 2010

5.3 Particulate Matter (PM_{10})

Finally, Figure 5.4 shows the trends in PM_{10} particulate matter across Scotland. These are of great interest since:

- Scotland has adopted a more stringent annual mean PM_{10} objective than the rest of the UK, of 18 µg m^{-3},to have been achieved by the end of 2010.
- Scientists believe there is no safe threshold for this pollutant, in terms of human health effects.

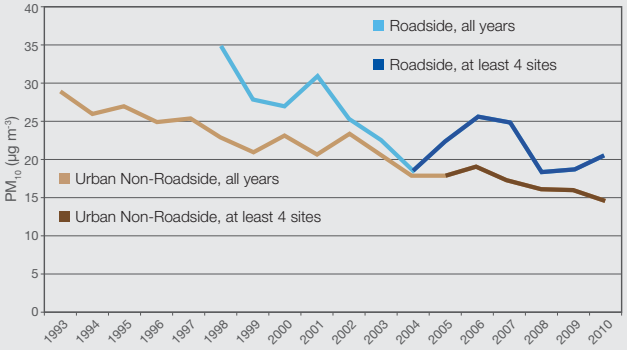


Figure 5.4

Trends in annual mean concentration of PM_{10} particulate matter at urban background and roadside sites in Scotland: 1993 - 2010.

Figure 5.4 shows that average urban background PM_{10} concentrations have decreased since 1993, and are below the Scottish objective of 18 µg m^{-3}. For roadside sites the trend is similar but with more year-to-year variation. There are two possible reasons for this:

1. Concentrations at roadside are more likely to be affected by localised or short-term factors – such as road works or traffic flow changes.
2. The number of roadside monitoring sites in particular has increased year-on-year since 2004 (Table 5.1). As highlighted above, this may affect the trends observed.

Table 5.1 Numbers of PM_{10} Monitoring Sites in Scotland

	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Roadside	-	-	-	-	-	-	-	-	-	-	-	5	13	18	27	41	49	69
Urban Background	1	1	1	1	2	2	2	3	3	2	3	3	4	5	6	8	9	10

6

Maps of Air Quality

This section discusses the maps of pollutant concentrations produced for the Scottish Government, as introduced in Section 2. The full range of maps, together with a technical report describing the method[8], can be found on the "Maps" page of the Scottish Air Quality website at www.scottishairquality.co.uk/maps.php. Here we summarise the main findings of this work.

6.1 NO_2 maps for 2009

The 2009 annual mean concentration of NO_2 was modelled for Scotland at background and roadside locations. Only the background maps are discussed here.

Figure 6.1 shows modelled annual mean background concentrations of NO_2. Throughout much of Scotland, the 2009 ambient NO_2 concentration was low. Typically NO_2 concentrations were less than 10 µg m^{-3}, and therefore well below the Scottish Air Quality Objective of 40 µg m^{-3}. Higher NO_2 concentrations can be seen within built-up areas due to combustion-derived NO_2 emissions, mainly from road transport. The outlines of major cities such as Glasgow, Edinburgh, Aberdeen and Dundee are clearly visible in Figure 6.1 for this reason, as are main road links between them.

Figure 6.2 shows an enlargement of Figure 6.1 allowing these features to be seen more clearly around the urban conurbations of Edinburgh and Glasgow and along the length of the M8 commuter belt between the two cities.

6.2 PM_{10} maps for 2009

The 2009 annual mean concentrations of gravimetric PM_{10} were modelled for Scotland at background and roadside locations. Again, only the background maps are discussed here: the roadside maps can be found on the Scottish Air Quality website.

Figure 6.3 shows modelled annual mean PM_{10} concentrations for 2009. Throughout much of Scotland, the 2009 ambient PM_{10} concentrations were low. Typically PM_{10} concentrations were less than 10 µg m^{-3}, and therefore well below the Scottish Air Quality Objective of 18 µg m^{-3}. Like NO_2, the spatial variation of PM_{10} reflects the location of built-up areas, major road links, and moreover the contribution of combustion derived PM_{10} emissions to ambient concentrations. For example, the A74 heading southwards from Glasgow towards the border is clearly visible in Figure 6.3.

Road transport is not the sole source of ambient PM_{10}. Other components include:

a) secondary inorganic aerosols (e.g., sulphate, nitrate, ammonium-based particles)

b) secondary organic aerosols

c) particles from long range transport

d) sea salt aerosol, and

e) iron and calcium based dusts.

These natural and secondary components contribute to the total PM_{10} mass particularly in background areas where there are limited numbers of combustion sources. Wind-blown sea salt and dusts, e.g., soil, are believed to be the source of the elevated PM_{10} concentrations along the eastern coast of Scotland and Shetland.

Figure 6.4 shows an enlarged image of the central belt of Scotland. The influence of road traffic emissions is clearly visible. The triangle of roads formed by the M8, M9 and A80 linking Glasgow, western Edinburgh and Falkirk can be clearly seen. The modelled annual mean PM_{10} concentration exceeded the Scottish PM_{10} Air Quality Objective by 2 µg m^{-3} in two grid cells. The grid cells were located on the western outskirts of Edinburgh, not in the centre, around the junction of the M9, M8 and A8. This location is also close to Edinburgh airport and contains various industrial sources which were believed to contribute to the elevated modelled PM_{10} concentrations in this area.

[8]Lingard, J.J.N., and Kent, A.J.: Scottish air quality modelling for 2008 and projected concentrations for 2010, 2015 and 2010: annual mean PM_{10}, NO_x and NO_2. AEAT/ENV/R3030 Issue 1.

www.scottishairquality.co.uk/documents/reports2/296100915_ScottishAQmapping2008_Issue1.pdf

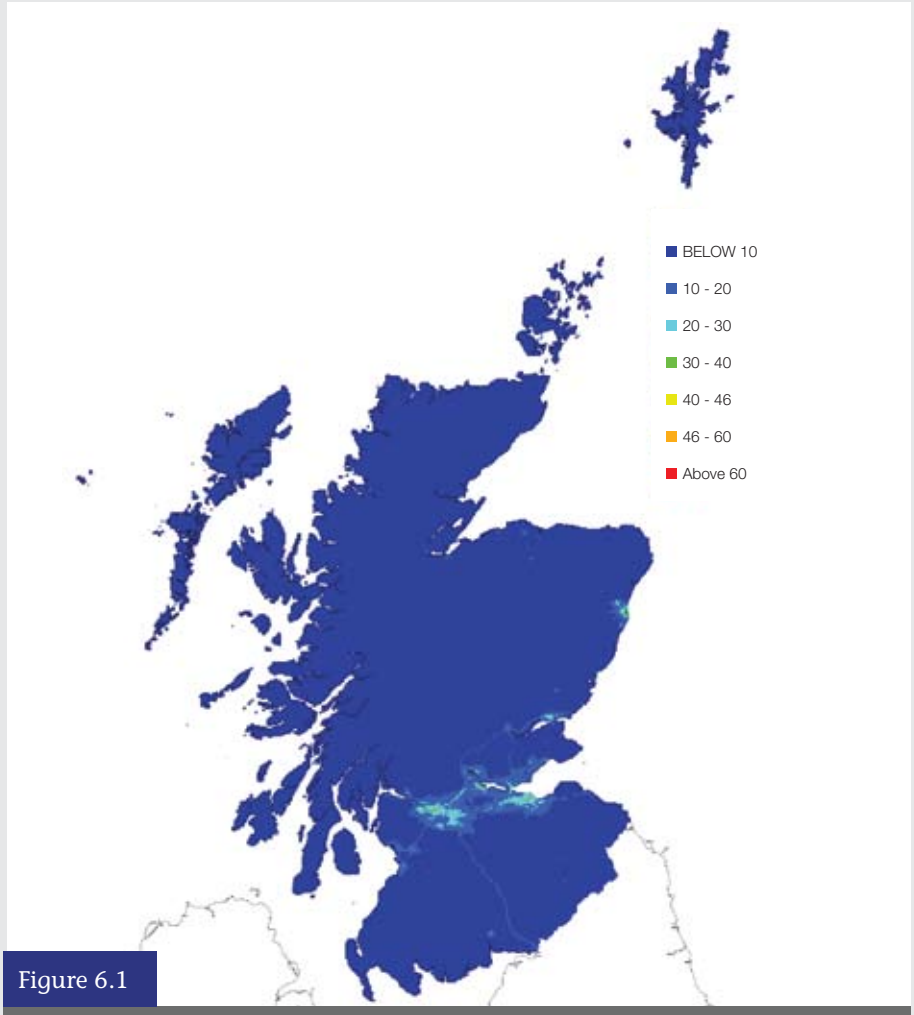


Figure 6.1

2009 background annual mean NO_2 concentration (Scotland-specific model, µg m^{-3}).

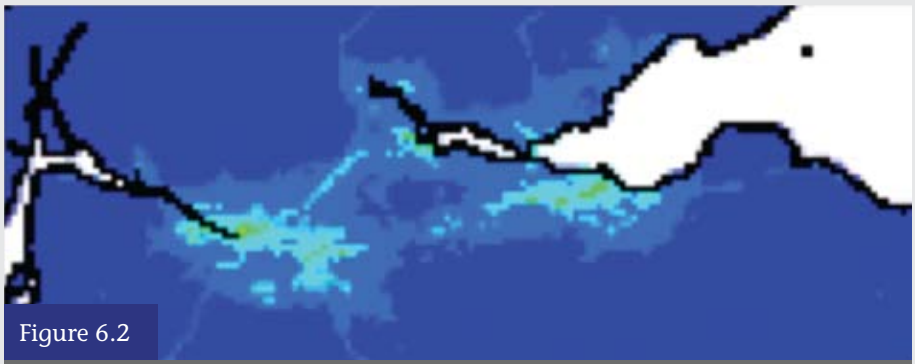


Figure 6.2

2009 background annual mean NO_2 concentration in central Scotland (Scotland-specific model, µg m^{-3}).

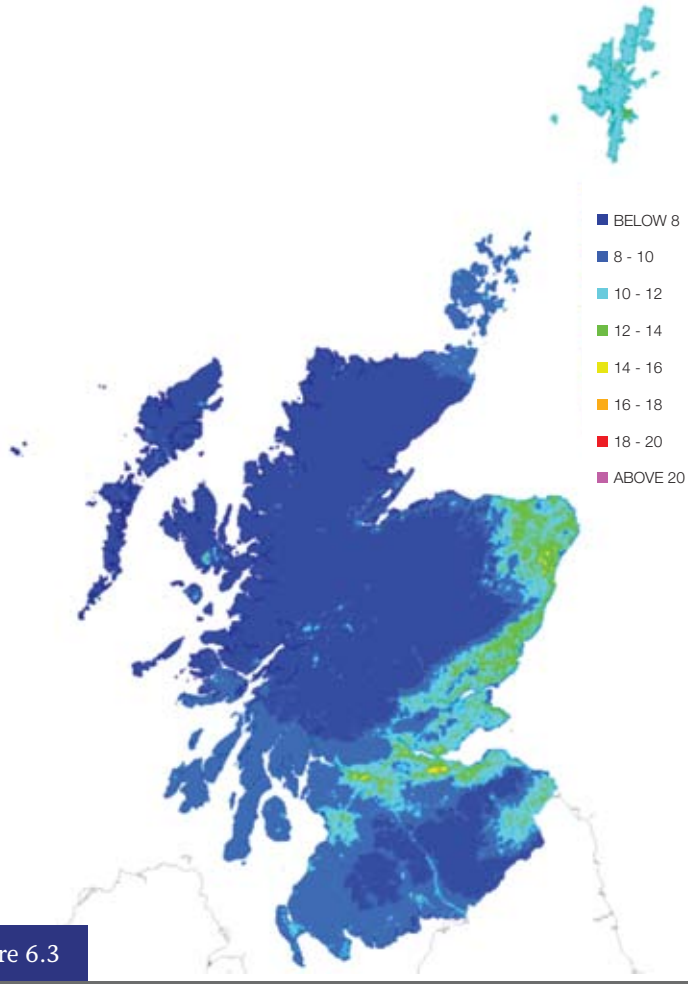


Figure 6.3

2009 background annual mean PM_{10} concentration in Scotland (Scotland-specific model, µg m^{-3}).

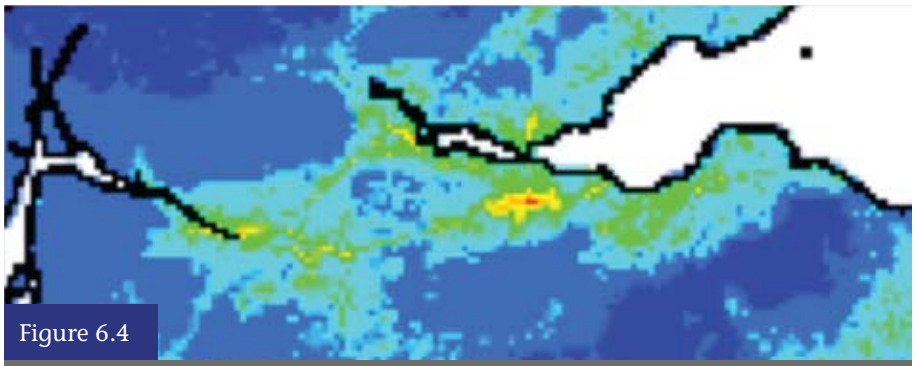


Figure 6.4

2009 background annual mean PM_{10} concentration in central Scotland (Scotland-specific model, µg m^{-3}).

7

More information

(i) The Air Quality Scotland Website

The national website, 'Air Quality Scotland' at www.scottishairquality.co.uk provides information on all aspects of air pollution in Scotland. Funded by the Scottish Government, the website provides information on;

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

A Discussion Forum was added in 2010 to allow the Scottish Air Quality Database Stakeholders to exchange information on latest data, reports, research, seminars etc. An account for the Forum can be requested at www.scottishairquality.co.uk/forum.

www.scottishairquality.co.uk/children

Powerful Openair data analysis tools are now available at www.scottishairquality.co.uk/openair/openair.php. They can be used to summarise, analyse and download results including timeseries, diurnal and trends composition.

The website includes an interactive map showing the locations of Scotland's automatic monitoring stations. By clicking on the map, users can view details of each monitoring site and current levels of the pollutants monitored. An 'Air Pollution Index' is used to provide a simple indication of current pollution levels. The website also incorporates an advanced Google Earth™ mapping feature, which allows users to "zoom in" on a site location, using both satellite photos or maps. It is also possible to register to receive daily or hourly e-mail updates of the latest air quality data.

New this year, a series of children's web pages have been added. Developed in consultation with education professionals, and reviewed by primary schoolchildren in Edinburgh, the pages follow the young Air Pollution Detectives, as they find out what causes air pollution, how it can affect them, and what they can do about it.

The website has also recently been upgraded to allow latest information to be displayed on your mobile phone or PDA whilst you are on the move. Just access www.scottishairquality.co.uk/mobile. In 2011, a free subscription service will be launched to allow you to receive text alerts when air pollution in Scotland is expected to reach levels where susceptible members of the public may wish to take preventative action to protect their health.

(ii) Forecasts and Current Air Pollution Levels

Forecast and current air quality (national and local) information is also readily available from:

- The Air Pollution Information Service on freephone 0800 556677; and,
- The UK-AIR information resource at http://uk-air.defra.gov.uk/.

(iii) Local Air Quality Issues

For further information on air quality issues in your area, please contact the Environmental Health Department at your local district council office. Further information on Local Air Quality Management may also be found at ww2.defra.gov.uk/environment.

The Scottish Government

AEA

This report has been produced by AEA on behalf of the Scottish Government.

Its main authors are Alison Loader, Stuart Sneddon, Paul Willis, Ken Stevenson and Rachel Yardley, with maps by Justin Lingard.

www.scottishairquality.co.uk