Air Pollution in the UK: 2004

Part 1

In this part of the report, we describe the reasons for monitoring air quality and examine how the UK networks have evolved over the years to meet our changing needs and objectives.

We then review recent air pollution episodes and assess variations in pollution levels across the country. Finally, we examine long-term trends in order to see if pollution is getting worse over time.

In this part of the report, we also provide details of how to obtain more information about UK air quality, particularly from the World Wide Web.

3. UK and International Policy for Tackling Air Pollution

The policy background to why we monitor air quality…

To understand why and how we measure air pollution in the UK, it's first necessary to consider the broader policy and regulatory background to the monitoring, both at national and international level.

Over the past decade, air pollution has becoming an increasingly important focus of interest for UK, European and international policy makers. This has been triggered by increasing evidence that air pollution poses significant risks to our health and amenity, as well as threatening our natural environment. In recognition of this, the European Union's Sixth Environment Action Programme, "Environment 2010: Our future, Our choice"[1], includes Environment and Health as one of the four main areas where new effort is targetted, with air pollution identified as one of the priority issues to be tackled. The need to protect human health and welfare is also a central feature of the UK's Air Quality Strategy[2], discussed later in this section.

Another factor in the increased attention paid to air pollution is emerging evidence of its relationship to broader global issues; recent years have shown the dramatic impacts of a series of unusually hot summers throughout many parts of Europe. Some of these impacts have been a consequence of elevated levels of air pollution. We are learning that our atmosphere is a complex, dynamic and fragile system, in which global warming, climate change and stratospheric ozone depletion are all inter-linked with air pollution.

3.1 European Background

Air quality is an area in which Europe has been particularly active in recent years. The European Commission's aim has been to develop an overall strategy through the setting of long-term air quality objectives. Within the European Community, a series of air quality Directives and Decisions over the last decade has:

- Established Limit Values for key air pollutants and defined overall requirements for monitoring progress against these targets
- Defined the monitoring, modelling and air quality management obligations of Member States
- Set targets for pollutant emissions in different types of industry as well as in the transport sector
- Confirmed the need to communicate information on air quality to the public at large.

In 1996, the Environment Council adopted Framework Directive 96/62/EC[3] on ambient air quality assessment and management. This key Directive revised and harmonised pre-existing legislation for a range of air pollutants. It also extended the scope of legislation to cover an increased range of pollutants, and set a timetable for the development of Daughter Directives; these have specified the detailed Limit Values, monitoring and assessment methods for:

1) Sulphur dioxide, nitrogen dioxide, lead and particulate matter (1st Daughter Directive)
2) Benzene and carbon monoxide (2nd Daughter Directive)
3) Ozone (3rd Daughter Directive)
4) Arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons (4th DD)

A list of current EC Directive Limit and Target Values for air pollutants covered by the Directives is provided in Appendix 5. Further detailed information on the major sources and impacts of these pollutants is provided in Appendix 1.

A primary objective of the EU's Sixth Environment Action Programme is to achieve levels of air quality that do not give rise to unacceptable impacts or risks to human health and the environment. The Community is acting at many levels to reduce exposure to air pollution, through:

- Legislation such as the Framework and Daughter Directives
- Work at the wider international level aimed at reducing cross-border pollution
- Agreement with transport and industrial sectors responsible for air pollution, for example under the Auto Oil II umbrella
- Effective liaison with national, regional authorities and Non Governmental Organisations
- Research undertaken in its own or Member States' institutes and universities.

There is no cause for complacency on the human health impacts of air pollution at a pan-European level. In a report [4] published in the Lancet during 2004, experts assessed for the first time the overall impacts of air quality and other environmental risk factors on child health in the WHO European Region: 14-24000 deaths every year, representing 6-10% of all mortality in children and adolescents from birth to 19 years of age, are caused by outdoor and indoor air pollution.

The focus within the European Community for the next ten years will be implementation of air quality standards and increasing the coherency of all air legislation and related policy effort through large-scale initiatives such as CAFE (Clean Air For Europe)[5].

A Community-wide procedure for the exchange of information and data on ambient air quality in the European Community has also been established by Council Decision 97/101/EC[6]. The decision introduces a scheme for the reciprocal exchange of information and data relating to the networks and stations established in the Member States to measure air pollution, together with the air quality measurements from those stations.

Although progress towards Europe-wide ratification has been patchy, the 1998 Århus convention[7] on environmental openness is another important instrument; this is intended to guarantee citizens across the continent the right to information, public participation in decision-making and access to justice in environmental matters.

We identify throughout this report a series of information resources enabling UK technical, local authority and public end-users to obtain up-to-date information on local or national air quality; this report, in itself, represents one of the range of published, media and web resources intended for this purpose in the UK.

3.2 The UK Perspective

Although the lethal smogs in London and other cities caused by coal burning have now gone for good, air pollution remains a problem in the UK. Medical evidence shows that many thousands of people die prematurely every year because of its effects, and this can accelerate during extreme weather conditions. Many more become unwell or may require hospital treatment. The young and infirm are often particularly affected, as well as people living in deprived areas. The costs to individuals, families and the national economy are substantial.

Air quality is therefore now one of the UK Government's key headline indicators of sustainable development[8]. These provide a 'quality of life barometer' measuring everyday concerns, and are intended to give a broad overview of whether we are achieving a better quality of life for everyone, now and for generations to come. We'll be looking more closely at the latest air quality indicator levels in Section 7 of this Report.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, first published in March 1997 and revised in January 2000, has established a strong framework for tackling air pollution over the coming years. The overall objectives of the Strategy are to:

- Map out future ambient air quality policy in the United Kingdom in the medium term
- Provide best practicable protection to human health by setting health-based objectives for air pollutants
- Contribute to the protection of the natural environment through objectives for the protection of vegetation and ecosystems
- Describe current and future levels of air pollution
- Provide a framework to help identify what we all can do to improve air quality.

The Strategy established objectives for eight key air pollutants, based on the best available medical and scientific understanding of their effects on health, as well as taking into account relevant developments in Europe and the World Health Organisation. As our knowledge of these effects has deepened, the objectives have been progressively refined and strengthened. Moreover, objectives for a ninth pollutant, Polycyclic Aromatic Hydrocarbons (PAHs)[9] were introduced in 2003.

A summary of the current UK Air Quality Objectives in Regulation is provided in Table 1. Note that important deadlines for meeting objectives for Benzene, 1,3-Butadiene, PM_{10} particles, Sulphur Dioxide and Carbon Monoxide were passed in 2003 and 2004. Others – for nitrogen and sulphur oxides- must be met by the end of 2005. Corresponding objectives not to be included in Regulation for the purposes of Local Air Quality Management (LAQM) are summarised in Tables 2a and 2b. Details of corresponding EC Limit Values and WHO Guidelines are provided in the Appendices of this report.

Although comprehensive and soundly science-based, the UK's Air Quality Objectives are not particularly easy for the general public to understand, particularly on a day-to-day basis. A simpler air quality banding system is therefore used for media-based reporting of air quality and potential health effects to the public. This is summarised in Box 1 overleaf.

The UK Air Quality Strategy's main focus is on protecting the health of the population at large; however, the Strategy has also established corresponding targets for the protection of vegetation, ecosystems and the natural environment. Air monitoring provides a key tool in assessing how far the health objectives and other environmental targets are being met throughout the UK.

Box 1. The UK Air Quality Banding System

- When air pollution is LOW (1-3) effects are unlikely to be noticed even by those who are sensitive to air pollution.
- When air pollution is MODERATE (4-6) sensitive people may notice mild effects but these are unlikely to need action.
- When air pollution is HIGH (7-9) sensitive people may notice significant effects and may need to take action.
- When air pollution is VERY HIGH (10) effects on sensitive people, described for HIGH pollution, may worsen.

Table 1. UK Air Quality Objectives set in Regulation, 2005

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
England and Wales only	5.00 $\mu g\ m^{-3}$	Annual mean	31.12.2010
Scotland and Northern Ireland	3.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g\ m^{-3}$	Running annual mean	31.12.2003
Carbon monoxide England, Wales & N. Ireland	10.0 $mg\ m^{-3}$	Maximum daily running 8-hour mean	31.12.2003
Scotland only	10.0 $mg\ m^{-3}$	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g\ m^{-3}$ 0.25 $\mu g\ m^{-3}$	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 $\mu g\ m^{-3}$ not to be exceeded more than 18 times a year 40 $\mu g\ m^{-3}$	1-hour mean Annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric) All authorities	50 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year 40 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2004 31.12.2004
Scotland only	50 $\mu g\ m^{-3}$, not to be exceeded more than 7 times a year 18 $\mu g\ m^{-3}$	24-hour mean Annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 $\mu g\ m^{-3}$, not to be exceeded more than 24 times a year 125 $\mu g\ m^{-3}$, not to be exceeded more than 3 times a year 266 $\mu g\ m^{-3}$, not to be exceeded more than 35 times a year	1-hour mean 24-hour mean 15-minute mean	31.12.2004 31.12.2004 31.12.2005

Table 2a UK air quality objectives not set in regulation, 2005

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Ozone *(for protection of human health)*	100 $\mu g\ m^{-3}$ not to be exceeded more than 10 times a year	Daily maximum of running 8-hour mean	31.12.2005
Nitrogen dioxide *(for protection of vegetation & ecosystems)*	30 $\mu g\ m^{-3}$	Annual mean	31.12.2000
Sulphur dioxide *(for protection of vegetation & ecosystems)*	20 $\mu g\ m^{-3}$ 20 $\mu g\ m^{-3}$	Annual mean Winter average (Oct-Mar)	31.12.2000 31.12.2000
PAHs	0.25ng m^{-3}	Annual mean	31.12.2010

Table 2b UK air quality objectives for particles (PM_{10} gravimetric) not set in regulation, 2005

Region	Objective	Measured as	Date to be achieved by
Greater London	50 µg m^{-3} not to be exceeded more than 10 times per year	24-hour mean	31.12.2010
Greater London	23 µg m^{-3}	Annual mean	31.12.2010
Greater London	20 µg m^{-3}	Annual mean	31.12.2015
Rest of England, Wales and Northern Ireland	50 µg m^{-3} not to be exceeded more than 7 times per year	24-hour mean	31.12.2010
Rest of England, Wales and Northern Ireland	20 µg m^{-3}	Annual mean	31.12.2010

3.3 A Local Focus

Central Government and the Devolved Administrations in Scotland, Wales and Northern Ireland are responsible for overall policy and legislation affecting the UK environment, including air quality. However, over recent years, the Air Quality Strategy has progressively enabled and encouraged Local Government to take a central role in air quality management. Authorities are required regularly to *Review and Assess* air quality in their area and take decisive action when the objectives in regulation cannot be met by the specified target dates.

When this happens, an Authority must declare an 'Air Quality Management Area' (AQMA) and develop an Action Plan - which may include such measures as congestion charging, traffic management, planning and financial incentives - to tackle problems in the affected areas.

Local authorities in England, Scotland and Wales have completed their first round of reviews and assessments against the Strategy's objectives prescribed in the 2000 Air Quality Regulations, together with subsequent amendments[10, 11, 12, 13, 41] and are now well into the second round of assessment.

To date over 150 Local Authorities – roughly 40% of those in the UK - have established one or more AQMAs, most of these in urban areas and resulting from traffic emissions of nitrogen dioxide (NO_2) or PM_{10} particles. An additional 45 Authorities expect to declare

AQMAs in the near future. Road traffic emissions are the main source in 95% of the AQMAs; only a few have been designated as a result of industrial sources, domestic or shipping emissions. A full list of these authorities declaring such areas may be found at: http://www.airquality.co.uk/archive/laqm/list.php. More information on AQMAs is summarised in Table 3 below.

Table 3. Current UK-wide status of Air Quality Management Areas and Action Plans (June 2005)

Region	Total No. of Local Authorities	AQMAs declared & (expected)	Due to NO_2	Due to PM_{10}	Due to SO_2	Draft (Full) Action plans submitted
England (excl London)	320	107 (+34)	99	34	9	64 (35)
London	33	31	30	27	0	29 (22)
Scotland	32	3 (+5)	3	1	0	3 (3)
Wales	22	4 (+1)	3	1	0	3 (2)
N. Ireland	26	15 (+2)	4	10	1	1 (0)
TOTAL	433	160 (+ 42)	139	73	10	100 (62)

The local authorities declaring AQMAs have undertaken further detailed assessments of the areas concerned, with a view to submitting a report within 12 months following initial designation of the AQMA. The authorities have been advised to prepare their action plans within 12-18 months of designation. Over 100 authorities have now produced such action plans, setting out the measures the authority proposes to take to work towards meeting the air quality objectives. Inevitably, the majority of the action plans focus on measures dealing with road traffic, such as local traffic management schemes, setting up Clean Air or Low Emissions zones - particularly in London - or working with the Highways Agency (or the Scottish Executive in Scotland) to tackle pollution on the motorways/trunk roads.

Recognising the strong linkage between transport and air quality, English local authorities (other than those classified as 'excellent') now have the discretion to either produce a stand alone Air Quality Action Plan or integrate this plan within their Local Transport Plan. More details are available from the Defra website at:
http://www.defra.gov.uk/environment/airquality/laqm/guidance/index.htm.

Methodologies for local review and assessment continue to develop and improve throughout the UK. To date, approximately 98 authorities in England, 7 in Scotland, and 2 in Wales have identified the need to designate new AQMAs as a result of Detailed Assessments carried out as part of the second round of reviews and assessments. Around 40% of these authorities previously declared AQMAs during the first round of the LAQM process. The increase in the number of AQMAs required is due in large part to the improved methodologies being employed to identify areas of poor air quality for the second and subsequent rounds; to the increasing scale of monitoring being undertaken by local authorities; and to the fact that UK-wide NO_2 concentrations are not decreasing as rapidly as was originally predicted.

Authorities in Northern Ireland have now moved onto Round 2 of reviews and assessments. Alongside the rest of the UK, they submitted Progress Reports in April 2005. Round 1 in Northern Ireland, which was undertaken on a different timescale to the rest of the UK, resulted in a number of AQMAs being declared. The review and assessment timetable in Northern Ireland is now running in parallel to that in the rest of the UK.

Through the UK-wide process of Local Air Quality Management, tackling air pollution is progressively focussing more on local 'grass-roots' concerns, initiatives and actions.

4. Where and how air pollution is measured in the UK

To manage something effectively, you first have to be able to measure it.

4.1 The Role of Ambient Air Quality Monitoring

Air quality monitoring is a key component of any effective approach to Air Quality Management (AQM). In order to develop or implement an effective air quality management plan at local, city or national level, it is first necessary to obtain reliable information on ambient pollution levels. This point was fully recognised in Agenda 21[14] of the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992 and during the more recent global Johannesburg Summit[15] held in 2002.

The ultimate purpose of air quality monitoring is not merely to collect data (a common perception) but to provide the necessary information required by scientists, policy makers and planners to enable them to make informed decisions on managing and improving our environment.

Air monitoring fulfils a central role in this process, providing the necessary sound scientific basis for policy and strategy development, objective setting, compliance measurement against targets, and enforcement action. Viewed in this context, monitoring serves the following essential key functions:

- Comparison of existing air quality against local, national or international standards
- Assessment of population health and ecosystem impacts
- Initial assessment of problem areas and pollutants requiring regulatory/control action
- Provision of baseline data for predictive models and environmental impact assessments
- Validation of emission inventory and model predictions
- Determination of long-term trends
- Assessment of the effectiveness - or otherwise - of control strategies over time
- Rising public awareness and promoting responsible action to tackle pollution

In the UK, air pollution policy development relies heavily on the national air quality monitoring networks to provide basic and scientifically robust data on ambient pollution concentrations. These data are used to establish priorities for policy development and to assess the effectiveness of control or regulatory action in reducing air pollution concentrations over time. Monitoring data have also played a central role in the development of the UK's Air Quality Strategy and in formulating national Air Quality Objectives. In addition, measurements from our networks provide the necessary data for determining compliance with the European Union's Air Quality Directives.

We are all polluters. Public awareness and co-operation is therefore an important pre-requisite to tackling air pollution at local, national and international level. To ensure a fully informed public, monitoring data are communicated rapidly and efficiently to air quality stakeholders and data users through a wide range of web and media outlets (discussed further in Section 4.5).

4.2 A Brief History of Monitoring in the UK

The history of air pollution monitoring in the UK goes back a long way. Primarily in response to the serious urban smogs of the 1950s and 60s, black smoke and sulphur dioxide have been monitored on a national scale in the UK since 1961. Initially called the National Survey, this major network - still operational today - has monitored the massive improvement of air quality since a succession of Clean Air Acts[16] successfully targeted domestic and industrial coal burning.

The emissions responsible for this type of winter smog have decreased substantially over the years and, as a result, road transport has now become the most important source of air pollution in many parts of the UK. It is by far the dominant source of pollution in all our cities. In response to this historic change, the emphasis in monitoring has moved progressively to pollutants such as ozone, nitrogen dioxide and fine particulate matter.

Research measurements of air pollution using automatic analysers commenced in the UK during the early 1970s. Later, continuous measurements were increasingly required for regulatory purposes and a UK urban monitoring network was first established in 1987 to monitor compliance with the emerging EC Directive limit values on air quality. This network subsequently expanded, following commitments by Government to expand urban monitoring in the UK and improve public availability of air quality information.

Another landmark year in the evolution of automatic monitoring in the UK was 1992, when the DoE-funded Enhanced Urban Network (EUN) was established. In 1996, this network expanded following an initiative designed to promote the integration of local authority sites into the national network where 1) this met national monitoring objectives and 2) when appropriate quality and consistency standards could be maintained. At the same time, increased decentralisation in the management and quality assurance of the networks was actively promoted. The net effect of these measures was to substantially increase the number and diversity of stakeholders and participants in the national monitoring effort.

In 1995, all statutory and other urban monitoring was consolidated into one comprehensive programme. Throughout the next five years, over 50 local authority sites were integrated into the resulting network, including 14 of the London Air Quality Monitoring Network sites. In 1998, the previously separate UK urban and rural automatic networks were then combined to form the current Automatic Urban and Rural Network (AURN). This presently (2005) consists of 123 sites and remains the most important single monitoring programme in the UK today. Data from the AURN, together with corresponding measurements from the 5 automatic hydrocarbon monitoring stations, are presented in this report.

The bulk of the data presented in this report originate from this network, which presently includes 87 urban, 22 rural and 14 London Network sites: 60 sites are directly funded by Defra and the Devolved Administrations, whilst 63 are affiliated sites owned and operated by Local Authorities and other organisations.

The dramatic continuing expansion in automatic monitoring is clearly illustrated in Figures 2 and 3, where we show the increase in site numbers and total measurements made since the commencement of automatic air quality monitoring in the UK. The AURN continues to evolve year-on-year; the changes in this important measurement programme during the past year are summarised in Table 4.

However, it's not just the UK's automatic monitoring networks that have expanded massively. In fact, all of the UK's monitoring programmes have evolved considerably over the past 10 years. This expansion has been driven by many factors, including increasing concern about health impacts, government's desire to inform the public of the quality of our air, the UK's Air Quality Strategy and a range of European commitments.

Figure 2. The number of automatic measurement stations in the UK has grown rapidly since 1972

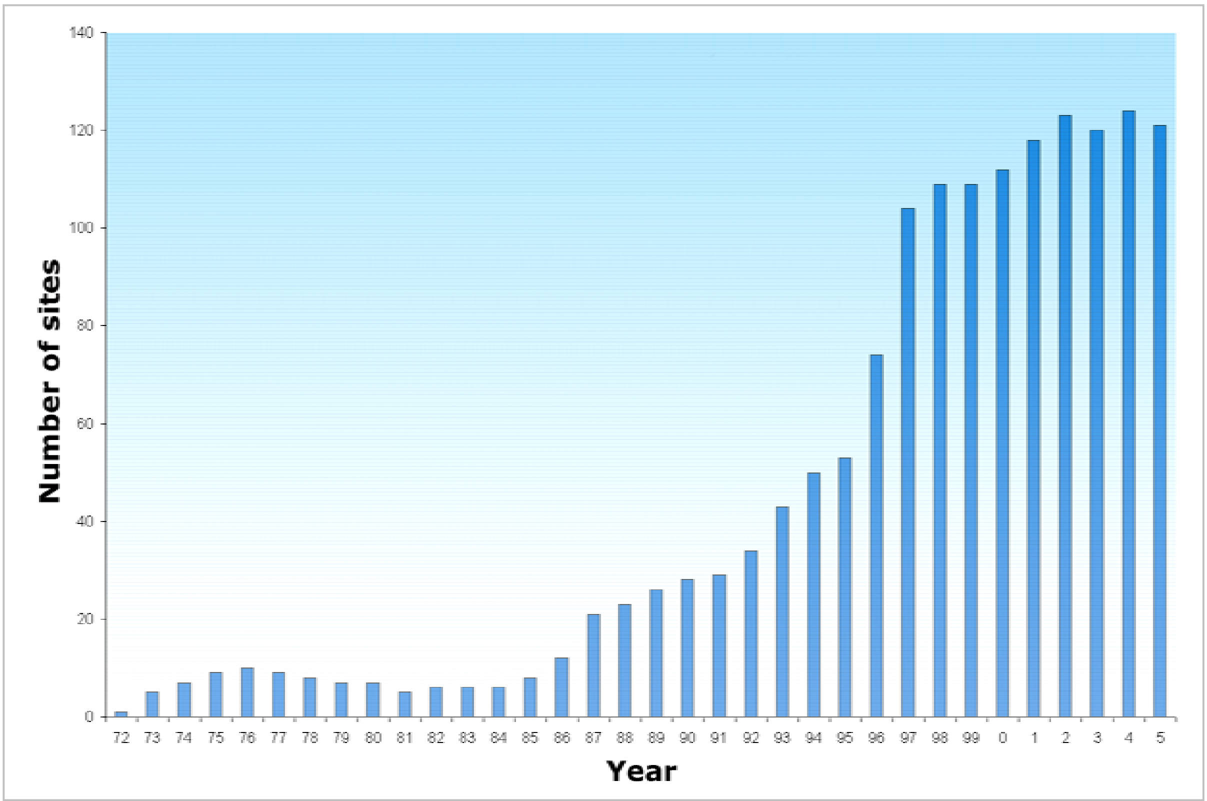


Figure 3. The number of measurements made every year has also increased dramatically for all pollutants in the automatic monitoring networks (O_3, NO_2, CO, SO_2 and PM_{10})

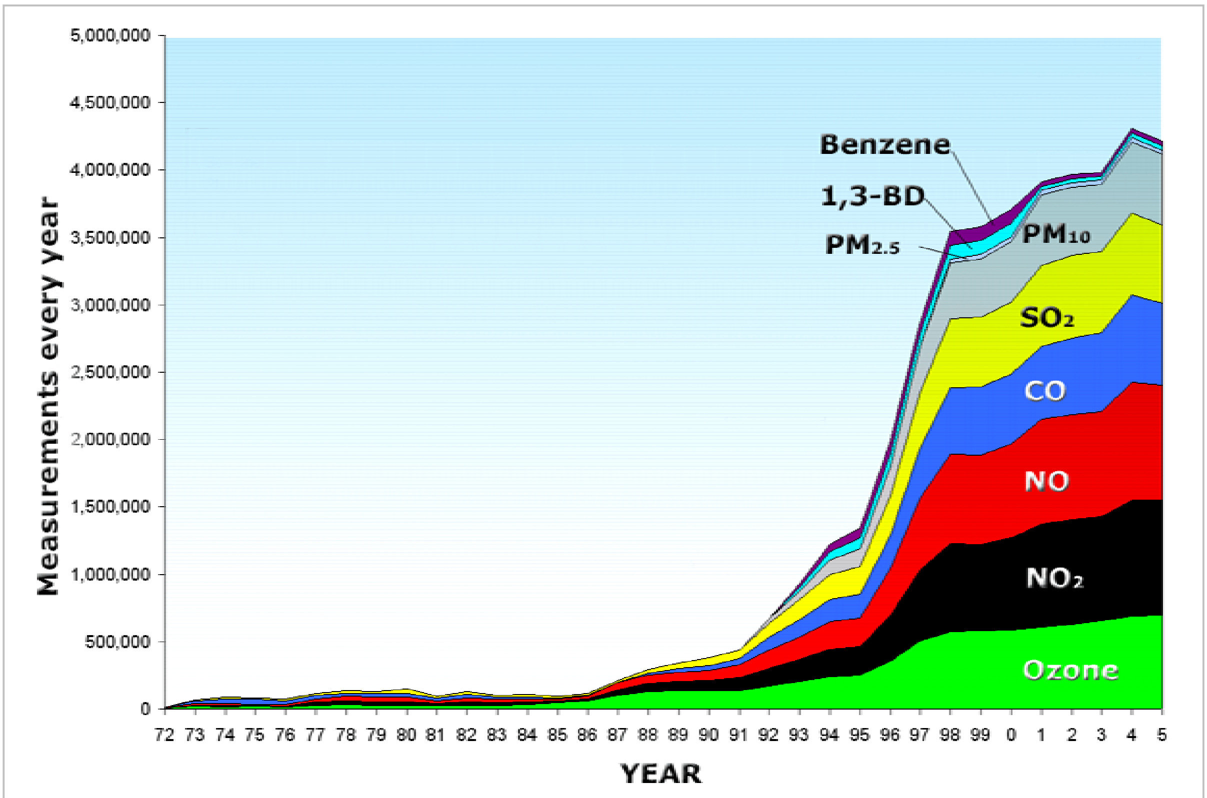


Table 4. Changes to the AURN between January 2004 and May 2005

Sites	Date Commenced	Pollutants
Newly established sites		
London Harlington	1/01/04	NO_2 CO O_3 PM_{10}
Brighton Preston Park	3/11/04	NO_2 and O_3
Sunderland Silksworth	9/12/04	NO_2 and O_3
Site Relocations		
Scunthorpe relocated to Scunthorpe Town	Scunthorpe closed 18/3/04 Scunthorpe Town started 6th June 2004	SO_2 PM_{10}
Wigan Leigh relocated to Wigan Centre	Wigan Leigh closed on 28th September 2004. Wigan Centre started on 8th October 2004	NO_x O_3 CO SO_2 and PM_{10}
Birmingham East relocated to Birmingham Tyburn	Birmingham East closed on 4th August 2004. Relocated to Birmingham Tyburn starting on August 16th 2004	NO_x O_3 CO SO_2 and PM_{10}
Norwich Roadside relocated to Norwich Roadside Forum	Norwich Roadside closed on 14 February 2004. Norwich Roadside Forum started on 1st April 2005.	NOx
Blackpool relocation in progress	Blackpool closed in November 10th 2004 and relocation is underway.	NO_x O_3 CO SO_2 and PM_{10}
Oxford Centre renamed	Change of name only in Feb 2005 to Oxford Centre Roadside.	All
Additional O_3 and/or NO_x introduced due to EU 3rd Daughter Directive		
Glazebury	NOx analyser commissioned on 26th January 2004	NO_x
Eskdalemuir	NO_x analyser commissioned on 9th December 2004.	NO_x

There has also been considerable growth in the amount of monitoring undertaken by Local Authorities. Many of these sites now contribute data to nationally organised measurement programmes funded and supported by Central Government and the Devolved Administrations.

It should be emphasised that this report deals only with measured data from national monitoring programmes, including Local Authority sites that are affiliated to these programmes. All sites in these networks are subject to stringent quality control programmes that ensure measurement consistency and accuracy - see Section 4.4.

The value of air quality monitoring undertaken by Local Authorities but outside the auspices of national networks should not be underestimated, however. Information from these monitoring sites provides a sound basis for Local Air Quality Management, planning and decision-making. The quality of data from these programmes can also be high. Many sites not affiliated to national networks are now subject to the same level of quality assurance and control procedures as used in these programmes; this ensures that measurement quality and integrity is fully harmonised with national networks.

4.3 The current situation

There are currently over 1400 national air quality monitoring sites across the UK, organised into several automatic and non-automatic networks with different scope and coverage. Clearly defined objectives have been set for each of these, in order to optimise network design, select priority pollutants and appropriate measurement methods, and determine the required level of quality assurance/control and data management. As noted in the introduction, the primary objectives of current UK networks are:

- To understand air quality problems in order that cost-effective policies and solutions can be developed
- To assess how far UK and European standards and targets are being achieved
- To provide public information on current and forecast air quality
- To assist the assessment of personal exposure to air pollutants.

However, in practice, each network offers a different balance of objectives, and is structured, organised and quality controlled accordingly.

128 of these sites in the AURN (123) and hydrocarbon networks (5) operate automatically; these split nationally as follows:

Country	Site numbers
England	103
N. Ireland	5
Wales	8
Scotland	12

These automatic sites provide high-resolution hourly information on a range of pollutants that is communicated rapidly to the public. The non-automatic sites measure average concentrations over a specified sampling period (typically from a day to a month) instead of instantaneous concentrations, but still provide invaluable data for assessing levels and impacts of pollution across the country as a whole.

A map of current UK automatic monitoring sites is provided in Figure 4. In the accompanying Figures 5.1-5.3, we map corresponding sampler-based measurement sites and show how the different networks provide comprehensive measurement coverage over the UK. Maps showing measurement coverage in different parts of the UK are presented in Appendix 2, whilst additional site maps for individual pollutants feature in Sections 8-16 of this report.

The UK's combined use of both automatic and sampler-based programmes for air monitoring has evolved over the last 40 years as the best way of quantifying pollutant behaviour in both space and time, whilst also maximising cost-effectiveness. This approach uses sampler measurements to provide good spatial coverage, area-resolution and 'hot-spot' identification. Samplers can also be used to provide compliance data for pollutants such as benzene, where European Limit Values apply for annual average concentrations. By contrast, automatic analysers, deployed at carefully selected locations, provide more detailed time-resolved data for assessing peak concentrations and for comparison with short-term UK Air Quality Objectives or European Limit Values.

The pollutants measured, site numbers and areas covered in the UK's nationally co-ordinated monitoring networks are summarised in Table 5, whilst the main features of individual programmes are summarised in Table 6. Further information on the different UK air monitoring networks is provided in Appendix 3.

Table 5. Summary of UK measurements made for the most important air pollutants

Pollutant	Major sources	Site numbers	Areas covered
Nitrogen Dioxide (NO_2)	Road transport and industry	108 (Automatic) 1216 (Non-automatic)	Mostly urban
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	85 (A)	All of UK- urban and rural areas
Particles (PM_{10} and $PM_{2.5}$)	Road transport, industry, construction, soil and natural sources	67 (A) 7 (NA) gravimetric 101 (NA) black smoke	Mostly urban
Sulphur Dioxide	Industry and fuel combustion	75 (A) 101 (NA) net acidity 40 (NA)	Mostly urban Rural
Carbon Monoxide (C0)	Road transport	78 (A)	Urban
Volatile Organic Compound (VOCs)	Industry, transport, solvent use and some natural sources	5 (A) 35 (NA) benzene 10 (NA) 1,3-butadiene	Mostly urban
Dioxins and PCBs	Combustion (dioxins) and past uses (PCBs)	6 (NA)	3 urban 2 rural 1semi-rural
Polycyclic Aromatic Hydrocarbons (PAHs)	Industry, domestic combustion and traffic (PAHs)	24 (NA)	Industrial, urban, rural and semi-rural
Metals- Pb, Cd, As, Ni and Hg	Industrial and other processes	17 (NA- lead and multi- element) 15 (NA- rural deposition)	Industrial, urban Rural
Acid Deposition	Atmospheric reactions involving fuel burning, agricultural and other emissions	38 (NA)	Rural
Ammonia	Agricultural activities	94 (NA)	Rural
Nitric Acid	Combustion and photochemistry	12 (NA)	Rural

Table 6. The major UK Air Quality Monitoring Networks

Network	Auto or Sampler?	No of Sites
The Automatic Urban and Rural Network (AURN)	A	123 (85 urban, 22 rural, 16 London)
The non automatic network for smoke, SO_2 and NO_2	S	101 (Smoke and SO_2) 1216 (NO_2)
Rural acid deposition, gases and particles	S	38 (acid deposition) 40 (SO_2)
Automatic Hydrocarbon	A	5
Toxic Organic Micropollutants (TOMPS)	S	6
Polycyclic Aromatic Hydrocarbons (PAHs)	S	18
UK Heavy Metals Monitoring Network (previously the Lead, Multi-element and Industrial Metals Networks)	S	17
Rural metal deposition network	S	10 particle and rain, Hg in rain & air 3 rainwater 2 cloud water all rural
Non automatic hydrocarbon- Benzene and 1,3-butadiene	S	35 (benzene) 10 (1, 3-butadiene)
Ammonia Network	S	94
Nitric Acid	S	12

Figure 4. Current UK Automatic Air Quality Monitoring Stations

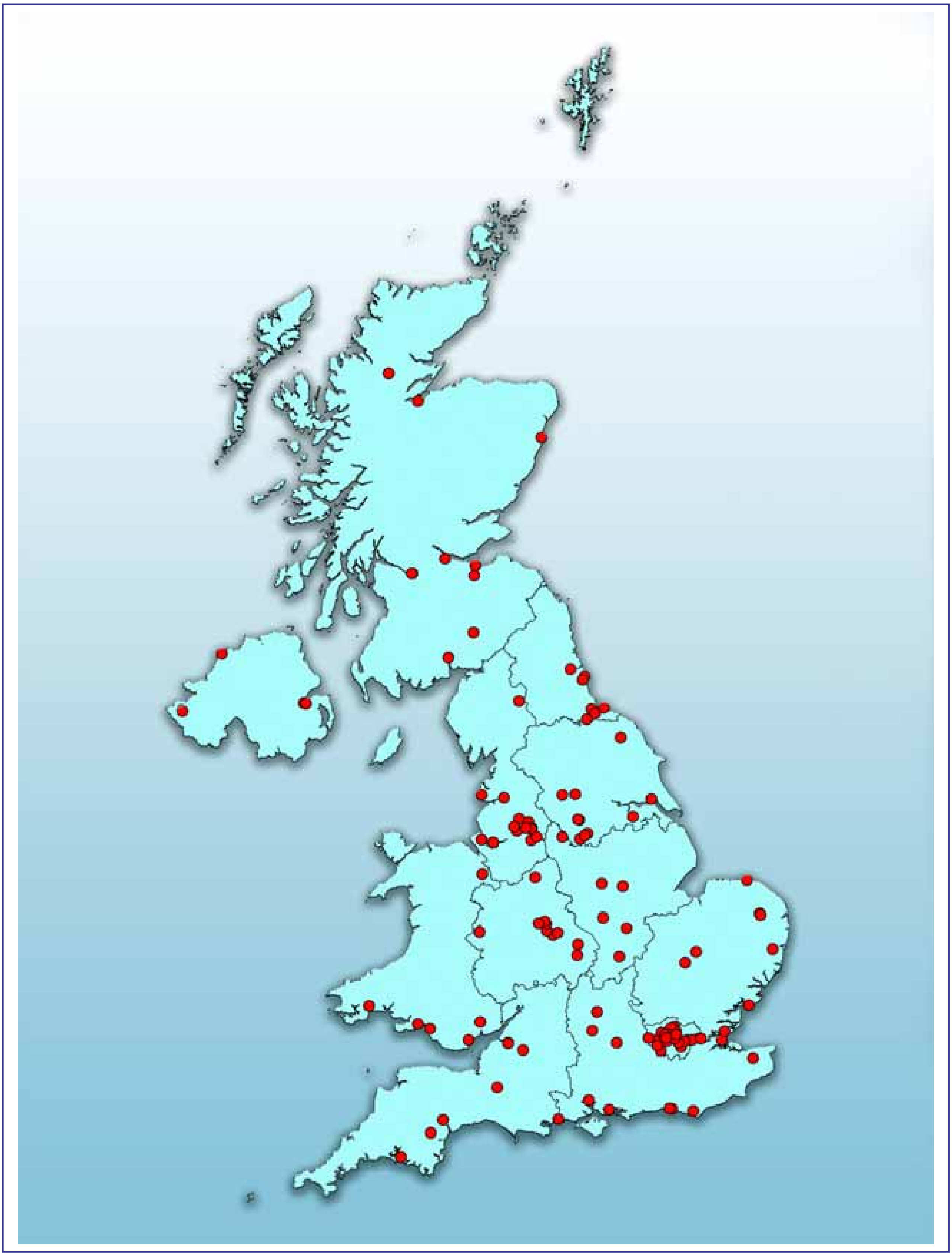


Fig 5.1 Current UK sampler-based measurement programmes in urban areas

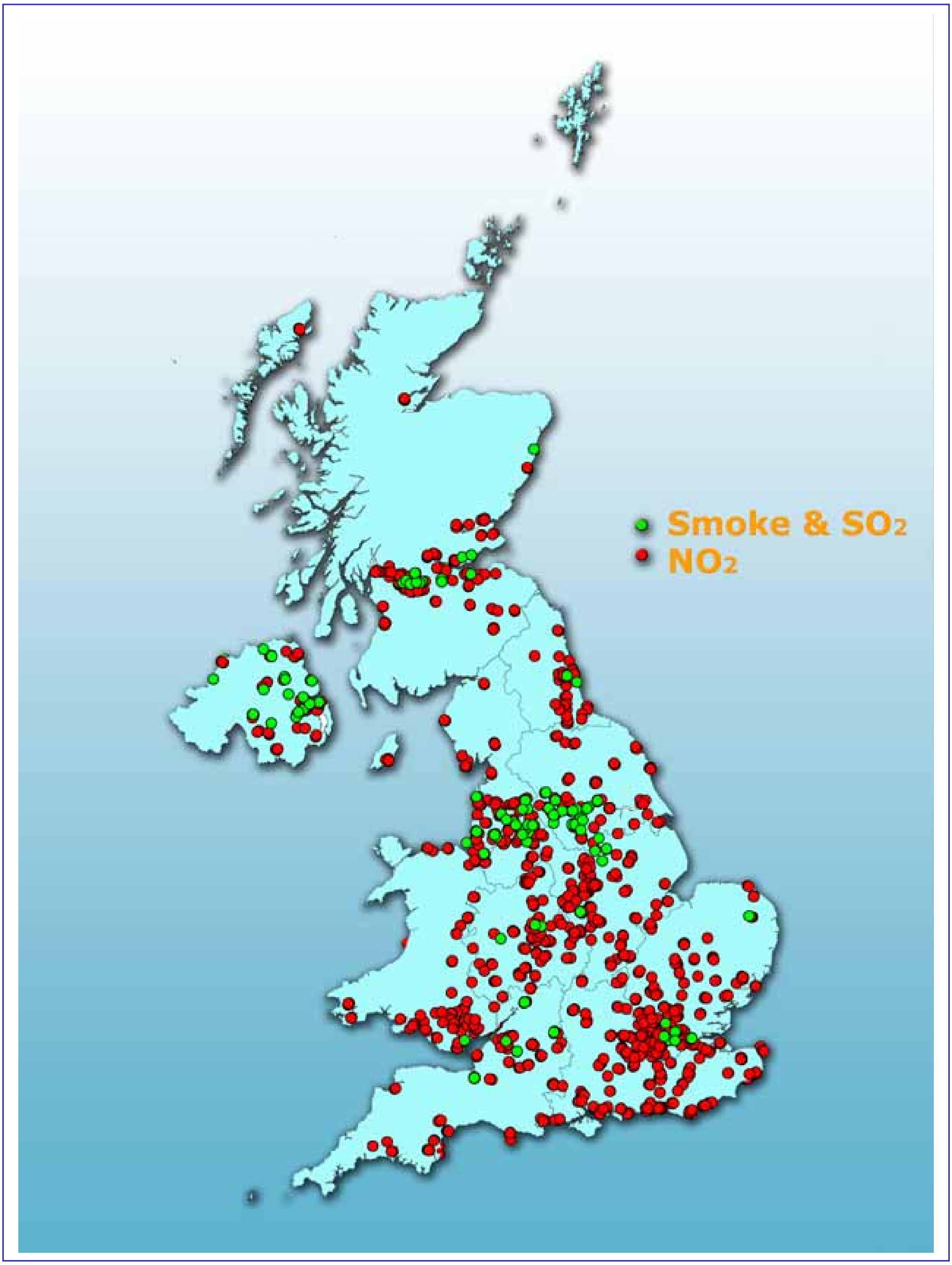


Fig 5.2 Current UK sampler-based measurement programmes for Persistent Organic Pollutants (POPs) and metals

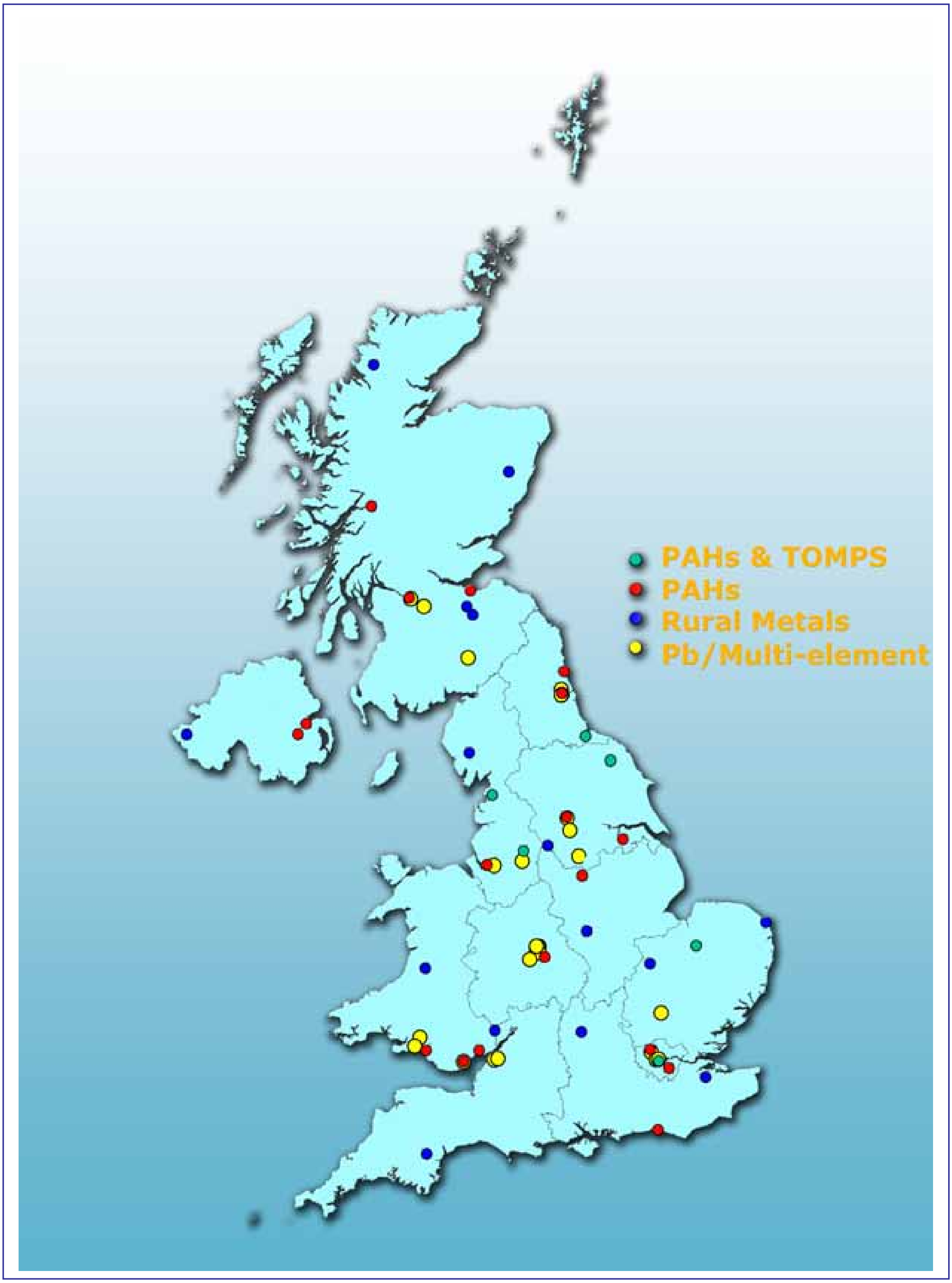
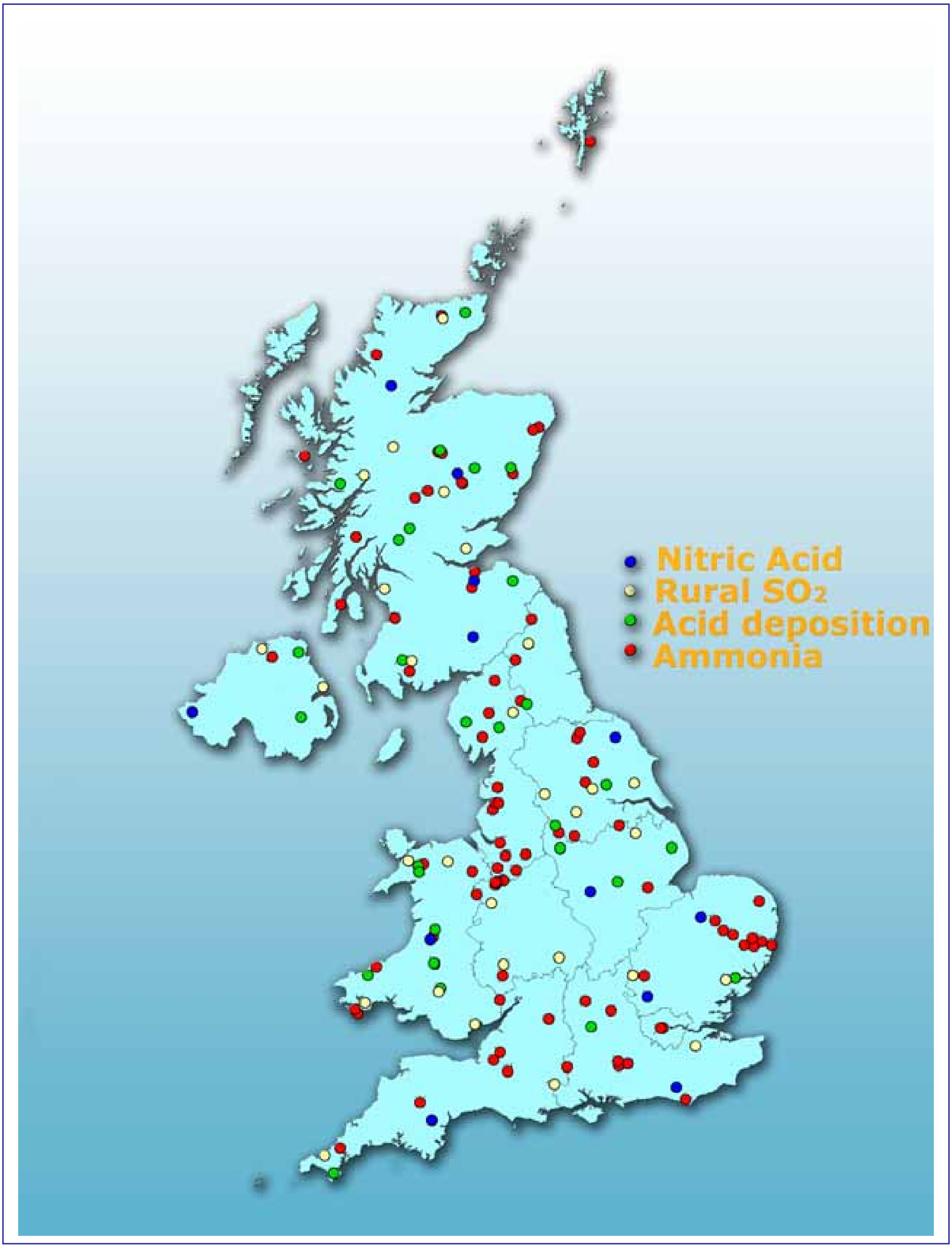
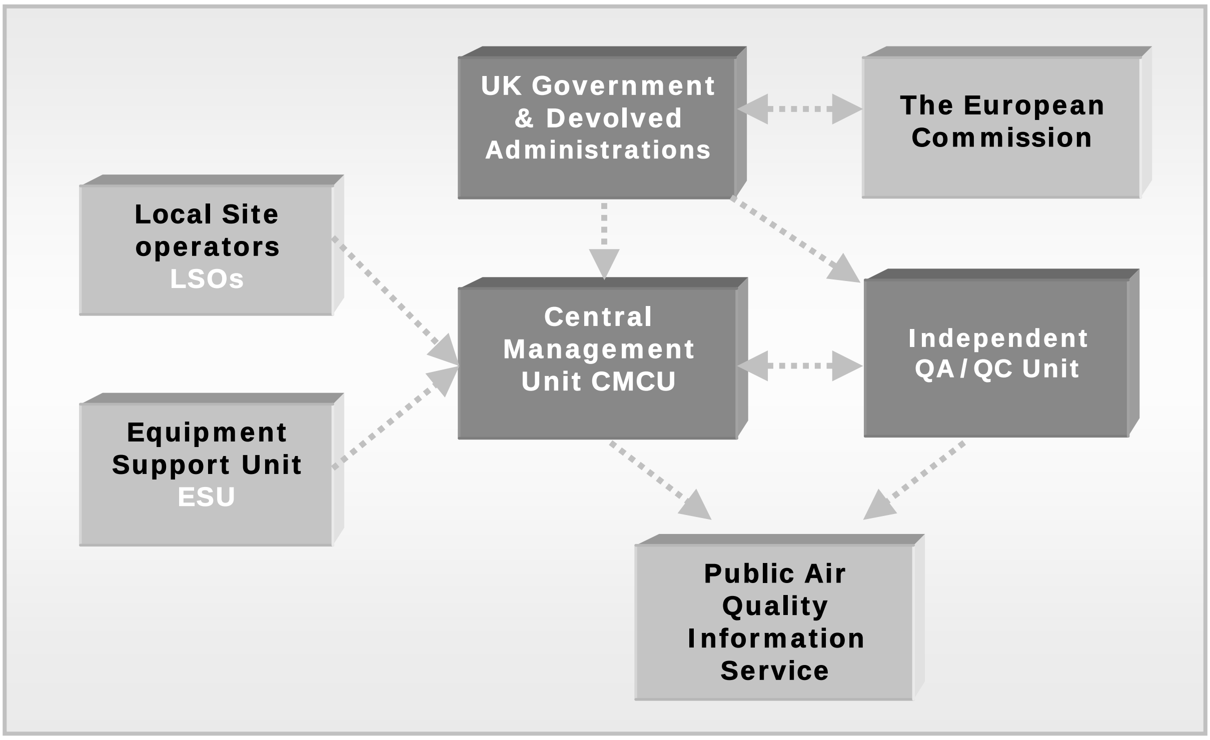


Fig 5.3 Current UK sampler-based measurement programmes: Acidification and Eutrophication



Many of the networks, and particularly those involving automatic measurements, are large-scale and involve a wide range of participating organisations. A good example is the AURN; this has a devolved structure with separate specialised organisations performing different duties (Figure 6). There is also an important role for local organisations, which are typically responsible for ongoing site operations. However, overall management and quality assurance functions for the network are centrally co-ordinated in order to ensure fully harmonised and consistent outputs. The data from this and similar networks, presented in this report, therefore represent the end-product of the efforts of many persons and organisations in the private sector, local and central government.

Figure 6. A devolved network organisational structure, as employed within the large-scale AURN programme.



Two defining characteristics of the UK national air monitoring effort may be seen as:

1) Its focus on quality assurance and control (QA/QC) to maximise measurement integrity and reliability
2) An emphasis on achieving the widest possible dissemination and use of both monitoring data and the information derived from this.

In subsequent sections, we will examine both the UK's QA/QC programmes (in section 4.4) and air quality information services (section 4.5) in more detail.

4.4 Emphasis on Data Quality

The UK air monitoring networks currently produce over 15 million individual measurements every year from its automatic and sampler-based monitoring programmes. In order for these data to be useful and provide a sound scientific basis for comparison against standards, public information or policy development, we need to be sure that they are accurate and reliable. This is why considerable attention is devoted in the UK monitoring networks to quality assurance and control.

Quality Assurance and Control

A system of activities that assures that measurements meet defined standards of quality with a stated level of confidence

Each UK network therefore has in place a strong QA/QC programme designed to ensure that its measurements meet defined standards of quality with a stated level of confidence. Essentially, each programme serves to ensure that the data obtained are:

(i) Genuinely representative of ambient concentrations existing in the various areas under investigation

(ii) Sufficiently accurate and precise to meet specified monitoring objectives

(iii) Comparable and reproducible. Results must be internally consistent and comparable with international or other accepted standards, if these exist

(iv) Consistent with time. This is particularly important if long-term trend analysis of the data is to be undertaken

(v) Representative over the period of measurement; for most purposes, a yearly data capture rate of not less than 90% is usually required for determining compliance with EC Limit Values

(vi) Consistent with the Data Quality Objectives and methodology guidance defined in EC Daughter Directives.

The UK's Quality Assurance and Control programmes typically include a broad spectrum of system design, operational management, training and review activities. These differ from programme to programme, depending on network objectives, methodologies and data quality targets. We highlight here some of the procedures employed for selected networks.

Automatic Urban and Rural Network (AURN)

For this network, all quality assurance activities are tasked to an independent QA/QC Unit (Figure 6), which carries out the comprehensive range of functions identified in Table 7.

There is an increasingly important European dimension to network quality assurance and control. The EU Framework Directive 96/62/EC on ambient air quality assessment and management, together with subsequent Daughter Directives, stipulate that once relevant performance standards are published by CEN, then these methodologies will become mandatory. CEN Working Group 12 of Technical Committee 264 has now published the relevant performance standards and these have been transposed as British Standards a BS EN 14211:2005 for NO_x, BS EN 14212:2005 for SO_2, BS EN 14625:2005 for Ozone and BS EN 14626:2005 for CO.

These describe in detail how analysers are to be tested, approved for use, calibrated and their ongoing performance determined. These procedures will allow Member States to reliably and consistently quantify the uncertainties associated with their measurements of air pollution.

Table 7. QA/QC activities in the AURN

Quality assurance (of measurement processes)	
Activity	**Function**
Advice on network design, site selection and siting	To ensure the data quality objectives of a network are fulfilled at the design stage
Support in instrument selection and sample system design	To ensure that the equipment used to sample ambient air are fit for purpose
Development of operations manual and monitoring compliance	To ensure that all monitoring stations are operated according to a consistent standard
Operator and personnel training	To ensure that all network participants perform to a consistent standard
Quality control (of measurement outputs)	
Activity	**Function**
Monitoring routine site visits and operations	To check that calibrations and operations are undertaken according to the prescribed procedures
Monitoring calibration gases and instrument response	To check that the equipment and gases used are performing within acceptable limits
Routine data inspection review and validation	To check, on a daily basis, that the data from analysers are scaled provisionally and are free from any obvious errors
Data ratification/finalisation before archival	Comprehensive checks every three months to: scale data, identify and remove any spurious information, use the network audit results to confirm satisfactory analyser performance
Quality Assessment	
Activity	**Function**
Regular network audits and site inspections (see Figure 7)	These tests assess the performance of the entire measurement system at a site: the stability of the site calibration cylinders, the performance of the analysers, ability of the Local Site Operators and the safety and general environment around the monitoring station.

The CEN/BS procedures are specifically targeted at Quality Assurance of a monitoring network by ensuring that the quality of the measurement inputs and systems are tightly specified. Individual instrument suppliers will be required to submit their analysers to an approved testing facility before their analysers may be used in a National Monitoring Network. The CEN procedures will require all analysers in a network to be type-approved.

The procedures will be adopted into the EC Daughter Directives during future reviews. It is anticipated that the UK monitoring network will need to demonstrate compliance with the requirements of the CEN protocols by September 2007.

The requirements of the CEN performance tests are exhaustive, but in general will include the following:

- All analysers must pass a rigorous series of tests using prescribed laboratory and field approval tests. The analysers must be field tested in the environments in which they are intended to be used

Figure 7 All UK automatic monitoring stations are audited regularly as part of their core quality assurance and control programme.

Here Diane is checking a Partisol Gravimetric PM_{10} sampler deployed at a rural monitoring station.

All AURN measurement sites are audited every six months. This involves:

- Thorough performance tests of all analysers on-site
- Verifying calibration gasses used at the site
- Inter-calibration of the network as a whole by checking response of all instruments with reference standard gasses
- Monitoring performance of local site operators
- Providing training if needed

- In addition to passing the individual performance tests, the analysers must also pass an overall uncertainty evaluation. For NOx, CO, O_3 and SO_2, this requirement is a measurement uncertainty of ±15% at the relevant EC Limit value
- Once deployed in a monitoring network, the analysers have to pass a number of ongoing performance tests. The results from these tests are used to determine ongoing measurement uncertainties, reported annually to the EC.

The UK Automatic Urban and Rural Monitoring Network already has a comprehensive suite of ongoing operational and performance tests that are used to evaluate the performance of site analysers. The majority of the tests required by CEN are either undertaken already, or require only minor modifications to ensure full compliance with the requirements. The procedures used to perform these tests are continuously refined and revised; they are sufficiently developed that they will be fully compliant with CEN well in advance of required timeframes.

During 2003 and 2004, a new operations manual for the AURN was produced and disseminated to all site operators. For the first time, this has been made available both in hardcopy form and on CD; the latter contains detailed instructions for operating all measurement and instrumentation types currently deployed in the programme.

Smoke and SO_2 Network

For sampler-based networks such as the Smoke and SO_2 and the NO_2 diffusion tube networks, the QA/QC programmes are rather different from those applicable to the automatic networks. For example, the QA/QC programme for the Smoke and SO_2 Network is based on the requirements of the British and ISO standards for the methods used. Two key components of this programme are:

(i) ***Data Verification***

The raw data are screened for any obvious errors or anomalies by experienced staff. Following this, dedicated data processing software is used to identify and highlight anomalies that might indicate either that the data have been recorded incorrectly, or that there is a fault in the sampling apparatus. The site operator will then be contacted to confirm the suspect value, or to check the sampler if necessary.

(ii) ***Quality Assurance Visits***

Periodic regional programmes of half-day site visits to participating Local Authorities. Each half-day visit includes:

- A visit to the sampler, with checks on the funnel inlet, and tests on the sampler itself (e.g. leak test, meter calibration),
- Tests on reagent solutions and titration procedures,
- Test of the reflectometer, and smoke stain measurement procedures.

NO_2 Diffusion Tube Network

The corresponding Quality Assurance/Quality Control programme for this network is based on:

(i) ***The Workplace Analysis Scheme for Proficiency (WASP) programme*** for NO_2 diffusion tube analysis. This independent performance-testing scheme makes use of artificial analytes (doped tubes) to test the quality of laboratory analyses on a monthly basis. It is operated independently by the Health and Safety Laboratory (HSL).

(ii) ***Field Intercomparison Exercises.*** Formerly an annual field trial, this is now an ongoing monthly exercise, operated by Health and Safety Laboratory. It is designed to complement the WASP scheme by providing information on the uncertainties arising from both the sampling and analysis phases of diffusive sampling in the field.

(iii) ***QC Solution Testing Scheme.*** This involves the monthly analysis of a nitrite solution of known concentration by all participating laboratories. Every six months, approximately 150ml of a stock nitrite solution is distributed to each laboratory. The laboratories analyse a sample of this stock solution on a monthly basis and return the results to the network managers.

(iv) ***Routine Data Screening.*** Experienced network managers carefully screen the data supplied by participating Local Authorities. Suspect values and possible errors are highlighted and checked with the site operators.

Criteria for data acceptance are set on the basis of items 1 and 2 above. Laboratories failing to demonstrate satisfactory performance in **both** these key quality systems may have their data excluded from the NO_2 Network's reported datasets.

Through a strong emphasis on data quality, we ensure that the measurements produced by all UK sampler and automatic monitoring networks - and reported here - are fit-for-purpose, reliable and accurate.

4.5 Disseminating and using air quality data - and where to find out more

As discussed previously, the UK's air monitoring programmes produce very large amounts of data. However, in isolation, these raw data are of very limited utility. We first need to ensure that the data are accurate and reliable; this is a major quality control task, as highlighted in the previous section. Once this has been done, the validated data are archived, useful information is derived and communicated to government, technical, local authority and public users in timescales and formats meeting their needs. This process of turning raw data into useful information, depicted in Figure 8, is vital to the success of the UK monitoring networks. The UK's **Air Quality Archive** and **Air Quality Information Service** are our key tools enabling the widest access and use of air quality information in the UK.

The main functions of these systems are:

1. To inform citizens about the quality of the air we all breathe
2. To provide information to Local Government
3. To provide public warnings in the event of extreme conditions, as required by a number of EC Directives
4. To raise awareness and educate
5. To provide a comprehensive data and information resource to scientists, doctors and epidemiologists, both in UK and world-wide.

The Archive and Information Service have evolved over many years to serve this wide diversity of end-user communities and objectives.

As noted in the introduction to this report, a primary objective of Government's air quality monitoring networks is to provide rapid and reliable air quality information to the public. The Air Quality Information Service provides the main link between the networks and the public at large. Data from all the UK's automatic monitoring stations are automatically collected every hour and uploaded to the UK's Air Quality Archive. Corresponding data from sampler measurements programmes are also collected and merged with the archive. The resulting archive contains over 170 million measurement and statistical records, making it one of the largest publicly accessible online databases in the world.

The UK's Air Quality Archive is the national repository for ambient air quality measurement and emissions data. It contains measurements from national automatic measurement programmes dating back to 1972, together with sampler measurements dating back to the early 1960s. The Archive brings together into one coherent database both data and information from all the UK's measurement networks, as well as corresponding detailed emission data from the National Atmospheric Emissions Inventory (NAEI).

All data and information stored in the UK's Air Quality Archive are freely available at **www.airquality.co.uk** The website provides user-friendly but comprehensive access to information on all air pollutant concentrations and emissions, together with up-to-date bulletins and measurements from the UK national monitoring networks. It also provides a twice-daily air quality forecast, which is further disseminated via TV Teletext, newspapers and a free telephone service (0800 556677). Finally, the website offers many pages of background information and advice on air quality, together with links to other UK and international information resources. See box 3 for further details of information available from the website and Figure 10 for a map of the site.

The UK's national air quality web site records over 4,000 hits each day and over 1.5 million every year; as well as its primary role in public information and awarenessraising, it has become a key resource for UK education and research. It has received wide praise, both within the UK and internationally.

In 2004, a new air quality archive was established for Wales. Publicly available through its website at **www.welshairquality.org.uk**, this mirrors many of the services and functions of the UK National Archive. It provides for the first time a comprehensive one-stop resource for data and analyses covering all aspects of air quality in the Principality. The site also includes for the first time measurements from a range of monitoring sites subject to QA/QC review comparable to that employed in the AURN.

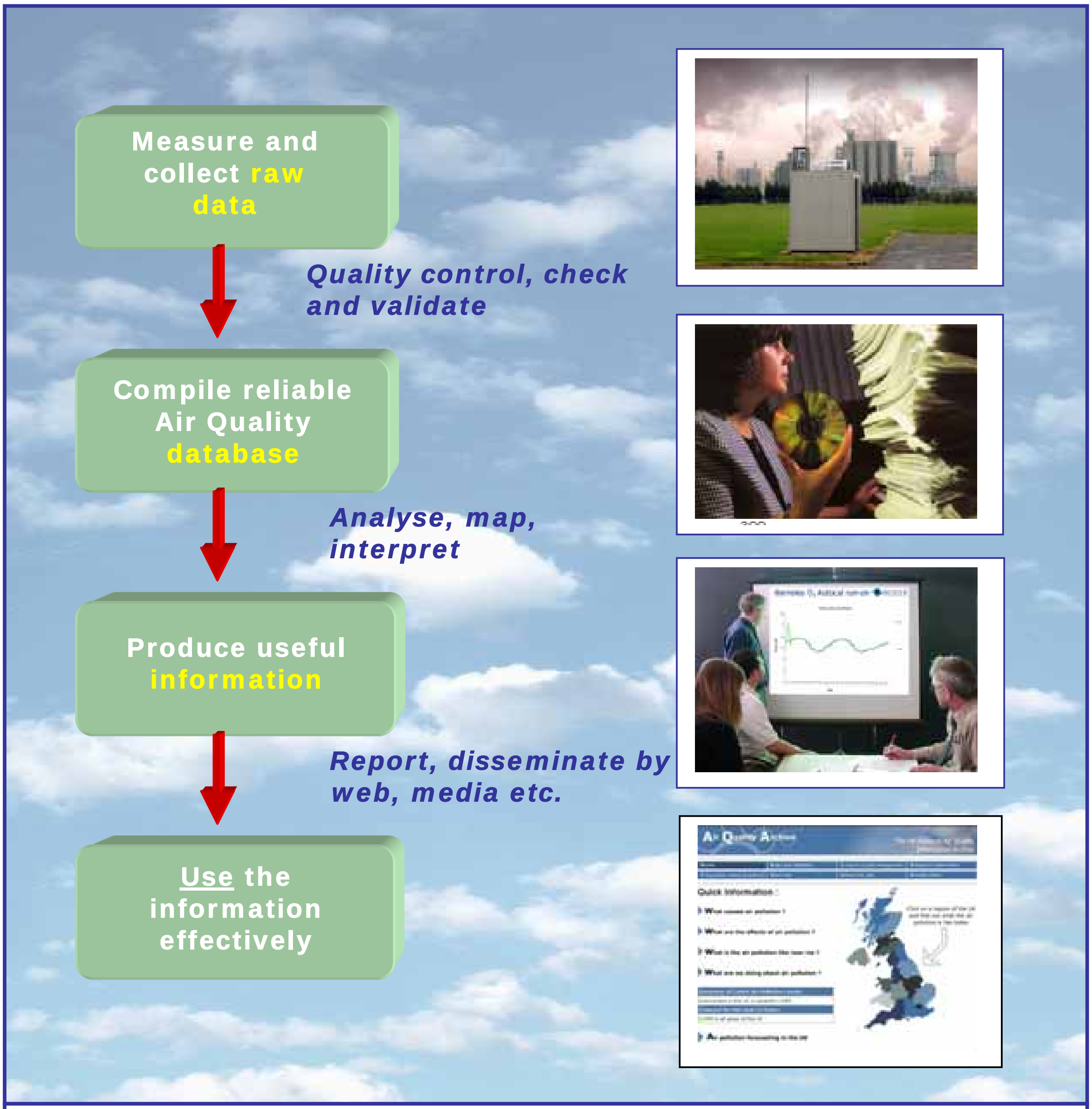
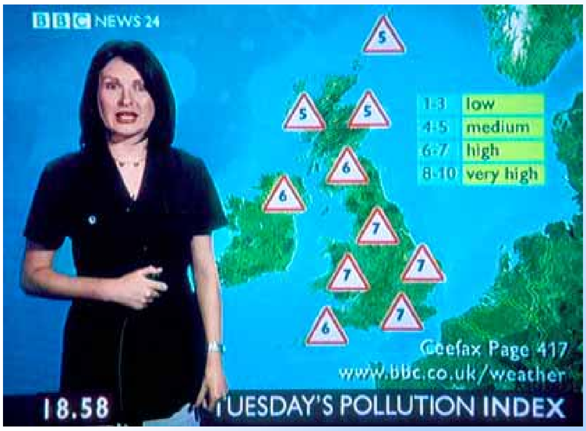


Figure 8. This report has been made possible by turning large quantities of raw air quality data into useful information

Figure 9. The UK Air Quality Information Service

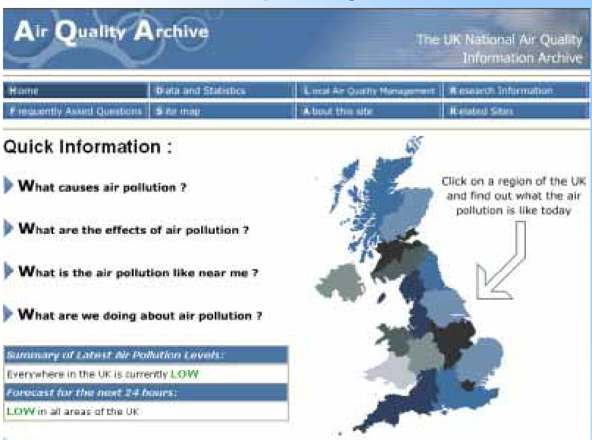
This utilises a wide variety of media, web and electronic resources to disseminate the latest air quality data and forecasts:

TV Weather Bulletins

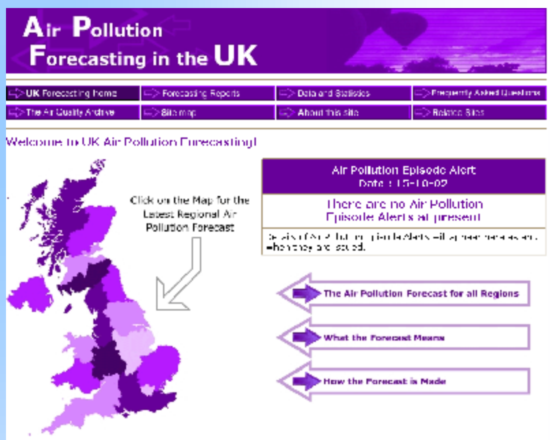


TV Teletext

The UK Air Quality Website



Twice daily web forecasts



A series of brochures & reports

Freephone 0800 556677

Box 2. Key Online and Media Information Resources on UK Air Pollution

1) How to obtain up-to date air quality information and forecasts for your area

- The Air Pollution Information Service on freephone 0800 556677
- The UK Air Quality Archive on www.airquality.co.uk
- The Welsh Air Quality Archive at www.welshairquality.org.uk
- Latest forecasts, issued twice daily, at http://www.airquality.co.uk/archive/uk_forecasting/apfuk_home.php
- The National Atmospheric Emissions Inventory on www.naei.org.uk
- The Defra air quality information web resource on http://www.defra.gov.uk/environment/airquality/index.htm
- The Scottish Executive Air Quality pages on http://www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561
- The Welsh Assembly Government Environment link at http://www.wales.gov.uk/subienvironment/index.htm
- The Northern Ireland Environment and Heritage Service website at http://www.ehsni.gov.uk/environment/environment.shtml
- Teletext page 156

2) Useful Sources of Background Information

A colourful brochure 'Air Pollution in the UK', suitable for educational or public use, is available from Defra Publications at: **defra@iforcegroup.com** or 08459 556000. This can also be downloaded from the UK Archive website.

A corresponding brochure 'Air Pollution in Wales' may be downloaded from the Welsh Archive website, as detailed above.

A brochure and report on Air Pollution in Northern Ireland is available from the DoE NI website at http://www.doeni.gov.uk/foi/search/

A comprehensive range of air quality research reports is available from http://www.airquality.co.uk/archive/reports/list.php

3) Health Effects of Air Pollution

A concise brochure entitled ***'Air Pollution, what it means for your health'*** is available to download from the Defra air quality information web resource listed above or free of charge from Defra publications or via Freephone.

4) Local Air Quality Issues

For further information on air quality issues in your area, please contact the Environmental Health Department at your local Council office.

Further information on Local Air Quality Management may also be found at:
http://www.defra.gov.uk/environment/airquality/laqm.htm and
http://www.airquality.co.uk/archive/laqm/laqm.php
http://www.scotland.gov.uk

Box 3. Information Available from the UK Air Quality Archive at www.airquality.co.uk

- Historic measurements from all national sampler and automatic air monitoring programmes
- Current measurements from automatic networks, speedily available for all UK regions and urban areas
- Detailed air pollution statistics derived from all current and historic data and available via interactive selections
- Twice-daily regional forecasts of air quality
- Maps, photographs and descriptions of all automatic network stations
- Information on causes and effects of the major air pollutants
- Details of UK and international efforts taken to tackle air pollution
- A database of Frequently Asked Questions (FAQs) and answers related to air pollution
- Search-driven information and access to reports covering a wide range of Air Pollution issues
- Background information on a range of Local Air Quality Management (LAQM) issues including:
  - Air Quality Management Areas
  - LAQM tools
  - Helplines
  - Reports and FAQs
- Links to the National Atmospheric Emissions Inventory (NAEI) site which offers:
  - Information on how the inventory has been prepared
  - A data warehouse of emission factors and inventory tools
  - UK–wide maps of emissions of the major pollutants (1km resolution)
  - Mapped emissions for different source types - industrial, transport etc
  - A powerful search facility for finding local emissions by postcode input
  - Information on a broad range of climate change issues
- A range of useful links to air pollution data resources, organisations and information in the UK, Europe and worldwide

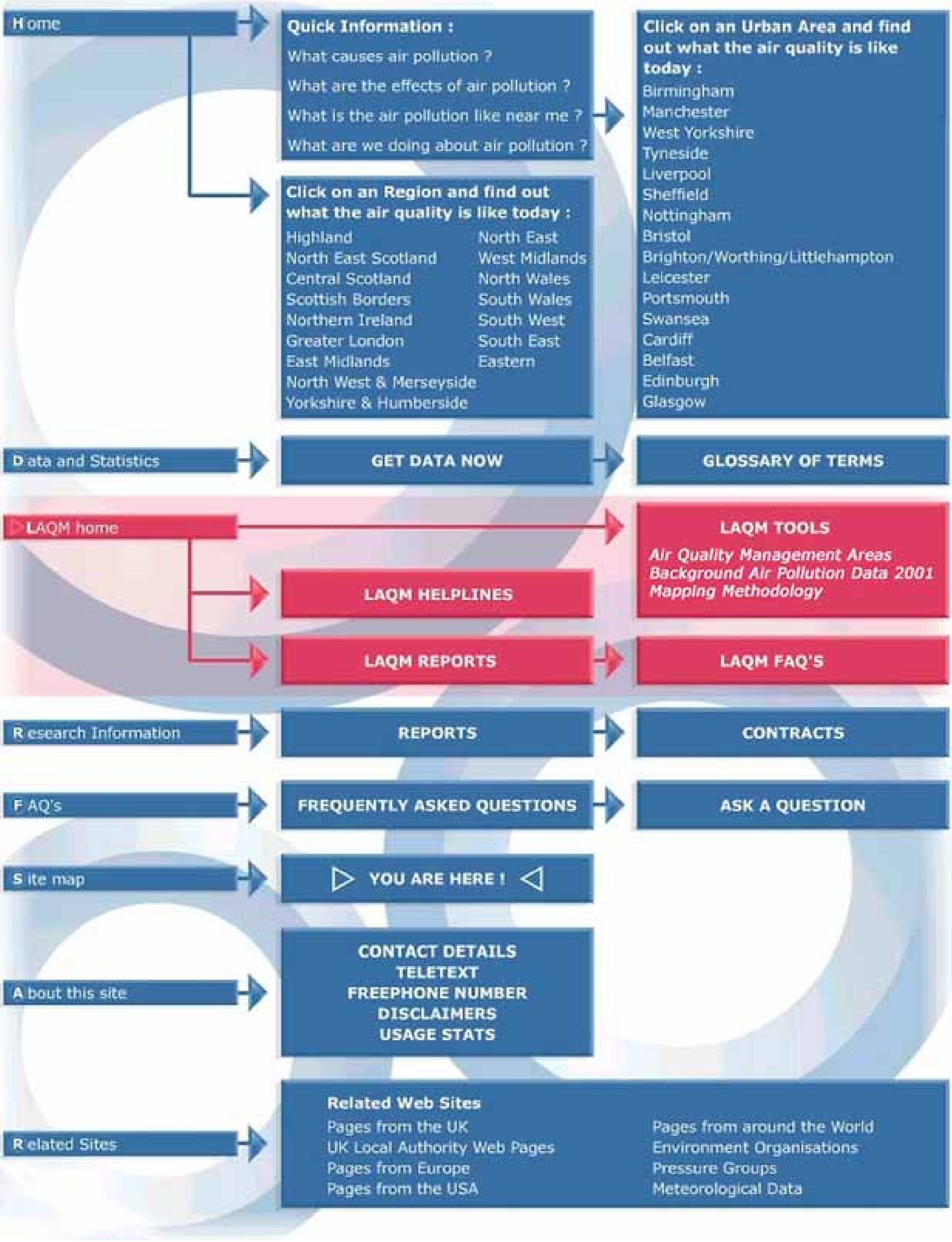


Figure 10. Map of the UK Air Quality Archive, showing the comprehensive range of available data and information from this resource

5. High Pollution Episodes

We focus in this section on the relatively few periods when pollution levels during 2004 were unusually high, either locally or UK-wide. Through examining such episodes, we identify causes and examine their possible impacts. We also compare and contrast episodes this year with those observed in 2003.

Air pollution levels can vary considerably from day to day, as well as from one part of the country to another. In this section, we'll look at short-term variations over time, and in particular some recent periods when pollution levels were particularly high. These are usually referred to as *episodes*. In the next section of the report, we focus more on variations in pollution levels from area to area within the UK.

Pollution levels vary over time for two main reasons:

1) Variations in pollutant emissions
2) Changes in atmospheric conditions that allow pollution levels to build up, result in the transport of pollutants from other areas or encourage their formation through chemical reactions.

All episodes occur because of a combination of these factors.

There are two main types of pollution episode in the UK- winter and summer smogs. ***Winter smogs*** typically occur in cold, still and foggy weather; this traps pollution produced by motor vehicles, space heating and other sources close to the ground and allows it to build up over time. City areas - in particular those close to major roads - are usually worst affected, together with sheltered or low-lying parts of the country. Winter episodes are usually characterised by elevated levels of nitrogen dioxide (NO_2), particles (PM_{10}) and volatile organic compounds (VOCs) such as benzene. High sulphur dioxide levels can also occur in some industrial or coal-burning regions.

Bonfire night can provide an interesting example of an emissions-driven winter episode. Given cold, stable weather – poor conditions for dispersing emissions - widespread bonfires may result in elevated levels of PM_{10} particles in many urban areas of the UK.

By contrast, ***summer smogs*** occur in hot and sunny weather. Sunlight and high temperatures accelerate chemical reactions in mixtures of air pollutants that are emitted from road vehicles, fuel burning and solvent usage. The pollutants that cause such an episode can often travel long distances - sometimes from other parts of Europe. During this large-scale air movement, they react together to produce high levels of ozone (O_3), together with other pollutants such as nitrogen dioxide and fine particles. Unlike the ozone layer in the upper levels of the atmosphere that protects us from ultraviolet radiation, ground level ozone produced in this way is harmful both to human health and vegetation, as well as damaging some man-made materials.

Long-range transport of pollutants from Europe, or occasionally from North Africa or North America, can on occasions cause another type of pollution episode. This tends to occur during the summer months, either in isolation or in combination with summer smog. ***Local transport*** episodes involving elevated levels of primary (directly emitted) pollutants may also occur in the proximity of large industrial plant.

Air pollution episodes in the UK vary widely in terms of the size and location of the areas they affect, as well as their duration and seriousness. Episode numbers can also vary markedly from year to year. We now compare and contrast episode numbers and types in 2004 with those observed during the previous year; these were analysed in detail in last year's annual air quality report.

5.1 Comparing the 2004 and 2003 Summer Episodes

2003 was a record-breaking year for the UK and global climate. It proved to be the sunniest on record for England and Scotland, the warmest ever in Scotland, and the second driest year in England and Wales since 1766. The highest ever UK temperature of 38.5°C was recorded in Faversham, Kent on 10th August. Taken overall, 2003 was the fifth warmest for Britain as a whole since records began in 1659.

The extreme meteorological conditions were not just confined to the UK. 2003 was the third warmest year worldwide since global records began in 1861, and the hottest ever over many parts of Europe. It is interesting to note that all of the planet's ten hottest years have occurred since 1990.

As highlighted in last year's report, these extreme weather conditions caused photochemical ozone production over large areas of UK and Europe. 2003 was notable both for very early (April) and late (September) summer smogs in the UK. The most exceptional of these was the extended episode that occurred during the very hottest part of the year from 1st to 15th August; this was discussed in some detail in last year's report. During this period, many rural and urban monitoring stations across England and Wales recorded hourly ozone levels in the HIGH (180-360 μgm^{-3}) band; moreover, high concentrations were recorded for 10 consecutive days, an unusually long period for an ozone episode.

By contrast, the summer of 2004 was far less exceptional in terms of both temperatures and sunshine levels. It was, for the most part, relatively cool, damp and cloudy - not conditions favourable for photochemical smog formation. Similarly, the cold, stable periods of misty weather conducive to winter smogs were notably lacking in 2004. In consequence, the number of periods of HIGH pollution, particularly for ozone and PM_{10} were markedly lower this year; this is shown clearly by Table 8, Figures 11.1 & 11.2. Please note that these two figures are drawn with the same axis scales, in order to facilitate direct comparison.

Table 8. The number of HIGH pollution episodes in 2003 and 2004

Pollutant	No. HIGH days, 2003	No. HIGH days, 2004
Ozone	**42**	**3**
PM_{10}	**59**	**9**
NO_2	**0**	**0**
SO_2	**1**	**5**
CO	**0**	**0**

Figures 11.1 and 11.2 also demonstrate that PM_{10} HIGH levels can occur at virtually any time of year, in association with:

- High ozone levels during summer smogs
- Winter stagnation episodes
- Long-range transport - for example, from fires, volcanoes or Saharan Dust
- Due to local sources - for example Bonfire Night (section 5.3) or industry (5.4)

By contrast, elevated ozone concentrations occur during discrete summer periods, typically of a few days duration. We now examine such a period during 2004 and also examine in greater detail how this differed from the notable large-scale photochemical episode of August 2003.

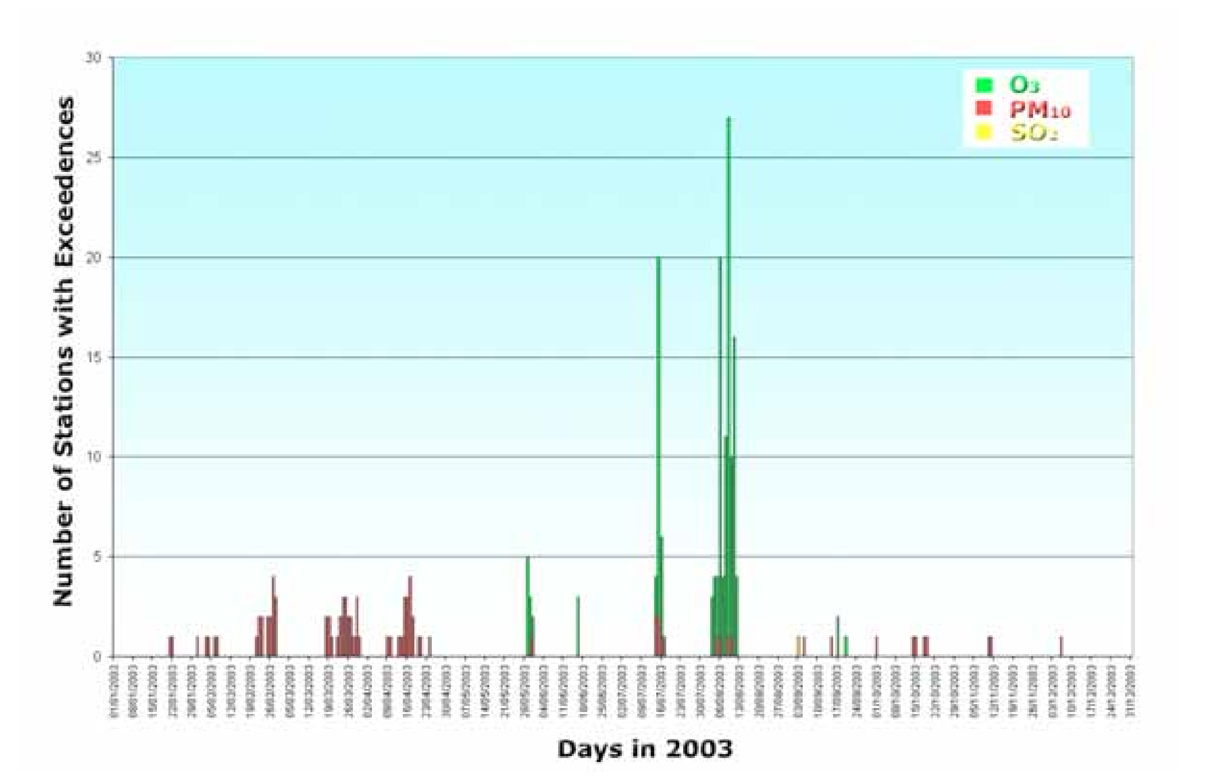


Figure 11.1 Number of station with air pollution levels 'HIGH' and above- 2003

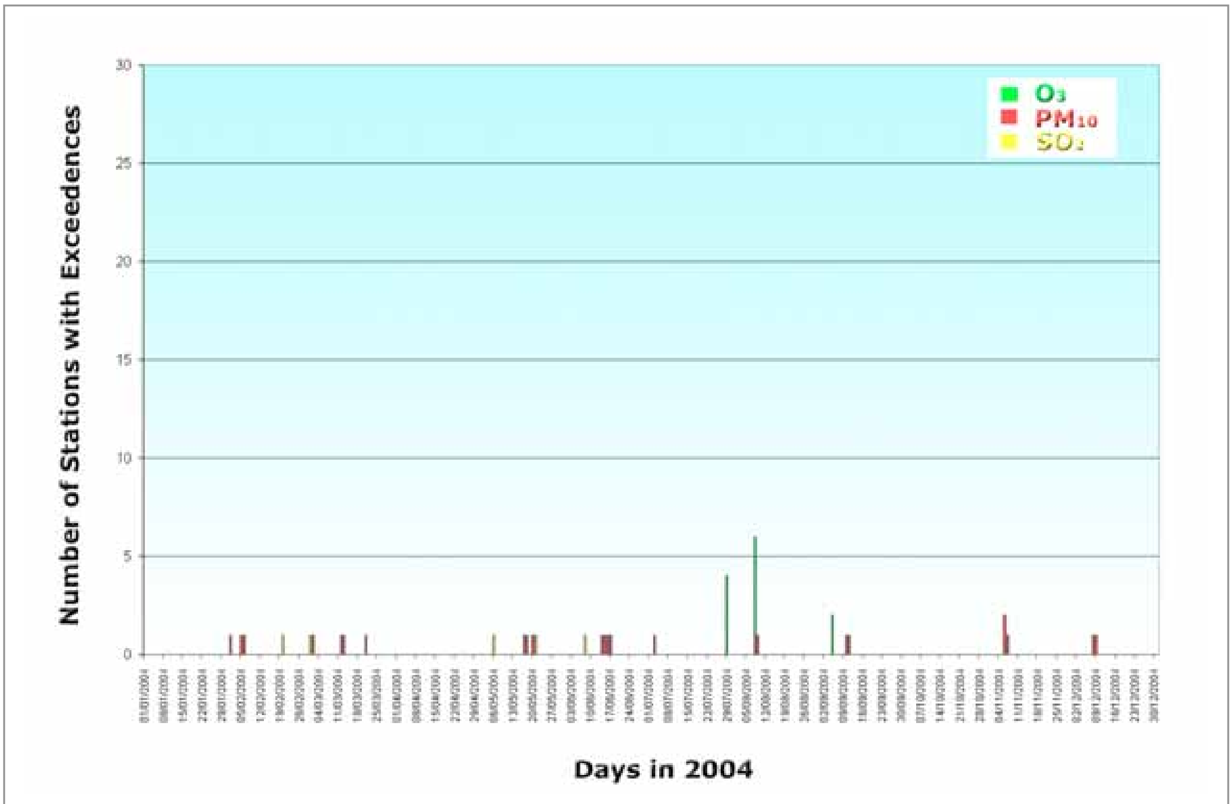


Figure 11.2 Number of stations with air pollution levels 'HIGH' and above- 2004

5.2 A Summer Smog Episode: July / August 2004

HIGH levels of ozone were measured at a range of UK locations from the end of July and early August 2004. The automatic network recorded ozone levels in the HIGH band 7 (90-119 ppb, 180-239 µgm^{-3}) between 28th July to 10th August. HIGH ozone levels were reported on 5 days and MODERATE concentrations (50-89 ppb, 100-179 µgm^{-3}) were reported during all 14 days. The highest concentration of the episode was 105 ppb (210 µgm^{-3}, index 7), which occurred at Sibton on 8th August. Within the 14 days covered here which may be considered as covering the full extent of the episode, three days are of greater relative importance: 29th July, 1st and 8th August. During these three days, high levels of ozone were recorded at three, one and six stations respectively. Moderate levels were recorded at 61, 59 and 45 locations respectively on these days (Figure 12).

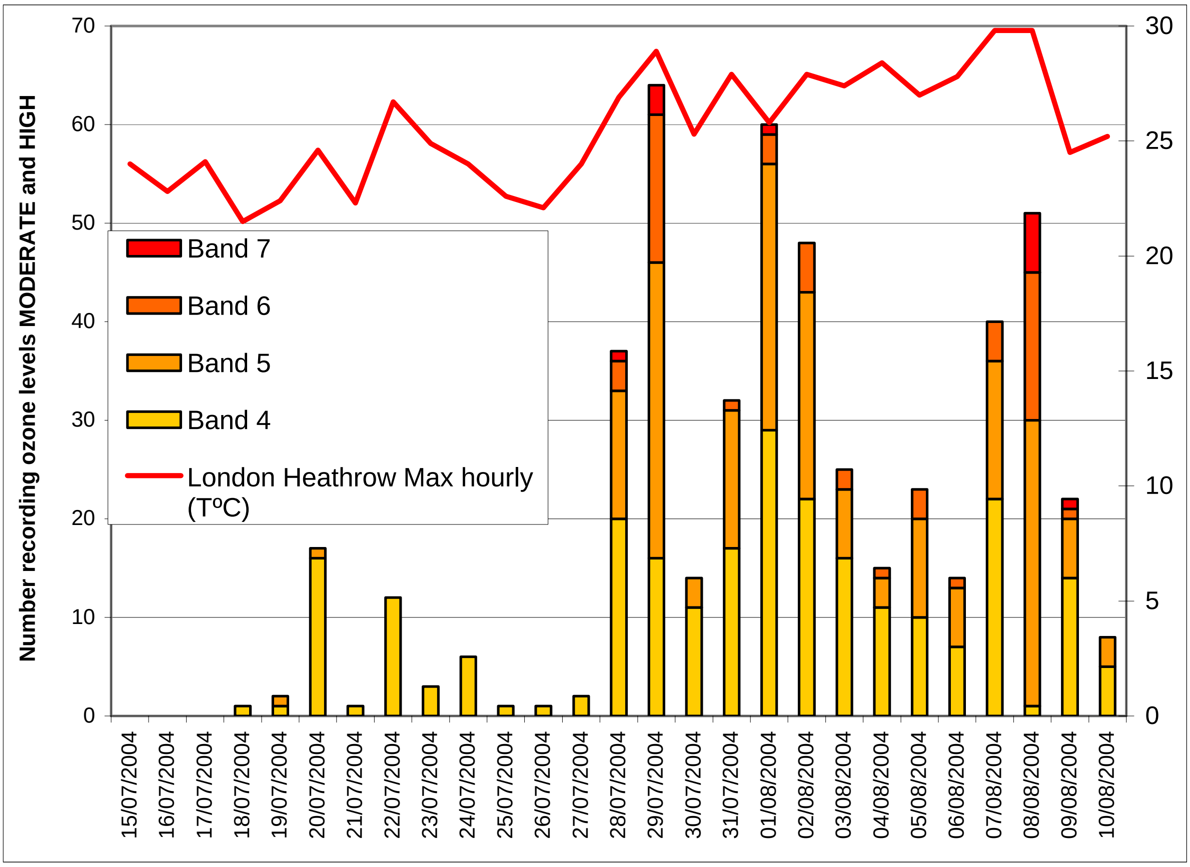


Figure 12. Ozone Episode Days – number of stations with levels MODERATE and HIGH between the 15th July and 10th August; temperatures at London Heathrow are also shown.

Measured ozone levels during the episode did not exceed the population warning threshold (an hourly mean concentration in excess of 360µgm^{-3} or 180 ppb) and therefore did not trigger a formal public alert. The 3rd Daughter Directive (Directive 2002/3/EC) on ozone in ambient air, implemented on 9th September 2003, establishes a stricter alert threshold of 240 µgm^{-3} (120 ppb) as an hourly average over three consecutive hours. During the episode, this alert threshold was not exceeded.

The areas affected by the episode were predominately located in the South East of England and the Midlands. During the first peak of the episode, ozone levels were HIGH in the following zones: Eastern, South West, East Midlands and West Midlands. At the end of the episode, apart from these areas, the Highland and North East zones also measured HIGH levels of pollution.

This summer ozone episode was focussed on days when temperatures were high and air masses re-circulating over northern Europe. Throughout much of the latter half of the episode period, maximum daytime temperatures at Heathrow exceeded 25ºC (Figure 12). However, it is clear that elevated temperatures alone were not sufficient to lead to high ozone; favourable transport patterns were also necessary conditions for HIGH ozone to occur.

This becomes clearer when we examine the 72-hours air back-trajectories on the key three days over the episode- see Figure 13. It is clear that the re-circulation of air masses over Europe - and then over the UK - had a great influence on HIGH levels measured on these days (especially on the 29th July and 8th August); such conditions bring continental ozone precursors to the UK. This re-circulation, in conjunction with high temperatures and UK ozone precursor emissions (specially over Greater London Urban Area), was the main reason for ozone levels reaching the HIGH band during this episode. By contrast, however, most other days during the episode were characterised by predominantly westerly airflow from the Atlantic and - in consequence - showed markedly reduced pollution levels.

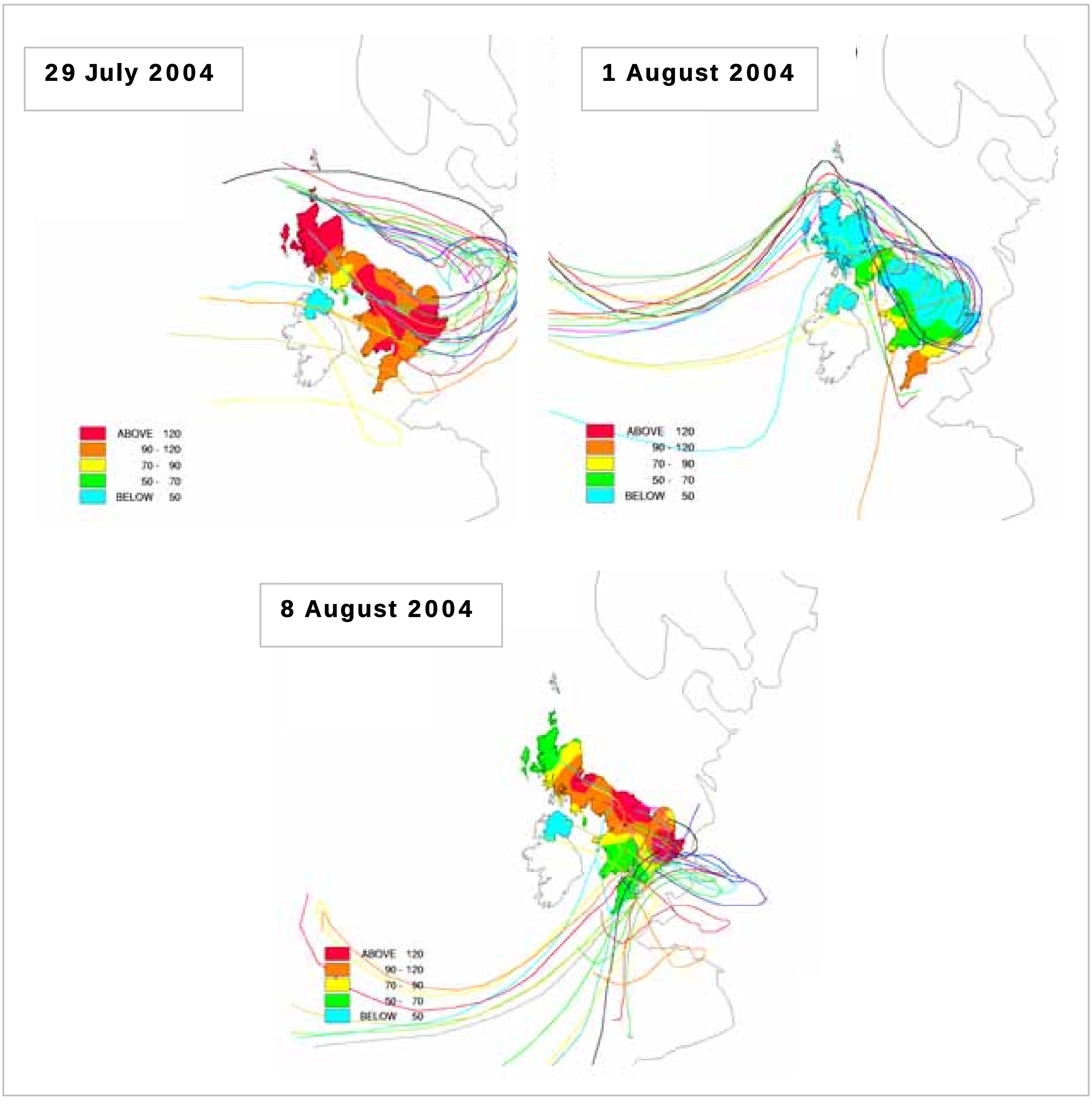


Figure 13. Airmass trajectories during the three key days of the episode

Figure 14. Detailed trajectory typical 29th July and 8th August

Figure 14 above shows greater geographical detail of trajectories that were typical of the 29th July and 8th August. On both days, air masses re-circulated over Europe before entering the UK. Air then circulated from south England (Lullington Heath in this example) to the Midlands (e.g. Northampton) across the Greater London Urban Area. Clearly, on these days, HIGH ozone was generated from precursors (NOx and VOCs) emitted both from continental European and UK domestic emissions.

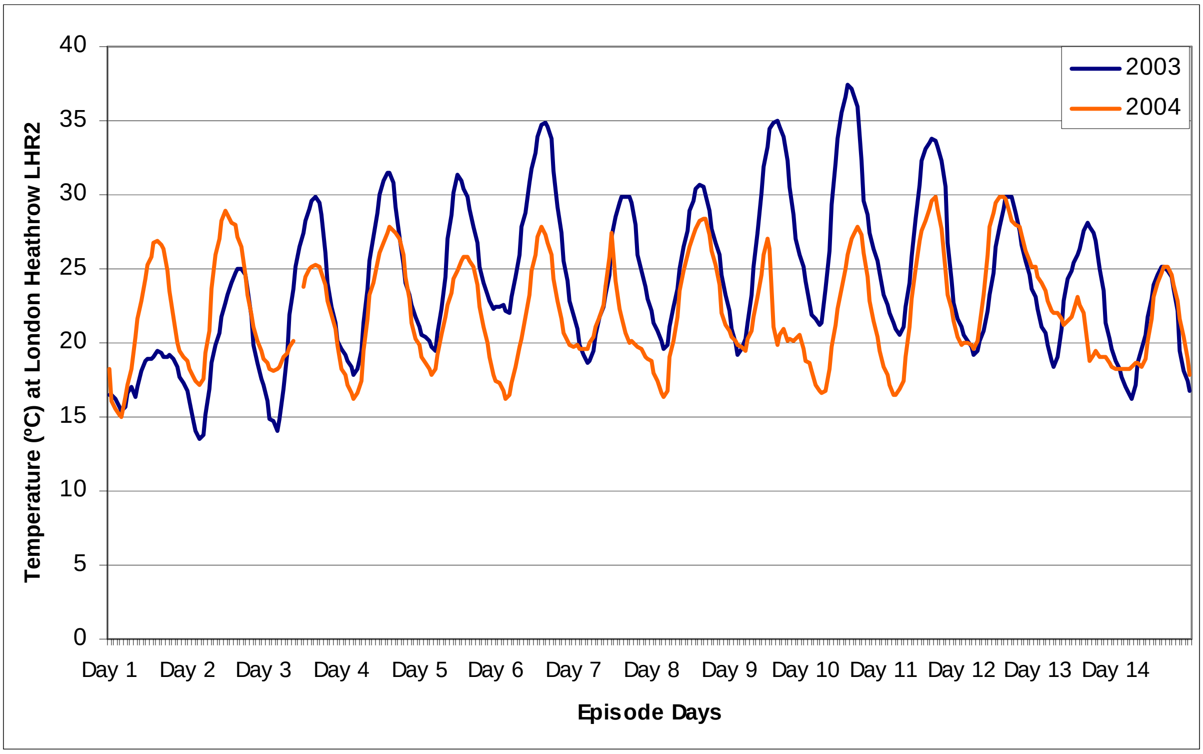


Figure 15- Temperatures during the 2004 & 2003 summer episodes compared

Comparison between the major summer episodes of 2004 and 2003 show a number of significant differences:

- **Temperatures were substantially lower in 2004**, reducing overall ozone production rates- see Figure 15.
- **The trajectory patterns were characteristically different**; there was greater sustained influence of Continental rather than Atlantic airmasses in 2003. During 2004, clean Atlantic air was the major influence over much of the period- only trajectories for the three days highlighted in Figure 13 show significant re-circulation or continental origin. By contrast, as we saw in last year's full analysis of the 2003 episode, air mass recirculation over Europe persisted over an extended period, enabling ozone levels to build up and persist for a number of days.
- **A smaller area of the UK was affected** overall in 2004.
- **Peak ozone levels were lower** in 2004- 210 μg m^{-3}, compared to 250 μg m^{-3} during the previous year.

5.3 A Bonfire Night Episode: 5 November 2004

Bonfire Night 2004 proved once again that a high pollution episode is rarely caused by emissions alone; favourable meteorological and dispersion conditions are also required. Although bonfires and firework displays occur in many parts of the UK every November 5th, as well as during adjacent weekends, meteorological conditions strongly affect the resulting pollutant concentrations from year to year. Wet, windy or unsettled conditions result in low concentrations, whilst cold and still weather may result in elevated levels of PM_{10} particles and other pollutants.

Generally, PM_{10} levels during the Bonfire Night weekend of 2004 were relatively low, with elevated measured concentrations being confined to a few small areas, often at sites having comparatively high background levels. Celebrations this year were split between two consecutive evenings- Friday 5th and Saturday 6th; consequently, elevated PM_{10} levels were measured on both nights at some locations. In general, higher levels were recorded on Friday night, partly due to colder conditions and lower wind speeds.

Two sites reached into the HIGH band: Hillingdon measured a daily maximum 24-hour running mean of 90 μg m^{-3} (index 8) on Saturday as a result of an usually high Saturday evening hourly average maximum of 758 μg m^{-3}. Thurrock measured a daily maximum 24-hour running mean of 75 μg m^{-3} (index 7) on Saturday. There was activity on both nights at Thurrock- up to 182 μg m^{-3} as an hourly average on Friday evening and 157 μg m^{-3} on Saturday.

Four sites reached the MODERATE band: Plymouth recorded MODERATE levels due to daytime paving slab installation work that was clearly not related to the bonfire celebrations. Birmingham Tyburn recorded 159 μg m^{-3} maximum hourly average on Friday evening and 136 μg/m^3 Saturday evening. Scunthorpe reached 122 μg m^{-3} as an hourly average measured on Friday evening. Port Talbot reached 185 μg m^{-3} as an hourly average on Friday evening, apparently as a result of nearby celebrations and not industrial activity (see next section).

Figure 16 shows very clearly how Bonfire Night particle concentrations can vary markedly from year to year. It confirms 2004 to have been a relatively quiet year, with 1994 and 1995 being the most recent years characterised by UK-wide exceedences of the 24-hour average PM_{10} objective of 50 µg m^{-3}.

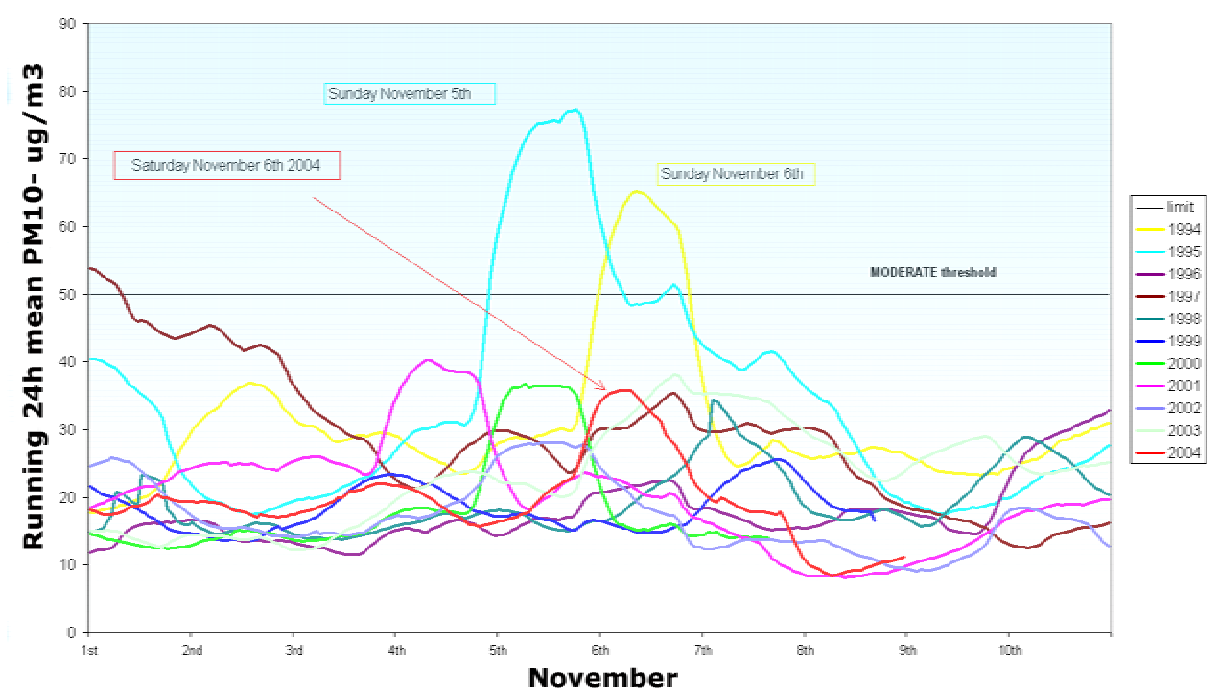


Figure 16. Bonfire night PM levels (running 24-hour average over all UK sites) compared to objective of 50 µg m^{-3} for all years from 1994 to 2004

5.4 Episodes at industrial locations involving short-range Transport

Grangemouth SO_2

Short-term elevated levels of primary pollutants can be observed in the proximity of major emission sources such as power stations, refineries or large industrial plant. Such episodes tend to be intermittent, highly localised and are often associated with rapidly fluctuating concentrations. In the case of sulphur dioxide, for instance, increasingly stringent emission controls and the move towards lower-sulphur or clean fuels such as natural gas mean that such events are now becoming increasingly rare - but not unknown.

The Grangemouth monitoring site is located in a heavily industrialised area of Central Scotland; nearby pollution sources include a number of small industrial plants, the Longannet Power Station and the large BP petrochemical and refinery complex situated 1km from the measurement point (Figure 17.1).

In 2004, there were 60 exceedences of the 15-minute SO_2 concentration target level of 266 µg m^{-3}; these were observed on a total of 18 days during the year. Although some other UK sites showed sporadic exceedences of this target level, Grangemouth was the only UK site where over 35 exceedences – the number permitted under the UK short-term Objective for this pollutant - were recorded during 2004. This Objective was therefore breached at this location.

An Air Quality Management Area (AQMA) is due to be established in the area by the end of 2005; this will be one of the few to have been declared in the UK due to sulphur dioxide (Table 3).

Figure 17.1. The Grangemouth monitoring station, with the large BP refinery in the background

Figure 17.2. The Corus Steelworks and Port Area- courtesy Corus/Peter Knowles

Port Talbot PM_{10}

Another example of short-range transport of industrial pollutants causing local problems may be seen in Port Talbot, Wales. An important characteristic that this area shares with Grangemouth is the multiplicity of pollution sources; these include the M4 motorway, port activities (iron ore offloading) and the large Corus steelworks (Figure 17.2).

38 exceedences of the PM_{10} daily mean of 50 $\mu g\ m^{-3}$ were recorded here during 2004, exceeding the permitted number of 35 exceedences allowed under the UK Objective. The Objective was also not complied with in 2003, when there were 43 such exceedences. There remains some doubt about the causation of these high levels; these continue despite the commissioning of a new blast furnace at the Corus plant in 2003, as well a range of measures adopted to minimise fugitive particle emissions from ship offloading, ore stockpiling, containment and transport at the nearby dock area.

In order to tackle the continuing problems at this location, an area covering the majority of land and properties between the Corus Steel Works and the M4 Motorway has been declared an AQMA by Neath Port Talbot due to PM_{10}.

6. How air pollution varies across the UK

We examine how levels of air pollution vary across the UK, and see how these variations relate to both emissions and the behaviour of pollutants once emitted into the atmosphere.

Levels of air pollutants vary markedly across the country. Measurements from the national air monitoring networks clearly show that these patterns differ for each pollutant, depending on how they are formed and where their major sources are located.

Levels of ***primary pollutants***, those emitted directly into the atmosphere, tend to be highest around their sources; these are usually located in urban and industrial areas. Sulphur dioxide provides a good example of such a pollutant, with domestic or industrial fuel burning being its major sources nationwide. The highest sustained levels of this pollutant are often found during winter in parts of Northern Ireland, where solid fuel is still used extensively for domestic heating.

Measurements from the UK monitoring networks can be combined using empirical models with detailed pollutant emissions data from the UK's National Atmospheric Emissions Inventory (NAEI). Together, these provide the basis for robust, empirical pollutant models which now enable us to produce detailed maps (1km resolution) of average or peak pollutant concentrations across the country. The mapping method is detailed in a number of published reports on the UK Air Quality Archive- for example, the report for Defra and the Devolved Administrations entitled 'Mapping of nitrogen dioxide and PM_{10} in the United Kingdom for Article 5 Assessment' and subsequently published at http://www.aeat.co.uk/netcen/airqual/reports/aeat-env-r0707.pdf. The main benefit of the model is that it is simple and directly related to the measurements. No complicated meteorological fields, emissions factors or local information is required.

These maps enable the UK to fulfil its European commitments to assess nationwide pollution patterns prior to implementing the European Air Quality Directives. They also provide an extremely powerful tool for identifying pollutant 'hot-spots' and managing UK-wide air quality problems in the most direct and cost-efficient manner.

A map showing average SO_2 levels across the country is shown in Figure 18. This clearly shows the impact of power station and industrial emissions in Northern England, the Thames Estuary and Forth Valley, as well as domestic emissions focussed around Belfast in Northern Ireland. It is not always meaningful to deduce trends from changes from one year to the next. However, some shrinking of the higher concentration contour areas is apparent when comparing Figure 18 to its counterpart from last year's report, particularly in SE England.

Motor vehicles are now a major source of air pollution in many large cities. In particular, most of the carbon monoxide, nitrogen dioxide, and volatile hydrocarbons (VOCs) such as benzene and 1,3-butadiene are emitted from traffic, together with a significant proportion of particles (PM_{10}). Concentrations of all these pollutants are therefore usually highest in built-up urban areas.

In general, patterns of ***secondary pollutants*** such as ground-level ozone - which are formed by chemical reaction in the atmosphere - are markedly different from those of primary pollutants; they are characteristically less dependent on emission patterns, and tend to be more strongly influenced by meteorology and atmospheric chemistry. As a result, they also change more from year to year than those of primary pollutants. UK-wide concentrations of ozone (expressed here as the accumulated hours above $80\mu g\ m^{-3}$)

are shown in Figure 19. As expected, this map shows a marked reduction in the areas covered by the higher concentration contours when compared to the same plot for 2003.

As highlighted previously, ground-level ozone is formed by a series of chemical reactions involving precursor pollutants - oxides of nitrogen and hydrocarbons – together with oxygen. Ultraviolet radiation drives these reactions and, as a result, ozone production rates are highest in hot, sunny weather. Ozone formation can take from hours to days to complete. Consequently, high levels of ozone can often be formed considerable distances downwind of the original pollution sources in UK or Europe.

UK-wide patterns of ground-level ozone are also influenced by other factors. Concentrations in busy urban areas are often lower than in the surrounding countryside. This is because road transport emissions react very quickly with ozone to remove it from the atmosphere. Because ozone is very reactive, it is also readily deposited onto the ground or adsorbed onto vegetation. These removal processes tend to be more important in sheltered, lowland areas than exposed higher altitudes. As a result, ozone levels are usually higher on elevated ground.

The net result of all these effects, acting together, is shown in Figure 19. The highest summer ozone concentrations are seen in the rural parts of South and Eastern England; these areas tend to be hotter and sunnier than other parts of the UK, and are often downwind of polluted areas of Northern Europe. It can also be seen, particularly clearly in the ozone 'hole' around London, that levels of this pollutant are characteristically depressed in urban areas, as a result of its 'scavenging' from the atmosphere by road transport emissions.

The vast majority of Air Quality Management Areas (AQMAs) in the UK are due to current or predicted exceedences of air quality objectives for nitrogen dioxide (NO_2) or PM_{10} particles. We'll now examine UK-wide patterns of these pollutants more closely.

UK-wide patterns of nitrogen dioxide concentration are shown in Figure 20; these are markedly different from those of ozone or sulphur dioxide. Although some NO_2 is emitted directly from vehicles or other sources, most is formed by rapid chemical reaction in the atmosphere. This pollutant therefore has both secondary and primary characteristics. Concentrations of nitrogen dioxide tend to be highest in urban areas such as in London, where traffic densities are high. Although the data mapped in the figure are background rather than roadside pollution levels, they clearly follow closely the country's major motorways and road network infrastructure. Figure 20 is remarkably similar to the corresponding NO_2 contour plot for 2003, shown in last year's report.

Particles are not a distinct chemical species like the other pollutants measured in the automatic networks; rather, they consist of material from many sources and are usually classified on the basis of size and not chemical composition. In the UK automatic networks, particles of average aerodynamic diameter less than 10 microns (where one micron is a thousandth of a millimetre) are measured. These fine particle fractions can be inhaled deep into the lungs, and therefore provide a better indication of potential health impacts than larger particle size ranges.

The sources of PM_{10} particles are diverse. They are produced from motor vehicles, fuel burning, building work, industrial emissions, soil and road dust and quarrying. A significant proportion of PM_{10} particles are secondary, formed by the reaction of gases in the air. Particles of ammonium sulphate and ammonium nitrate are produced by the same photochemical reactions that give rise to ozone. Like ozone, secondary particles can therefore be formed considerable distances from the emission sources. This diversity of PM_{10} source types and influences is reflected in the map of average concentrations in Figure 21, which shows markedly less variation across the country than for the other pollutants assessed here.

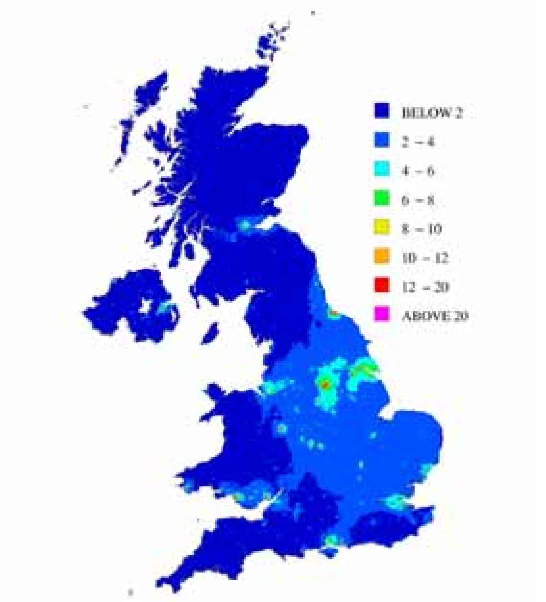


Figure 18. Background **SO_2**, annual average concentrations in 2004 (μgm^{-3})

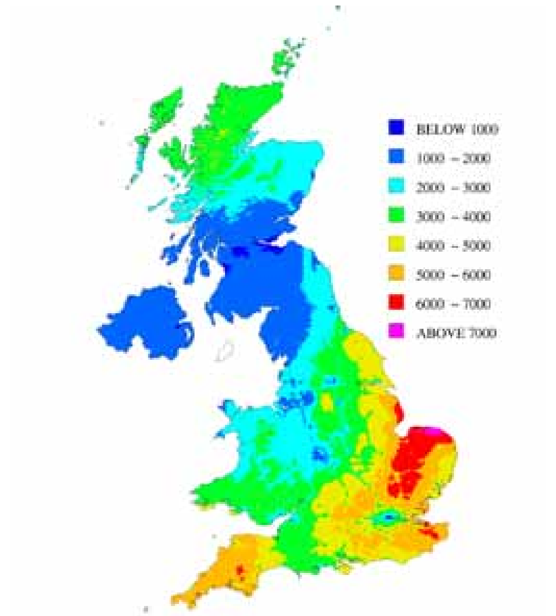


Figure 19. Accumulated **ozone** hours over 80 μgm^{-3}, 2004

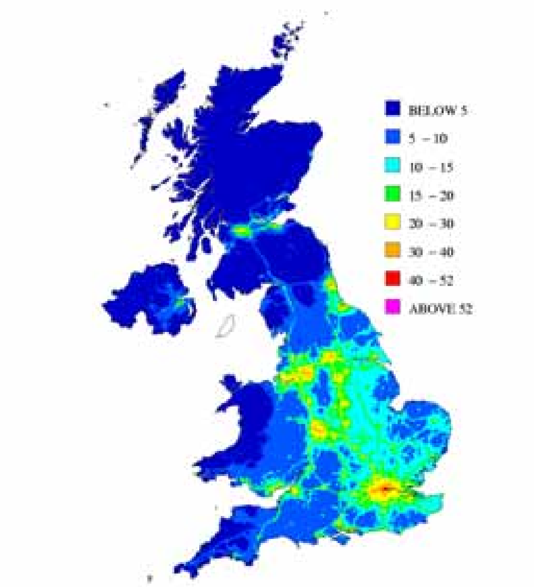


Figure 20. Annual average **NO_2** levels in 2004 (μgm^{-3})

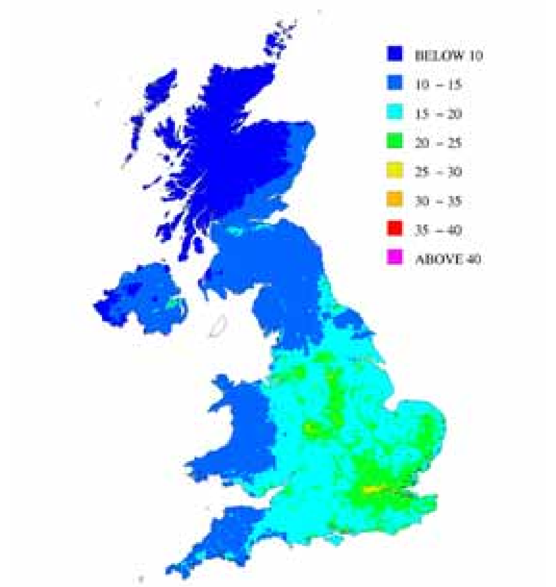


Figure 21. Background **PM_{10}** levels in 2004 (μgm^{-3} gravimetric)

Figures 18-21 show mapped concentrations of four major pollutants (SO_2, O_3, NO_2 and PM_{10}); these have been estimated using models based on national monitoring and emissions inventory datasets.

7. How air pollution has changed over time

Is air pollution getting better or worse? Here we find out, but the answers are not always clearcut.

As highlighted in previous sections, the concentrations of air pollutants in the atmosphere can vary over the course of a day, the seasons of a year and from year to year. In this section, we focus on long-term trends in the UK's air quality, and attempt to answer the perennial question - 'are things getting better or worse?' As always, the answer to such a straightforward question is not clearcut. It really depends on what pollutants we're examining, and over what timescales.

In this section, we primarily examine:

1) Trends in UK Government's **air quality indicators** over the period that sampler and automatic networks have been in operation.
2) Trends showing how **compliance with UK Air Quality Objectives** for individual pollutants is changing over time.

Very reliable indications of long-term trends can be derived from UK monitoring data. As noted previously, large-scale national measurements of black smoke and sulphur dioxide began in the early 1960s. This national network, established in response to the recurring serious smogs of that era, was probably the earliest air quality measurement programme of this scale and sophistication in the world. At its peak, it included over 1200 measurement sites. The main objectives of this network were to assess nationwide levels of these ingredients of coal smog, and to analyse how these have changed over time; over the 40 years of its operation, both of these network goals have been met in full.

In Figure 22, we show annual average levels of both pollutants from the establishment of the network in the 1960s. The picture shown here is most encouraging. It demonstrates that overall levels of sulphur dioxide have fallen nearly 10-fold, and smoke levels 20-fold. Corresponding measurements from later automatic measurements since 1970 tell the same story, with urban background SO_2 levels now barely distinguishable from those in rural areas.

The dramatic decline in atmospheric concentrations of these pollutants mirrors closely the fall in national emissions of both pollutants. This is because far less coal is used for domestic and small-scale heating, smoke control measures have been universally applied through a series of Clean Air Acts, and cleaner fuels and fuel-burning technologies have been widely adopted. Overall, the successful regulation and taming of coal burning and its emissions represent a remarkable success story for air quality management in the UK.

However, this did not mark the end of air pollution problems in the UK. Road transport and industry remain major sources of pollution, with vehicle emissions being the most important factor affecting air pollution in our cities. The shift from an air pollution climate dominated by coal burning to one most influenced by road transport has occurred in countries world-wide. In many parts of China, for instance, we see pollution climates in a state of transition, with coal burning and a burgeoning vehicle fleet both adding to the urban air quality burden.

Long-term trends of a wide range of air pollutants can be tracked in Britain since the early 1970s; this was when automatic measurements of many other species- including secondary pollutants and those produced primarily by road transport- commenced in earnest. Even clearer trends have become apparent since the massive expansion of the scale and coverage of national measurements over recent years.

Long-term trends for individual pollutants are graphed for a range of site types- urban, rural, near-road and others- in Part 2 of this report. Statistically significant trends at all automatic network sites are also summarised in Appendix 4.

In Figure 23, we show the UK Government's air quality headline indicator of sustainable development since 1987; urban and rural trends are shown separately. This figure shows the average number of days on which levels of any one of a basket of five pollutants (carbon monoxide, nitrogen dioxide, ozone, fine particles and sulphur dioxide) were 'MODERATE or higher' according to the Air Pollution Information Service bandings listed earlier in Box 1 of section 3.2. These five pollutants are recognised as the most important for causing short-term health effects. To supplement this information, we show separately in Figure 24 the average number of days of pollution at urban sites since 1993 caused by each individual pollutant.

There is a wealth of information contained in these two figures, from which we can extract a number of key conclusions. Firstly, it's clear that 2003 was an exceptional year as regards both weather conditions and air pollution. Although the headline indicator had been showing an overall downward trend in both UK urban and rural areas since the early 1990s, 2003 showed a sharp rise, due primarily to an increased number of MODERATE or worse ozone days. In urban areas, ozone accounted for approximately 70% of the increase over previous years, with the remainder due to PM_{10} particles. The increase in the rural indicator figures was due overwhelmingly to ozone.

2004 was clearly a more 'typical' year. A return to the downward trend of previous years is not really apparent, however. There is a suggestion that the downward trend in the headline indicators shown over much of the 1990s may, in fact, be flattening out.

The main causes of days of moderate or higher air pollution at UK urban sites are now ozone and fine particles (PM_{10}). The number of days caused by ozone pollution has fluctuated in both rural and urban areas. Although no overall trend is evident when examining rural sites (figure not shown), Figure 22 suggests that the number of moderate/high days has been rising at urban locations over the past decade. As noted previously, the production of ozone is strongly influenced by the weather; as a result, the exceptionally hot, sunny summer in 2003 led to the greatest number of days of moderate or higher ozone pollution since this modern air quality indicator time series began in 1987.

Ozone causes the overwhelming majority of pollution days in rural areas but, since 1999, it has also caused more days of poor air quality in urban areas than particles or any other pollutants. Between 1993 and 2002, the average number of days of pollution at urban sites caused by fine particles, solely or in combination with other pollutants, fell from an average per site of about 43 days to 6 days per year, but rose again to 17 days in 2003. By 2004, however, it had fallen back to 5 days, apparently showing a return to the overall downward trend shown since 1992. UK-wide emissions of particles have declined substantially in recent years, but the number of pollution days can still fluctuate from year to year due to variations in weather conditions and the impacts of long-range transport from outside the UK.

Sulphur dioxide, which used to make a significant contribution to the index, has now fallen to relatively very low levels nationwide. Short-term levels of the other two pollutants included in the index, carbon monoxide and nitrogen dioxide, have very rarely reached moderate or higher levels since 1993. However, long-term exposure to nitrogen dioxide remains a problem in many parts of the UK; this is why it triggers the declaration of Air Quality Management Areas in many urban areas with high traffic densities.

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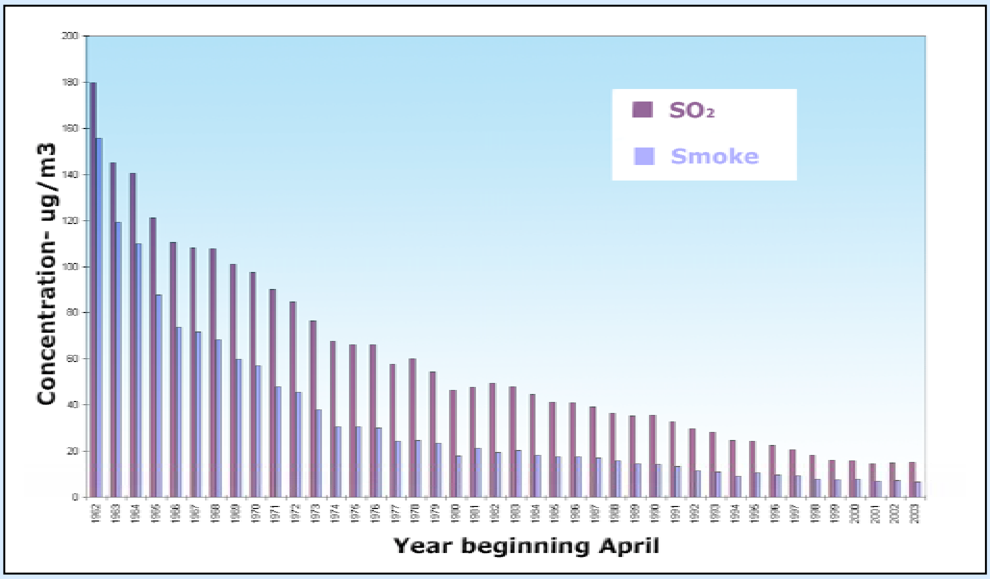

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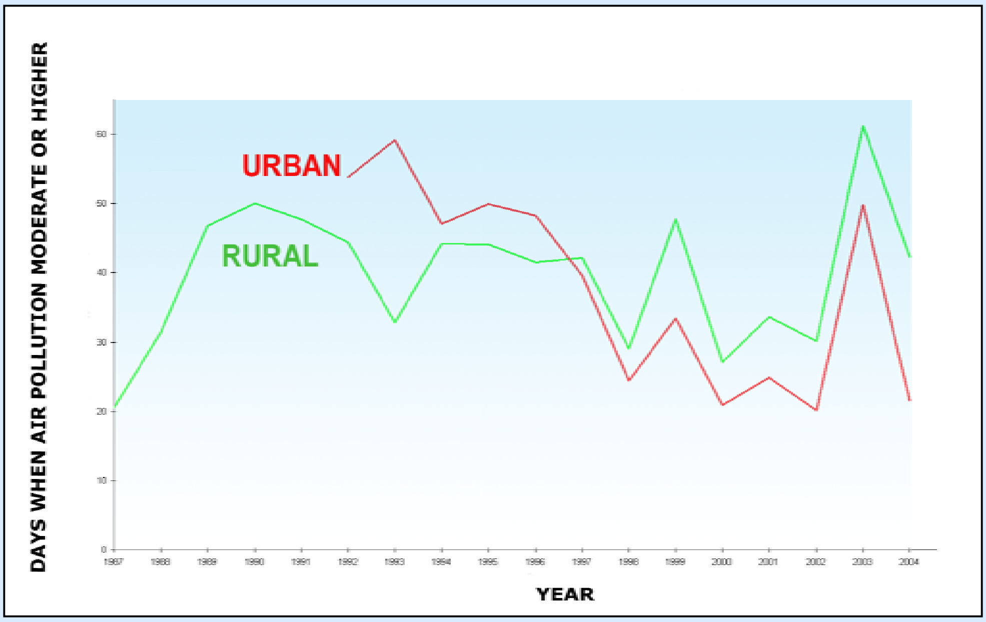

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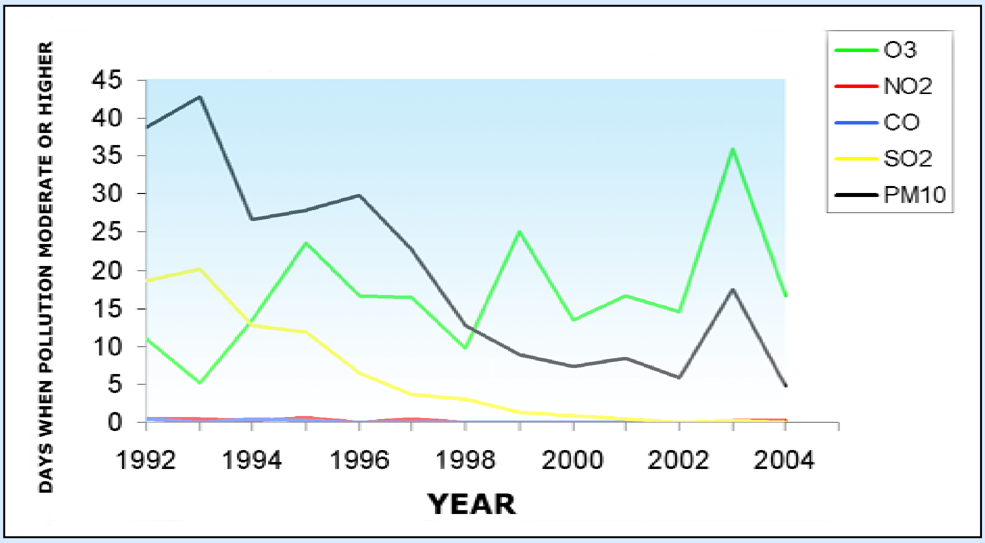


Figure 22- Smoke and SO_2 trends over the last 42 years
Figure 23- Number of days of moderate or higher pollution at urban and rural sites, 1987-2004
Figure 24- Number of days of moderate or higher pollution caused by the different pollutants, Urban sites, 1992-2004

Every year, a comprehensive analysis is undertaken of how UK-wide air quality measurements from the national networks compare with the Air Quality Objectives –both those established in Regulation (and summarised in Table 1 of section 3) and those not in Regulation or of more localised coverage for London and other parts of the country. Results from the latest such analysis carried out in 2003 are summarised in Figure 25. In this figure, the mean compliance statistics, averaged over all measurement sites, are normalised and expressed as a percentage of that Air Quality Objective. To provide additional information, the maximum site statistic is also graphed. The height of each yellow bar in the figure therefore shows how that all-site average statistic in 2004 compares with the relevant national objective, whilst the blue line show how the ‘worst’ site compares with that objective.

For example, Figure 25 shows that whilst current site-averaged annual average benzo[a]pyrene (BaP) levels are comparable to the relevant 2010 objective of 0.25µgm^{-3}, some sites substantially exceed it. Similarly, whilst the overall site-average annual NO_2 level is less than the 2005 objective of 40µg m^{-3}, many sites still exceed this objective, with a maximum of over twice this value. The figure also shows widespread non-compliance with a range of 2004 and 2010 PM_{10} objectives. Clearly, there remains cause for concern in relation to levels of these pollutants.

By contrast, the objectives for many pollutants- including benzene, 1,3-butadiene, lead, CO and SO_2 (excepting the 15-minute objective at some locations- see Section 5.4)- are already being met throughout the UK.

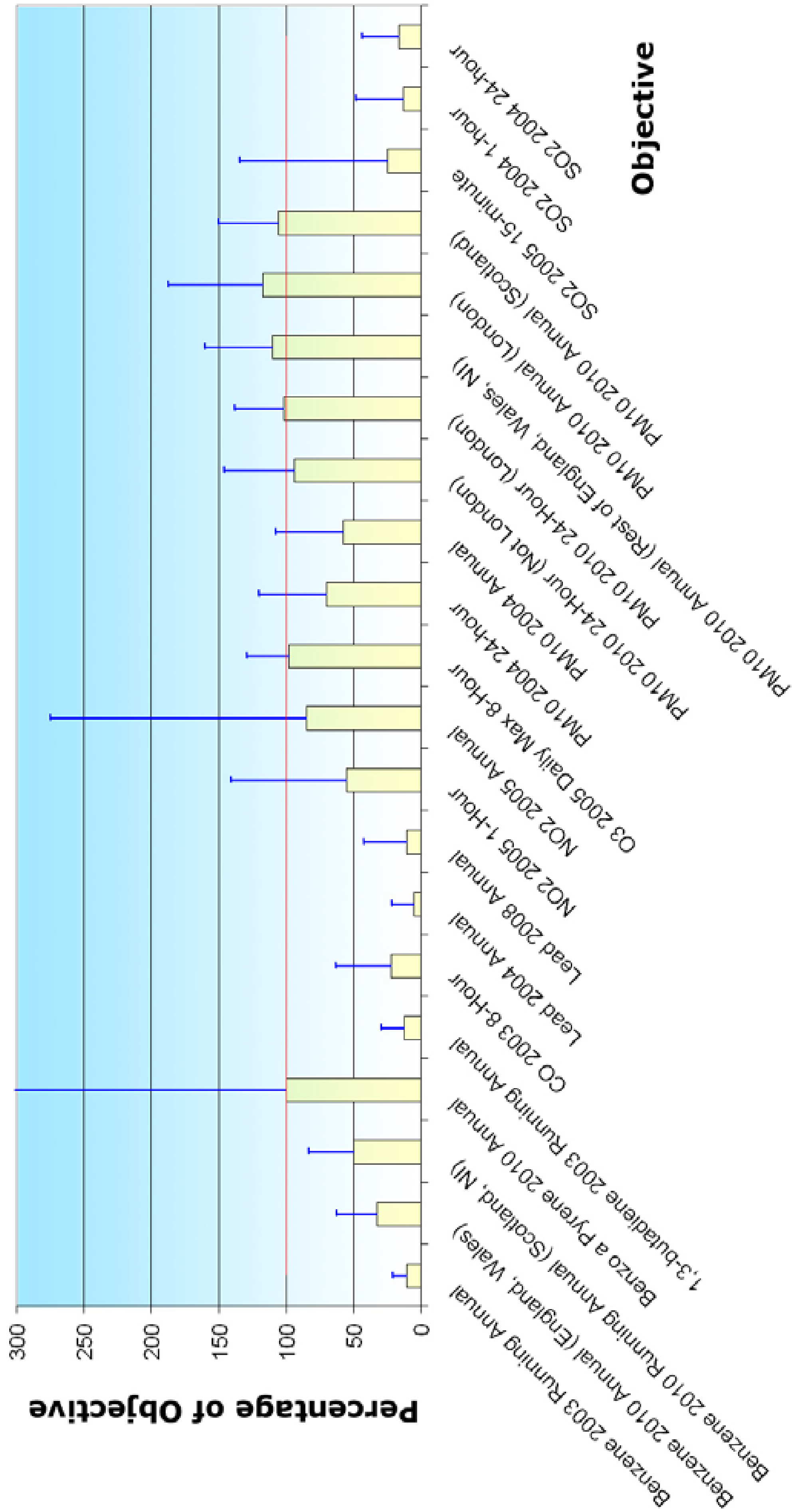
It is interesting to examine how the situation now compares with that revealed by similar analyses undertaken in previous years. Figure 26 shows how the mean and maximum measured concentrations for BaP, NO_2, O_3 and PM_{10} have varied against corresponding UK Objectives over the last 8 years; these graphs show whether the situation as regards compliance with these Objectives is getting better or worse over time. Please note, however, that some of the Objectives only come into force in 2005 or 2010 (see Table 1), so comparisons for earlier years should be regarded as being for information only.

Figure 26.1 confirms that some sites continue to exceed the BaP 2010 Objectives, and also suggests that there has been little or no improvement at these locations since 2001. Turning to Figure 26.2 for NO_2 this demonstrates the mean value averaged over all UK sites to be significantly lower than the 2005 hourly objective of 200 µg m^{-3}, but also indicates that - over time- an increasing number of sites is not complying with the Objective.

Figures 26.3 and 26.4 for ozone and PM_{10} are particularly interesting; these clearly show the impact of the exceptional year of 2003. However, little trend in compliance with Objectives is apparent for either pollutant.

So, although the objectives for several important criteria pollutants are already met throughout the UK, there is no room for complacency as other pollutants show little clear sign of improvement over recent years.

Figure 25 Measured pollutant concentrations in 2004 as a percentage of the relevant objectives (mean of all sites and highest site)



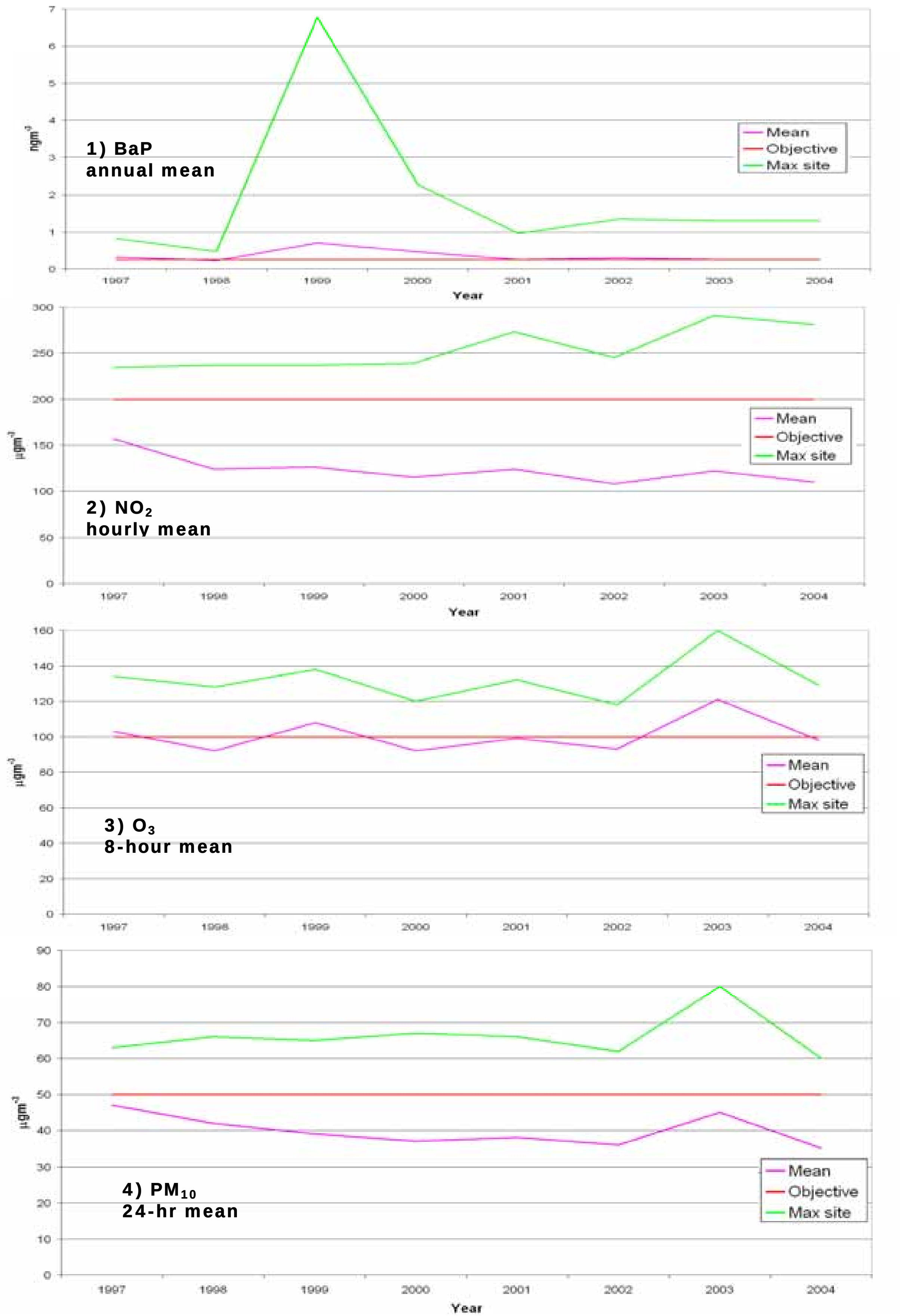


Figure 26. Trends from 1997 to 2004 in mean and maximum measured site concentrations for four selected pollutants against corresponding UK AQS Objectives