Air Pollution in the UK: 2005

A report prepared by Netcen for
Defra and the Devolved Administrations

Front cover image
December 2005: The Buncefield plume photographed from the air

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A report prepared for the Department for Environment, Food and Rural Affairs, the Welsh Assembly Government, the Scottish Executive and the Department of Environment in Northern Ireland

This report has been compiled and written by Jon Bower, Jeff Lampert, Geoff Broughton, John Stedman, Andrew Kent, Jaume Targa, Paul Willis, Stephen Pye, Susannah Grice and many others within Netcen; however, the data here presented represent the end-product of the efforts of many persons and organisations in the private sector, local and central government.

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Our ultimate objective- clean air for all **© Jon Bower**

1. Executive Summary

For those of you who are short of time…

This is the latest in a long-running series of annual reports summarising measurements from national air pollution monitoring networks operated on behalf of Defra (the Department for Environment, Food and Rural Affairs) and the Devolved Administrations of Scotland, Wales and Northern Ireland. In order to maximise user-friendliness, we have written these reports- as far as possible - in simple and non-technical language.

This report includes data and analyses from the calendar year (January to December) of 2005. The pollutants summarised and analysed are:

- Ozone (O_3)
- Nitrogen oxides (NO_x = NO and NO_2)
- Sulphur dioxide (SO_2)
- Carbon Monoxide (CO)
- PM_{10} and $PM_{2.5}$ particles
- Benzene
- 1,3-butadiene

Because of their potential impacts on human health, welfare and natural environments, ambient concentrations of these pollutants are routinely measured at a wide range of urban, suburban, roadside, industrial and rural locations throughout the UK.

The measurements we report here were made in national automatic air monitoring networks, comprising 133 stations during 2005. These networks serve a variety of policy, regulatory, scientific research and public health objectives.

In this report, we:

1. ***Consider current UK and European efforts to tackle air pollution.*** These both progressed significantly during 2005; we identify and discuss the major developments.
2. ***Describe current UK air monitoring networks, their objectives and methodologies.*** Major changes to these programmes – in particular the national Smoke/SO_2 and NO_2 diffusion tube networks -are considered.
3. ***Review current UK Air Quality Objectives*** and examine how and where these were exceeded during the year. We also identify exceedences of the UK Air quality Strategy daily objective for PM_{10} particles at a number of near-road locations.
4. ***Investigate how pollution levels vary across the country.*** We go further than in previous years in examining these important national-scale patterns of pollution.
5. ***Examine major periods of elevated pollution*** (so called pollution 'episodes') that occurred during 2005. This year, we examine a summer photochemical smog event, together with air quality impacts from the Buncefield fires.
6. ***Assess long-term trends*** in order to identify how pollution levels in the atmosphere have changed over time. This year, we examine for the first time both past and projected future changes in UK's pollution climate.
7. ***Examine social aspects of air pollution in the UK.*** Again, this is a first for these annual reports.
8. ***Identify published, web and media sources for information*** on the UK's air quality. In particular, we provide details of new national air quality archives and websites for Scotland, Wales and Northern Ireland.
9. ***Provide detailed statistical summary tables*** for each measured pollutant

The report, together with the UK Air Quality Archive at www.airquality.co.uk, provides the most comprehensive and complete analytical picture of UK's air pollution in 2005.

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2. Introduction

An outline of what's in this report…

The quality of the air that we breathe can have important impacts on our health and quality of life. It can also have major impacts on ecosystems and climate change. Measuring and understanding air pollution provides a sound scientific basis for its management and control. Considerable effort is therefore devoted in the UK to the systematic measurement of levels of air pollution nationwide. This effort started in earnest following the infamous coal-burning smogs of the 1950s and 60s, but has expanded massively in scope, coverage and sophistication since then. These developments to monitoring programmes continued apace during 2005.

Air quality monitoring, together with the information derived from it, should not be seen as an end in itself; rather, it offers us the best way of understanding our pollution problems, so that they can be tackled effectively at local, national and international level. Some of the very latest actions being taken on a number of fronts in the UK and Europe are described in further detail in this report.

Monitoring air pollution in the UK has the following broad objectives:

- To provide a sound scientific basis for the development of cost-effective control policies and solutions under the UK Air Quality Strategy and Local Air Quality Management (LAQM)
- To assess how far air quality standards, limit values and objectives are being met
- To evaluate potential impacts on population health and welfare
- To determine the impact of air pollution on ecosystems and our natural environment
- To provide the public with open, reliable and up-to-date information on air pollution
- To fulfil statutory air quality reporting requirements

Figure 1. The rural air monitoring station at Aston Hill, Powys, Wales

This report aims to provide a simple guide, written as far as possible in non-technical language, to what the latest measurements tell us about air pollution in the UK.

The report comprises three parts. The first is primarily descriptive. In it, we'll:

- Summarise current UK and European policy efforts and initiatives to tackle air pollution. This year, we highlight a number of significant developments in both areas *(Section 3)*.
- Review where and how air pollution is measured in this country, examining monitoring networks, site locations and measurement techniques, as well as recent changes to UK measurement programmes *(Section 4)*.
- Provide information on where and how to find out more about air pollution emissions, levels and effects in the UK. We also introduce important new web-based air quality information resources for Scotland, Wales and Northern Ireland, as well as important changes to the long-running UK national website *(Section 4.7).*
- Examine key episodes - major periods of elevated pollution - that occurred in 2005. We give particular prominence this year to the Buncefield Incident, discussing why such a large-scale event appeared to have so little impacts on ground-level air quality *(Section 5).*
- Investigate through a series of detailed maps and analyses how pollution levels vary across the UK *(Section 6).*
- Assess long-term pollution trends in order to see whether pollution levels are declining over time. For the first time, we also try to examine how UK pollution may change over the coming years. (*Section 7).*
- Examine some of the social aspects of air pollution. Is there a relation between air pollution, inner cities and deprived areas? We examine these and other important questions for the first time in this series of annual air quality reports *(Section 8).*

The second part of the report is primarily statistical, providing a detailed pollutant-specific summary of measurements. From Sections 9 to 17, we provide for each pollutant measured in the UK's national automatic monitoring networks, together with other programmes measuring compliance with UK Air Quality Objectives:

- Information on measurement and calibration techniques, instruments utilised, estimated accuracy and precision
- A summary of relevant UK objectives
- A map of the measurement sites
- A detailed statistical summary of all the measurements made in 2005
- Matching information on exceedences of UK Air Quality Objectives
- Graphs showing variations in pollutant concentrations throughout the year at typical urban, rural and other site types
- Analyses showing typical variations in pollutant concentrations during the day
- Long-term trends in annual average measured concentrations.

In a series of Appendices, we'll also provide:

- Background information on the air pollutants measured in the national networks, their sources and effects
- Detailed maps showing the location of automatic monitoring stations in different parts of the UK
- More information on the different UK national air monitoring networks and their objectives
- A summary and analysis of UK monitoring locations showing statistically significant trends in pollution levels over time
- A full listing of current UK, European and World Health Organisation Air Quality Standards, Objectives, Limit Values and Guidelines for the major air pollutants
- An explanation of some of the terminology used in this report, together with a discussion of measurement accuracy, trend calculation and the mathematical methods used to calculate measurement statistics.

Air Pollution in the UK: 2005

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

We then review recent air pollution episodes and assess variations in pollution levels across the country. We examine long-term trends in order to see if pollution is getting worse over time, and also look forward to how things may change in the future.

To end this section, we discuss for the first time some of the important social aspects and impacts of air pollution in the UK.

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. There are also increasingly important local drivers and factors related to air monitoring nationwide.

Over the past decade, air pollution has becoming an increasingly important focus of interest for UK, European and international policy makers. This has been prompted 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. Our atmosphere is a complex, dynamic and fragile system, in which global warming, climate change, ecosystem impacts and stratospheric ozone depletion are all inter-linked with air pollution.

3.1 European Background: a year of rapid change

Aspirations and Instruments

Air quality is an area in which Europe has been strongly proactive in recent years. The Community as a whole is acting at many levels to reduce exposure to air pollution, through:

- Established legislation such as the Air Quality Framework and Daughter Directives- discussed below
- 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 NGOs
- Research undertaken in its own or Member States' institutes and universities.
- Reducing emissions from large combustion plant and mobile sources
- Improving fuel quality and
- Integrating environmental protection requirements more fully into the transport and energy sectors.

A series of Air Quality Directives and Decisions over the last decade has:

- Established Limit and Target 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 Daughter Directive)

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.

Open access to Information

The right of all citizens to information on the quality of the air we breathe is an important cornerstone of both UK and European air quality policy. In fact, the Daughter Directives impose important requirements on Member States to advise the public when Information and Alert Thresholds for specified pollutants are exceeded.

The Directives specify the detailed requirements for reporting measurements from national monitoring networks to the European Commission. In addition, 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.

The 1998 Århus Convention[7] on environmental openness is another important instrument for ensuring an informed public; this is designed 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.

Latest developments- the Thematic Strategy on Air Pollution

An important 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]. The CAFE Programme was set up to develop, collect and validate scientific information about air pollution throughout Europe, with the aim of reviewing current policies and assessing progress towards long-term objectives.

The European Commission has set out its intention to develop a new air quality policy approach based upon sound scientific information about pollutant levels, impacts and trends throughout Europe. This strategy, designed to achieving further significant improvements in air quality across Europe, was proposed in September 2005. It has been produced under the framework of the Sixth Environment Action Programme (6th EAP), a wide-ranging programme of Community action on the environment with key objectives covering a period of ten years. The priorities of the 6th EAP cover climate change, nature and biodiversity, environment, health and quality of life, and natural resources and waste.

The 6th EAP calls for the development of seven thematic strategies, including a coherent and integrated strategy on air pollution. The Thematic Strategy for air pollution proposed in 2005 is a major policy initiative; it presents a coherent and integrated policy on air pollution which:

- Sets out priorities for future action;
- Reviews existing ambient air quality legislation with a view to reaching long-term environmental objectives; and
- Develops better systems for gathering information, modelling and forecasting air pollution.

In essence, the Strategy sets out a long-term perspective for achieving cleaner air in Europe. It seeks to do this in a way that is cost-effective, as well as cconsistent with the objective of growth and employment (the Lisbon Strategy) and the EU Sustainable Development Strategy.

Despite significant improvements in Europe's air quality - driven both by legislation and other factors- air pollution continues to have serious human health and environmental effects throughout Europe. It results in several hundreds of thousands of premature deaths each year, together with increased hospital admissions, extra medication, and millions of lost working days. The health and societal costs to the European Union are substantial. In addition to these impacts, there are also additional costs relating to environmental damage through acidification of ecosystems and damage to crops and forests; however, these are often notoriously difficult to quantify.

The pollutants of most direct concern for human health are airborne particulates and ozone – indeed, no safe levels have yet been identified for either pollutant. The Strategy establishes ambitious targets for these and other pollutants that are intended to be achievable by 2020. The Strategy's ultimate aspiration is to achieve levels of air quality that do not give rise to unacceptable impacts or risks to human health and the environment.

The Strategy represents a modern way of decision-making. It has been based on extensive research and consultation with stakeholders, and seeks to address the core issues in a holistic way that takes into account links with other problems and policy areas. At the same time, it has been based on an integrated assessment of different environmental and health effects, and aims to provide the most cost-effective solution for the chosen level of objectives.

Full details of the Strategy are available at
http://europa.eu.int/comm/environment/air/cafe/index.htm

Thematic Strategy - objectives and tools

The Thematic Strategy on air pollution establishes interim objectives for air pollution throughout the European Union and proposes appropriate measures for achieving them. It recommends that current legislation be modernised, be better focused on the most serious pollutants and that more is done to integrate environmental concerns into other policies and programmes.

The Strategy is designed to substantially improve Europe's air quality over time. It aspires to prevent thousands of premature deaths from pollution-related illnesses and drastically reduce damage to crops, forests and other ecosystems. Although there will be significant costs involved in improving air quality, detailed cost/benefit analyses demonstrate that these will be offset many-fold by the overall benefits to society as a whole.

While covering all major air pollutants, the Strategy pays special attention to particles and ground-level ozone pollution, because it has been conclusively demonstrated that these pose the greatest danger to human health. Under the Strategy, the Commission is proposing for the first time to start regulating fine airborne particulates, known as $PM_{2.5}$, which penetrate deep into human lungs. For the first time, it would require reductions in average $PM_{2.5}$ concentrations throughout each Member State and set a cap on concentrations in the most polluted areas.

These developments are likely to have wide-ranging implications for the UK's national monitoring networks measuring particulate matter (see also Section 4.4).

It has been estimated that the Strategy will reduce the number of premature deaths across Europe that are related to fine particulate matter and ozone from 370,000 a year in 2000 to 230,000 in 2020. Without the Strategy, there would still be over 290,000 premature deaths a year in 2020.

It has also been calculated that the Strategy will deliver health benefits worth at least €42 billion per year through fewer premature deaths, less sickness, fewer hospital admissions and improved labour productivity. This is more than five times higher than the cost of implementing the Strategy. This is estimated at around €7.1 billion per annum, or about 0.05% of EU-25 GDP in 2020.

Although there is no agreed way to express damage to ecosystems in monetary terms, the environmental benefits of reduced air pollution are also significant. The Strategy will protect several hundred thousand square kilometres of forest and other sensitive ecosystems.

Moreover, it is intended that European companies will gain competitive advantage by focusing research and development on less polluting technologies that third countries may eventually need to adopt.

Current air quality legislation will be streamlined to help Member States implement it more efficiently. In fact, the Commission proposes to integrate air quality legislation by merging the existing key legal instruments - the Framework Directive, four Daughter Directives and Decision on exchange of information - into a single Ambient Air Quality Directive. This Directive will not only revise the Framework and Daughter Directives 1-3, but will also include $PM_{2.5}$ targets for the first time. At the time of this report's finalisation (August 2006), these proposals are still under negotiation.

The proposed new integrated Directive would substantially cut existing legal texts, clarify and simplify their provisions and modernise reporting requirements. At the same time as simplifying existing legal instruments, more flexibility will be given to the Member States. Where they can demonstrate that they have taken all reasonable measures to implement the legislation but are, nevertheless, unable to comply with air quality standards in certain places, it is proposed to allow them to request an extension to the compliance deadline in the affected zones; this would be granted provided that strict criteria are met and coherent plans are put in place to move towards compliance.

The Commission intends to propose a revision of the National Emissions Ceilings Directive to bring its emissions ceilings into line with the objectives of the Strategy. In addition, a range of other possible measures will be examined, such as the introduction of a new "Euro V" set of car emission standards and other initiatives in the energy, transport and agriculture sectors, the Structural Funds and international cooperation.

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. Air pollution from man-made particles is currently estimated to reduce the life expectancy of every person in the UK by an average of eight months. In addition, more than half of all natural and semi-natural habitats in Britain still have too high levels of harmful acidity.

Medical evidence shows that many thousands of people die prematurely every year because of the effects of air pollution, 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. Some of the social aspects and impacts of air pollution are addressed more fully in Section 8 of this report.

The new air quality indicator

Air quality is one of the UK Government's key headline indicators of sustainable development. 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.

Although an air quality headline indicator was first introduced in support of the UK Sustainable Development Strategy in 1999, this was substantially extended in scope when the strategy was revised in 2005. In particular, new components were added, better reflecting the effects on health of long term exposure to lower levels of pollution.

The extended indicator now includes trends for annual levels of particulate and ozone pollution, the two pollutants thought to have the greatest health impacts (part a), as well as the number of days on which levels of any one of a basket of five major pollutants were 'moderate or higher' (part b).

Part b) is the air quality headline indicator of the former (1999) sustainable development strategy, and the banding system it uses is that of the Air Pollution Information Service (www.airquality.co.uk/archive/standards.php#band). More detailed data and information on the indicator are available from the Air Quality Archive at www.airquality.co.uk.

We'll be looking more closely at the latest air quality indicator levels in Section 7 of this Report.

The UK Air Quality Strategy

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 Strategy is available in full from http://www.defra.gov.uk/environment/airquality/strategy/.

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 has 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. 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 overleaf. These are based on the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management.

Some explanation of terminology may assist in understanding Table 1.

Standards for air pollution are concentrations over a given time period that are considered to be acceptable in the light of what is known about the effects of each pollutant on health and on the environment. They can also be used as a benchmark to see if air pollution is getting better or worse over time.

An ***exceedence*** of a standard is a period of time (which is defined in each standard) where the concentration is higher than that set down by the standard. In order to make useful comparisons between pollutants, for which the standards may be expressed in terms of different averaging times, the number of days on which an exceedence has been recorded is often reported.

An ***objective*** is the target date on which exceedences of a standard must not exceed a specified number.

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

Exceedences of the current PM_{10} particles 24-hour mean objective at a number of roadside monitoring sites are reviewed in Section 5.4.

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 μg 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 μg m^{-3}	Annual mean	31.12.2000
Sulphur dioxide ***(for protection of vegetation & ecosystems)***	20 μg m^{-3} 20 μg 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

Consultation on the Air Quality Strategy

Despite overall improvements in UK's air quality, it is clear that additional controls may be needed to meet the Strategy's objectives for particulate matter, nitrogen dioxide, ozone and polyaromatic hydrocarbons in some urban areas.

During 2006, the process of further developing the UK Air Quality Strategy continues. A consultation document issued on 5 April by Defra and the Devolved Administrations seeks stakeholders' views on a number of potential additional national policy measures designed to cut air pollution, reduce breaches of air quality objectives and improve human health. Please see http://www.defra.gov.uk/corporate/consult/airqualstrat-review/index.htm for fuller details. The consultation ended on 11 July 2006.

The consultation concludes that health impacts of particles currently cost up to £21 billion per year and result in an average reduction of life expectancy of eight months. Existing controls are expected to reduce this to 5.5 months by 2020. However, Defra believes that new proposals could further reduce this to five months and cut particulate levels by 15%.

Air pollution also caused over half the UK's natural and semi-natural habitats to exceed harmful levels of acidity in 2003, and the review proposes improved protection for protected habitats.

Among the proposed package of measures are:

- Adoption of new tighter European vehicle emissions standards (so called Euro-standards);
- National road charging;
- Incentives for cleaner vehicles;
- Further reductions in emissions from small combustion plants; and
- Further reductions in emissions from ships.

In addition, a new programme is aimed at controlling fine particles; this marks a shift away from a focus on pollution hotspots towards a more beneficial approach of reducing exposure levels for the general population. The consultation poses the question of whether the UK should proceed alone with this new approach, or wait for the EU to formulate its own exposure-reduction objectives.

As well as direct benefits to public health, these new policies have the potential to provide important benefits to quality of life, reducing health inequalities and helping to protect the environment.

The consultation document also seeks views on the Strategy's current objectives for air pollutants and in particular:

- A new, more cost effective, policy framework and objectives for controlling pollutants for which there is no safe level such as fine particles (known as $PM_{2.5}$);
- Improved protection for Sites of Special Scientific Interest and other protected habitats; and
- A new objective on ozone for the protection of our environment.

The consultation process also sets an agenda for longer-term action to improve our understanding of air pollutants and attempts to qualitatively assess the potential for further air quality improvements in the very long term.

3.3 A Local Focus

UK Government and the Devolved Administrations in Scotland, Wales and Northern Ireland are responsible for overall policy and legislation affecting our 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 both their first and second rounds 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]; they are now commencing the third round of assessment.

As of August 2006, over 197 Local Authorities – roughly 45% of those in the UK - have established one or more AQMAs. Most of these are in urban areas and result from traffic emissions of nitrogen dioxide (NO_2) or PM_{10} particles. Road traffic emissions are the main source of declaration 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 (July 2006)*

Region	Total No. of Local Authorities	No. of LAs with AQMAs at end of Round 1 (April 2003)	Number of LAs with AQMAs (August 2006)	No of AQMAs due to C_6H_6	No of AQMAs due to NO_2	No of AQMAs due to PM_{10}	No of AQMAs due to SO_2	Draft (Full) Action plans submitted (June 2006)
England (excl London)	320	82	143	1	133	34	11	84 (52)
London	33	30	31	-	30	26	-	31 (24)
Scotland	32	3	8	-	5	3	1	0 (3)
Wales	22	4	5	-	4	1	-	4 (2)
N. Ireland	26	n/a	11	-	4	8	1	2 (2)
TOTAL	**433**	**119**	**198**	**1**	**176**	**72**	**13**	**121 (83)**

** data courtesy of University of West of England and Bureau Veritas*

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. These authorities have been advised to prepare their action plans within 12-18 months of designation. Over 121 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 Transport Scotland 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, since the end of the 1st round in April 2003, 61 authorities in England, 5 in Scotland, and 1 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. The increase in the number of AQMAs required in this round 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 are now well into Round 2 of their 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 11 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.

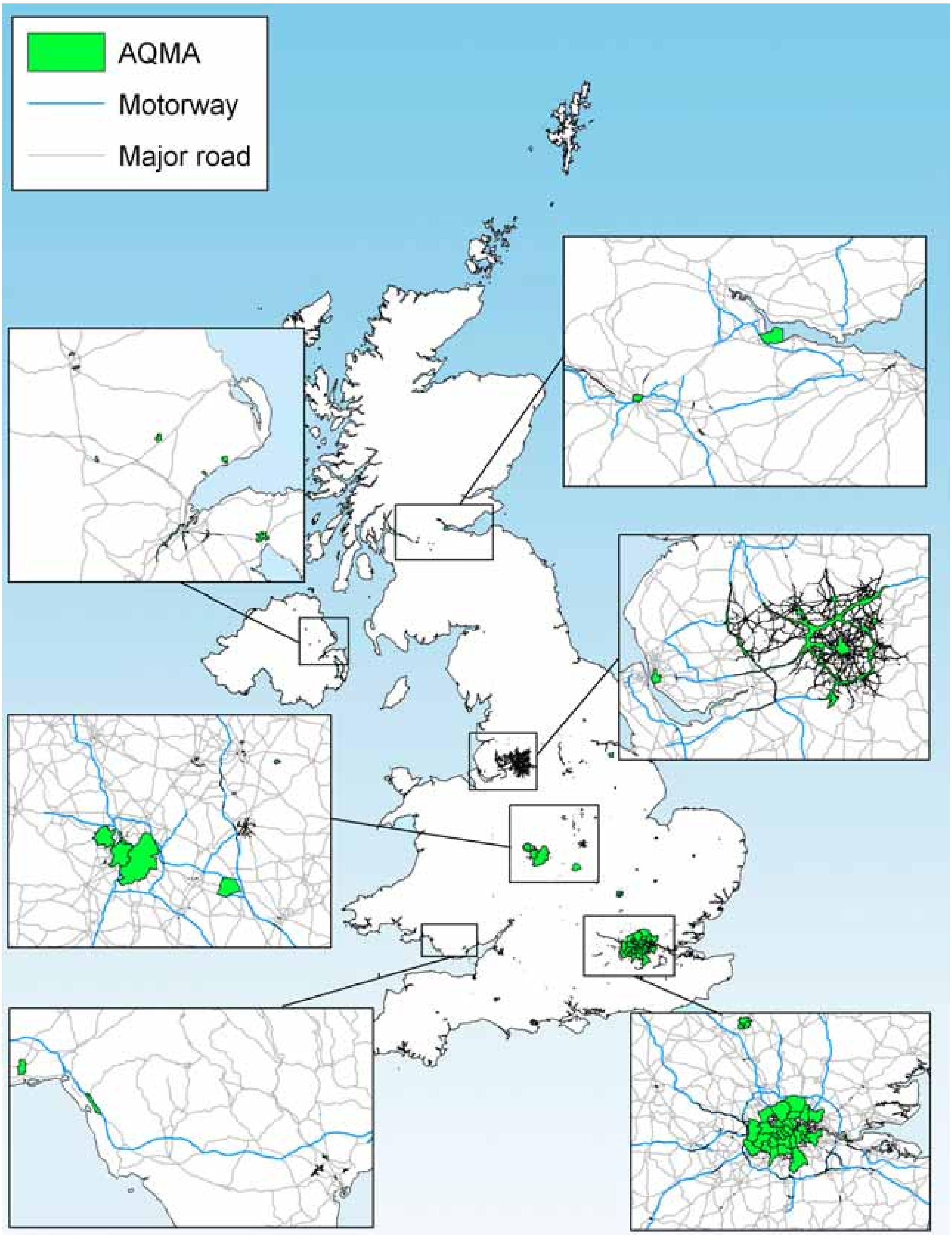


Figure 2. Map of current UK Air Quality Management Areas (AQMAs)

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 Johannesburg Summit[15] held in 2002.

The ultimate purpose of air quality monitoring is not merely to collect data, 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
- 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, UK monitoring data are communicated rapidly and efficiently to air quality stakeholders and data users through a wide range of web and media outlets. These media and web-based approaches to achieving open and free public access to air quality data are discussed further in Section 4.7.

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 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. Major changes to the long running 'National Survey' of smoke and sulphur dioxide and national NO_2 diffusion tube networks are reviewed in Section 4.3.

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 (2006) consists of 127 sites and remains the most important single monitoring programme in the UK today.

Data from the AURN, together with corresponding measurements from the 6 automatic hydrocarbon monitoring stations, are presented in this report. The AURN presently includes 89 urban or suburban, 24 rural or remote and 14 London Network sites: 64 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 expansion in automatic monitoring is clearly illustrated in Figures 3 and 4, where we show the increase in site numbers and total measurements made since the commencement of automatic air quality monitoring in the UK. The UK's automatic networks continue to evolve year-on-year; changes in these programmes 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. These changes have 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.

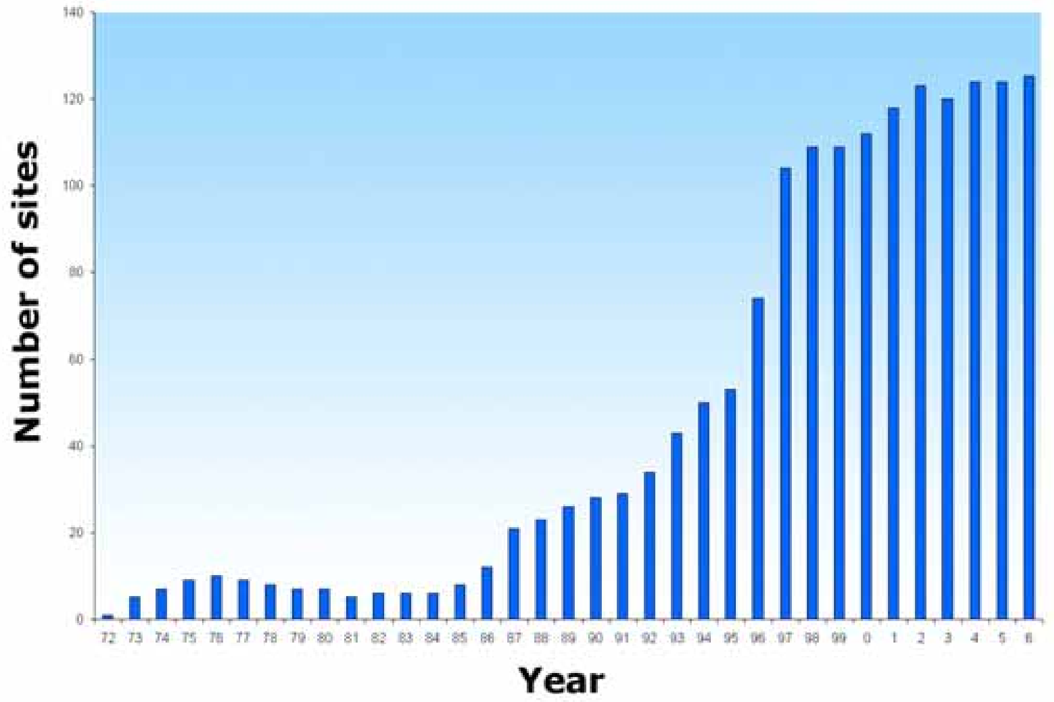


Figure 3. The number of automatic measurement stations in the UK has grown substantially since 1972

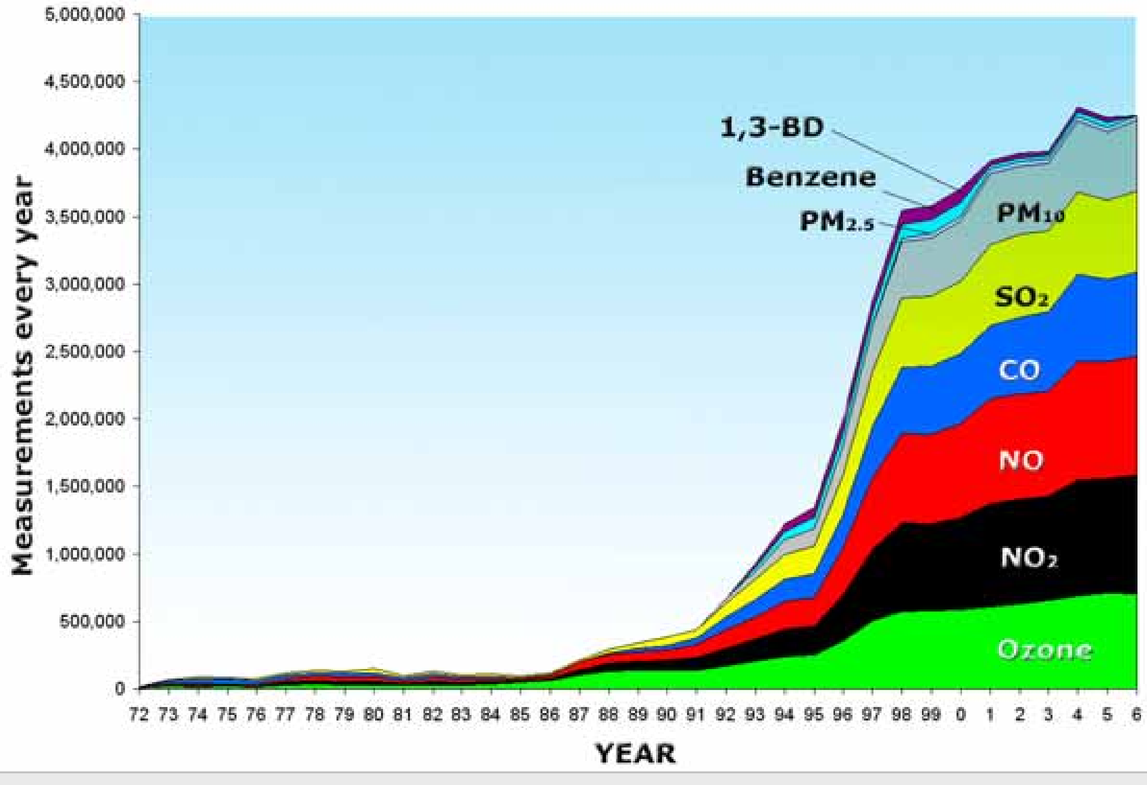


Figure 4. The number of hourly measurements made every year has also increased dramatically for all pollutants in the automatic monitoring networks (O_3, NO_2, CO, SO_2 and PM_{10}) and for other UK Strategy pollutants

Table 4. Changes to the automatic networks in 2005 and 2006

Sites	Date Commenced	Pollutants
Newly established sites		
Lerwick	25 May 05	Ozone
Leominster	18 Jul 05	NO_2 and O_3
Auchencorth Moss (HC network)	9 June 2006	VOCs, O_3, PM_{10}, $PM_{2.5}$
Fort William	22 June 2006	NO_2, O_3
Site Relocations		
Blackpool relocated to Blackpool Marton	Blackpool closed 10 November 2004. Blackpool Marton started 13 June 2005.	NO_x O_3 CO SO_2 and PM_{10}
Norwich Roadside relocated to Norwich Forum Roadside	Norwich Roadside closed on 14 February 2005. Norwich Forum Roadside started on 31 May 2005.	NO_x
Bath Roadside	Site moved short distance on 27 April 2005, name not changed.	NO_x CO
Oxford Centre renamed	Change of name only in Feb 2005 to Oxford Centre Roadside.	NO_x CO SO_2
Cardiff Centre	Site closed from 9 May 2005 till 30 September 2005 for refurbishment of cabin.	NO_x O_3 CO SO_2 and PM_{10} BTEX
Middlesbrough	Site moved 17m. Closed on 18 May 2005, reopened 23 May 2005, name not changed.	NO_x O_3 CO SO_2 and PM_{10}
Leamington Spa	Site relocated to new cabin. Closed on 25 July 2005 and re-opened 21 October 2005.	NO_x O_3 CO SO_2 and PM_{10}
Bradford Centre	Site moved 15m on 3 August 2005.	NO_x O_3 CO SO_2 and PM_{10}
Bristol Centre relocated to Bristol St. Pauls	Bristol Centre closed 15 September 2005. Bristol St. Pauls started on 15 June 2006	NO_x O_3 CO SO_2 and PM_{10}
Belfast Clara St.	BAM replaced with TEOM at the end of 2005	PM_{10}

There has also been continuing growth during 2005 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 4.6.

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 Changes to the smoke/sulphur dioxide and national nitrogen dioxide diffusion tube networks

Figure 5. The long-running national smoke/sulphur dioxide and nitrogen dioxide diffusion tube networks are disappearing or changing dramatically

The smoke and SO_2 network

The UK Smoke and Sulphur Dioxide (SO_2) Network has been operating since the early 1960s, and has tracked the massive decline in pollution from coal over the last 45 years (see Section 7). It measured two pollutant parameters: 1) particulate matter as black smoke, and 2) net gaseous acidity, expressed as SO_2 equivalents. The primary objectives of the network in recent years were:

- To monitor compliance with the original European Council Directive on Sulphur Dioxide and Suspended Particles (80/779/EEC).
- To provide a long-term database of suspended particulate matter (as black smoke) and SO_2 (as net acidity) measurements used to assess trends in concentration and spatial distribution.
- To highlight areas where elevated concentrations of black smoke or SO_2 occur, and where more detailed investigation, including the use of automated techniques, might be justified.

However, the repeal of the EC Directive 80/779/EEC on 1 January 2005 ended the network's compliance monitoring role. In response to this, and in recognition that the chemistry of the urban and rural environment has changed dramatically over the lifetime of the network, and that monitoring requirements have changed greatly as a result of the Air Quality Strategy, Defra and the Devolved Administrations commissioned an independent review of the network in 2005; this was designed to establish how the programme could best serve the needs of central and local government in the future. The review report has been published at http://www.airquality.co.uk/archive/reports/cat16/0604041119_UK_urban_network_review_summary.pdf .

The review's conclusions regarding the Smoke and SO_2 Network were as follows. Firstly, in view of the end of its compliance monitoring role, the changes in the UK's pollution climate, and the fact that automatic monitoring techniques are now widely used, the Smoke and SO_2 Network (in its present format) had come to the end of its useful life, and should therefore cease operation. However, the scientific community remains interested in black smoke as a useful particulate metric correlated with health effects, and there is a case for retaining around 20 sites monitoring smoke only.

Accordingly, Defra has taken the decision to cease operation of the Smoke and SO_2 Network as of 31st December 2005. In line with the recommendations of the review, it is likely to be replaced in the near future by a new, smaller network of sites monitoring black smoke only: however details of this new network have not yet been finalised.

The NO_2 diffusion tube network

The NO_2 Network was established in 1993, with the objective of assessing the spatial and temporal distribution of nitrogen dioxide (NO_2) concentrations in a variety of urban areas of the UK, ranging from the major cities to smaller towns.

This was done using NO_2 diffusion tubes: low-cost passive samplers ideal for indicative monitoring. The network was originally planned to operate for ten years, but was extended for a further three. However, since 1993, there have been many developments in policy and legislation on air quality. This has led to corresponding changes in monitoring requirements. Moreover, automatic monitoring techniques are now much more readily available than in the early 1990s, and are now widely deployed across the UK. As was the case for the smoke and SO_2 network, therefore, it could be argued that the basic rationale for the programme has disappeared.

Earlier in 2005, therefore, Defra commissioned an independent review of the NO_2 Network. The review concluded that the network was no longer required to assess spatial distribution of NO_2, this role being now more effectively fulfilled by a combination of computer modelling, and data from automatic monitoring sites. It also came to the view that the network was of limited use in monitoring compliance with today's limit values and objectives for NO_2. Consequently, the network was deemed to have served its purpose, and ceased operation at the end of 2005.

However, Defra appreciates that NO_2 diffusion tubes are widely used by Local Authorities for LAQM purposes, and that the old Network's QA/QC programme was beneficial not only to the Network but in the wider context of LAQM, as it helped to improve and maintain the quality of all NO_2 diffusion tube measurements carried out by Local Authorities.

Accordingly, Defra and the Devolved Administrations have decided to continue a central NO_2 diffusion tube data collation and QA/QC programme as part of a new contract, entitled "Support to Local Authorities for Air Quality Management"; this brings together the Air Quality Monitoring and Modelling Helpdesks, and QA/QC support for NO_2 diffusion tube monitoring. This contract also includes a data verification service for diffusion tube data, together with a working group aimed at harmonisation of diffusive sampling methods.

Further details of this project can be found at http://www.laqmsupport.org.uk.

4.4 Review of particle measurement methodologies

Particulate matter poses a public health risk in the UK. It is important, therefore, that this pollutant is measured accurately and reliably in the AURN, the UK's major automatic monitoring programme, as well as by Local Government for the purpose of Local Air Quality Management.

Unlike the standard 'reference' method of the EU first Daughter Directive used by some countries, which produces data several days after particles are collected, the majority of monitors in the UK's network allow near real-time dissemination of information to the public; these provide sensitive individuals with the opportunity to take appropriate action should particulate levels increase.

Figure 6. The TEOM instrument for PM_{10}, is widely used in the AURN

The Equivalence Programme for monitoring particulate matter is an EU requirement of all Member States not using the standard 'reference' method. It ensures that the data they produce are consistent, enabling a harmonised framework for comparison of air quality across Europe.

Under this programme, the UK has recently completed a comprehensive evaluation of particle measurement systems currently deployed in UK networks. The results of this study, one of the most extensive yet undertaken, show that:

- The EU's equivalence criteria are met by three monitor types (Partisol 2025 Sequential Sampler; Tapered Element Oscillating Micro-balance (TEOM) retrofitted with Filter Dynamic Measurement System (FDMS) for PM10 and PM2.5; and the OPSIS SM200 by Beta) without correction for slope and/or intercept.
- Two further monitor types (OPSIS SM200 by Mass, and Met One Beta Attenuation Monitor (BAM)) meet the criteria after correction for slope and/or intercept; and
- The conventional TEOM method does not meet the equivalence criteria, with or without a correction factor. This result is consistent with preliminary investigations carried out for Defra and the devolved administrations.

The findings have major implications for the future development of particle monitoring in the UK. Upgrade or replacement of the TEOMs in the UK monitoring network is currently being planned, and these instruments are also widely used by local authorities in their LAQM regimes. In both cases, the default correction factor of 1.3 for conventional TEOMs should continue to be used until existing equipment is changed. Further information is provided by Defra and the DAs via its local authority air quality support helpdesk (0870 190 6050; www.laqmsupport.org.uk- see also Box 4).

The report on the UK's Equivalence Programme evaluations is available in full on the UK Air Quality Information Archive at:
www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf

4.5 Current national monitoring programmes

There are currently over 400 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.

133 of these sites in the AURN (127) and hydrocarbon networks (6) operate automatically; these split nationally as follows:

Country	Site numbers
England	104
N. Ireland	5
Wales	8
Scotland	16

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 7. In the accompanying Figures 8 and 9, 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 9-17 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 EC 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	111 (Automatic)	Mostly urban
Ozone (O_3)	Sunlight and heat, acting on road transport and industrial emissions	90 (A)	All of UK- urban and rural areas
Particles (PM_{10} and $PM_{2.5}$)	Road transport, industry, construction, soil and natural sources	72 (A) - PM_{10} 5 (A) – $PM_{2.5}$	Mostly urban
Sulphur Dioxide	Industry and fuel combustion	76 (A)	Mostly urban Rural
Carbon Monoxide (C0)	Road transport	78 (A)	Urban
Volatile Organic Compound (VOCs)	Industry, transport, solvent use and some natural sources	6 (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, multi-element)	Industrial, urban Rural
Acid Deposition	Atmospheric reactions involving fuel burning, agricultural and other emissions	38 (NA)	Rural
Ammonia	Agricultural activities	57 (NA)	Rural
Nitric Acid	Combustion and photochemistry	30 (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	127 (89 urban, 24 rural, 14 London)
Rural acid deposition, gases and particles	S	38 (acid deposition)
Automatic Hydrocarbon	A	6
Toxic Organic Micropollutants (TOMPS)	S	6 (also measure PAHs)
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 5 rainwater 2 cloud water
Non automatic hydrocarbon- Benzene and 1,3-butadiene	S	35 (benzene) 10 (1, 3-butadiene)
Ammonia and Nitric Acid Network	S	94

Figure 7. Current UK Automatic Air Quality Monitoring Stations

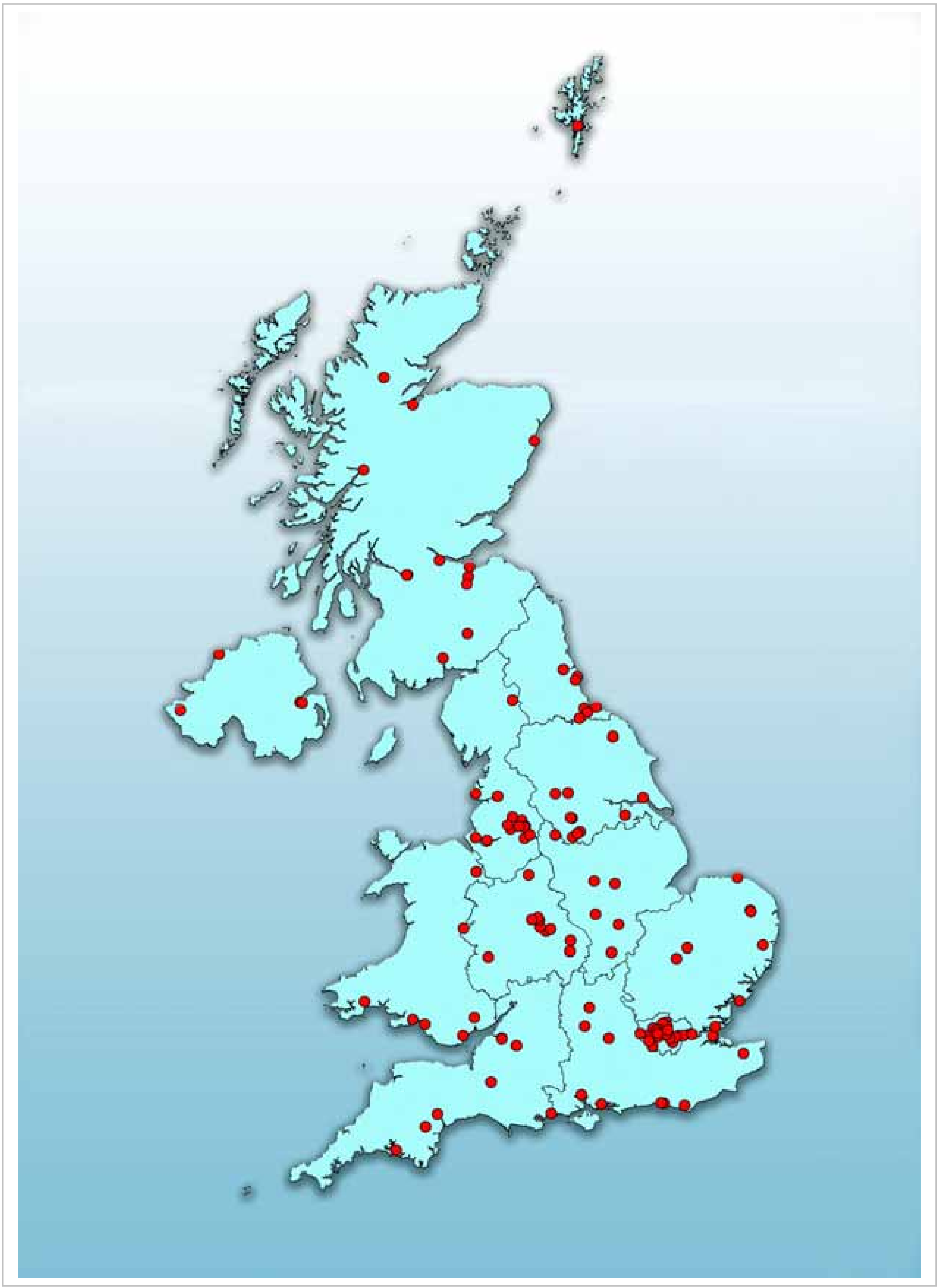


Fig 8 Current UK sampler-based measurement programmes for Persistent Organic Pollutants (POPs) and metals

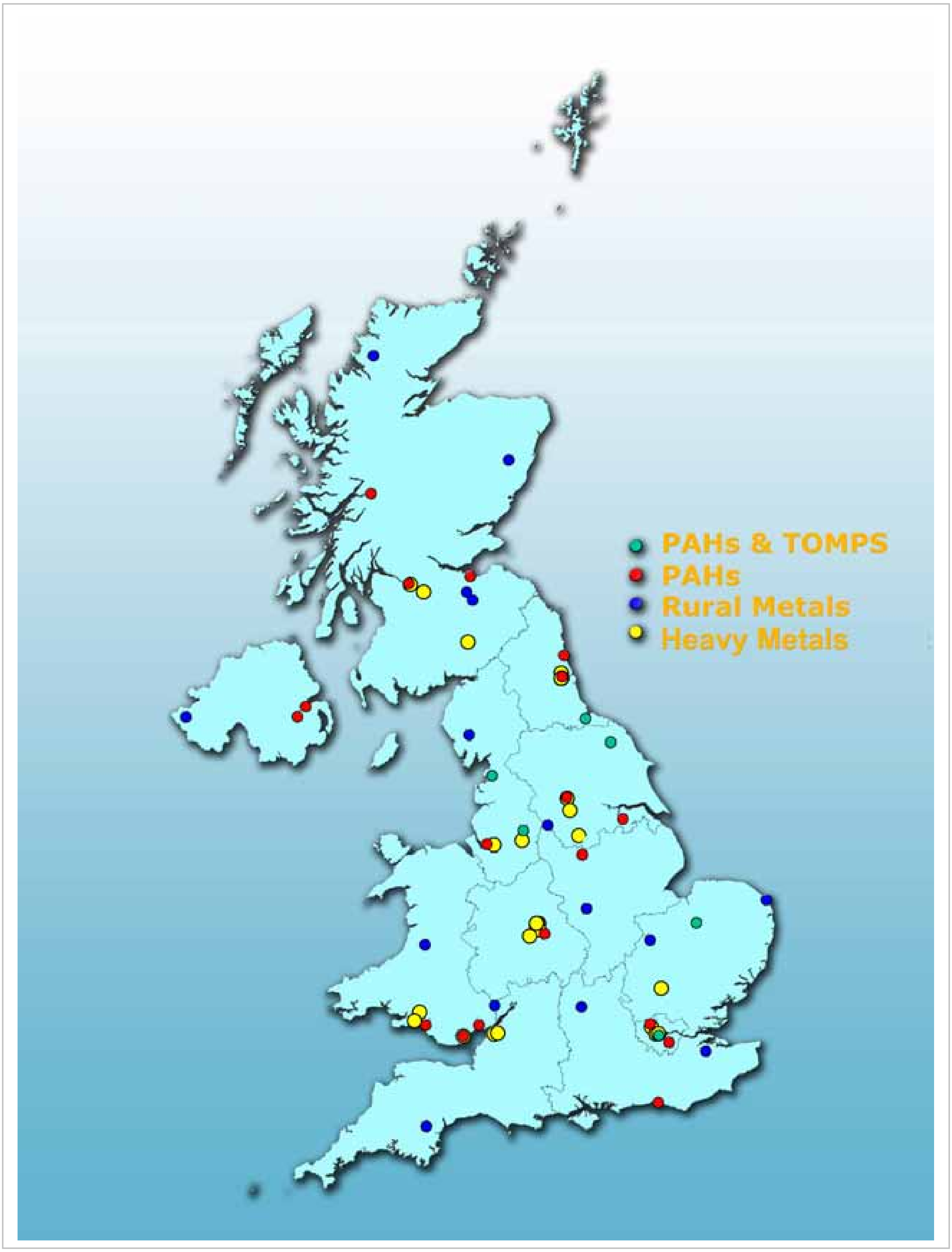
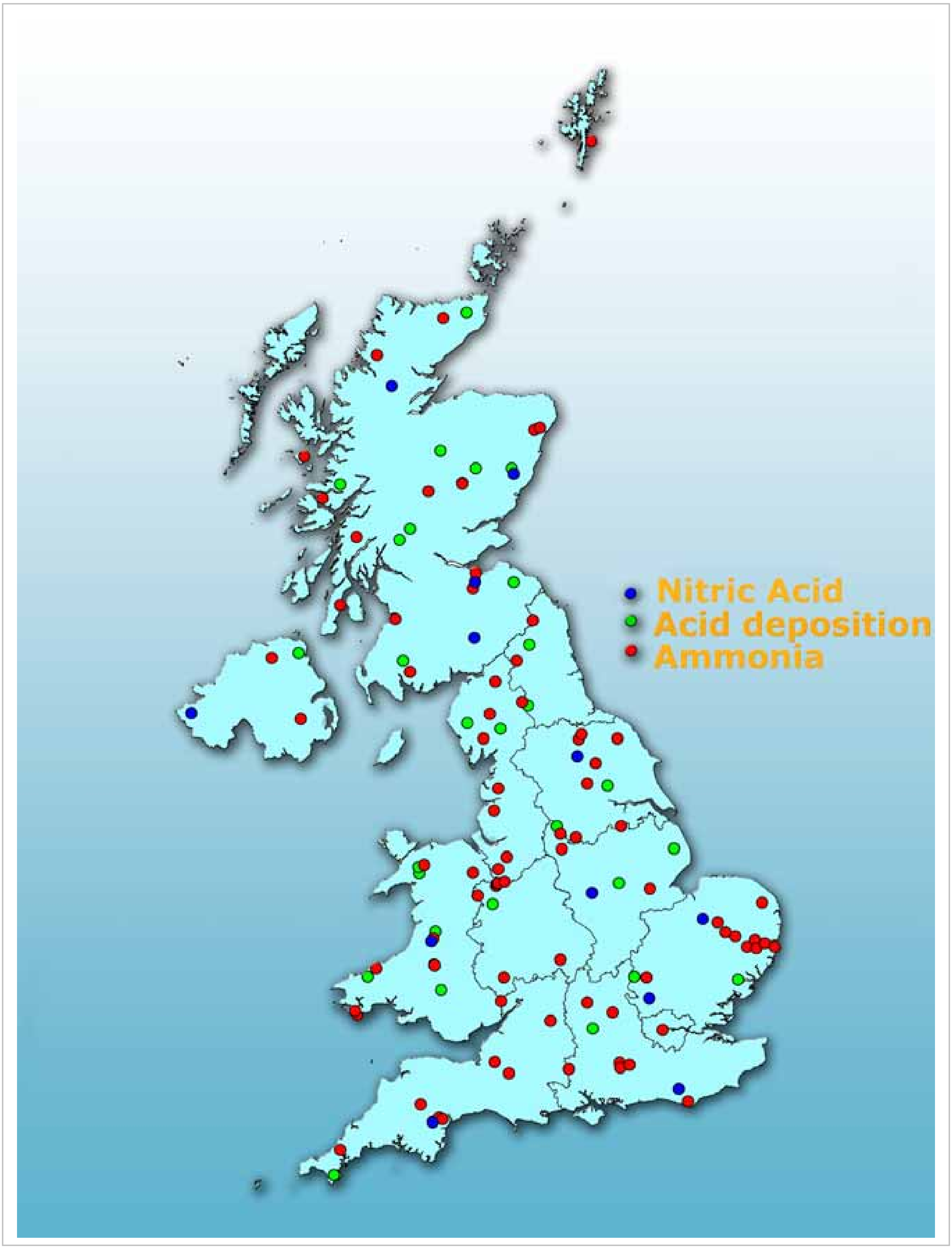


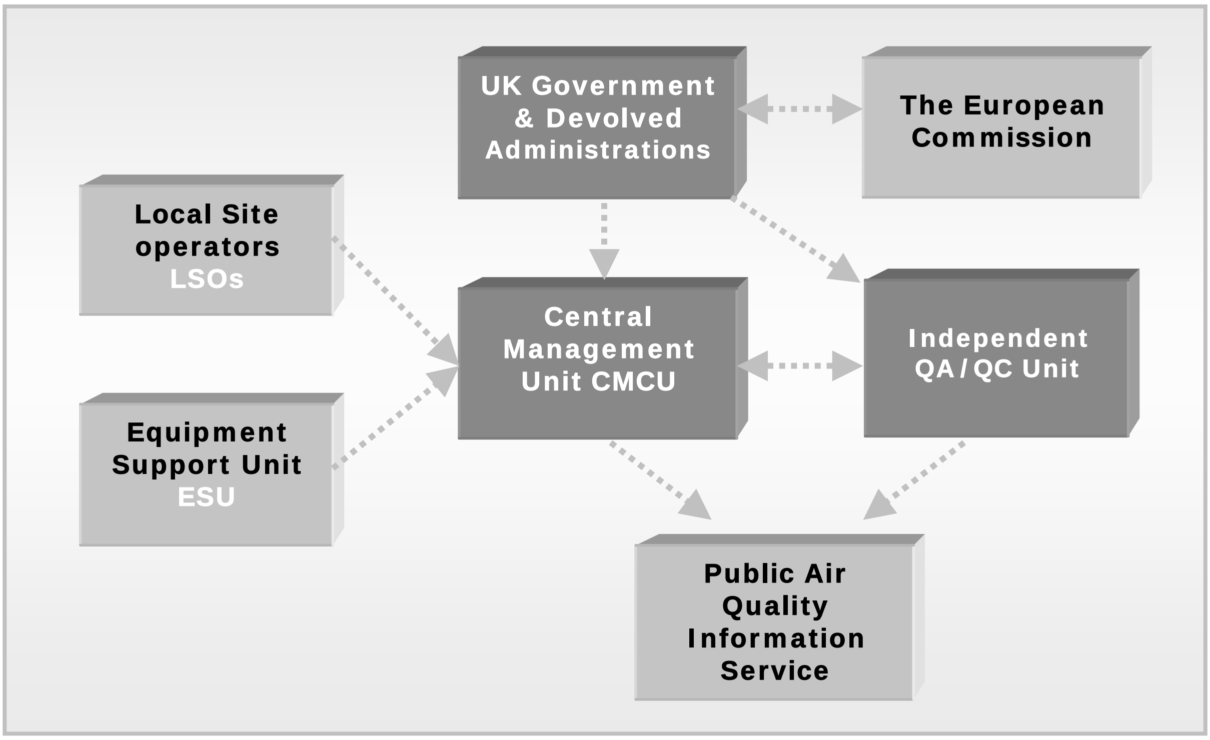
Fig 9 Current UK sampler-based measurement programmes: Acidification and Eutrophication



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 10). 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 10. 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 4.6) and air quality information services (Section 4.7) in more detail.

4.6 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. The system includes quality *assurance* of the measurement process and quality *control* of the measurement outputs.

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 programmes.

Automatic Urban and Rural Network (AURN)

For this network, all quality assurance activities are tasked to an independent QA/QC Unit (Figure 10), 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 can be adopted as the 'reference method'. Member States can use the reference method or one shown to be equivalent to it (for example, EN12341 for PM_{10}).

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. 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.

The CEN procedures will require all analysers in a network to be submitted to a designated testing facility for type approval before they may be used for statutory monitoring for the purposes of assessment against the EU Daughter Directives.

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 11)	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 procedures will be adopted into the EC Daughter Directives during future reviews. 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
- In addition to passing the individual performance tests, the analysers must also pass an overall uncertainty evaluation. The results of the individual tests above are used as components to calculate the overall uncertainty of measurement. For NOx, CO, O_3 and SO_2, the 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.

Figure 11. All UK automatic monitoring stations are audited regularly as part of their core quality assurance and control programme.

This involves:

- Performance tests of all analysers on-site
- Verifying calibration gasses
- Inter-calibration of the network as a whole
- Monitoring performance of local site operators
- Providing training

A comprehensive operations manual for the AURN has been produced and disseminated to all site operators. This is 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. The manual is also available for the UK Air quality Information Archive at http://www.aeat.co.uk/netcen/airqual/reports/lsoman/lsoman.html.

NO2 diffusion tube monitoring

As indicated ed in section 4.3, the NO_2 diffusion tube network ceased operation at the end of 2005, following the conclusion of an independent review that it had now served its purpose. However, Defra acknowledged the value of the network's QA/QC programme in the wider context of LAQM in helping to improve and maintain the quality of all NO_2 diffusion tube measurements carried out by Local Authorities. The database of tube data from over 1100 sites since the early 1990s will continue to be of great value, not least for comparison with newer measurements.

Defra's "Support to Local Authorities for Air Quality Management" contract now incorporates a centralised quality assurance/quality control (QA/QC) framework for laboratories carrying out diffusion tube preparation and analysis. The existing activities will be reviewed and enhanced, but at present comprise –

- Promotion of the independent Workplace Analysis Scheme for Proficiency (WASP) operated by the Health and Safety Laboratory, with yearly assessment against agreed performance criteria.
- A field intercomparison exercise, in which diffusion tubes are co-located with an automatic analyser: from January 2006 this has been operated at a roadside site.
- Operation of a QC solution-testing scheme.

A data verification service for diffusion tubes has recently been launched. This offers additional data management activities for any Local Authorities who wish to make use of it. It is operated along similar lines to the national Calibration Club, and it is envisaged that it will be particularly useful to authorities operating large numbers of diffusion tubes.

4.7 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 high-level process of turning raw data into useful information, depicted in Figure 12, is vital to the success of the UK monitoring networks.

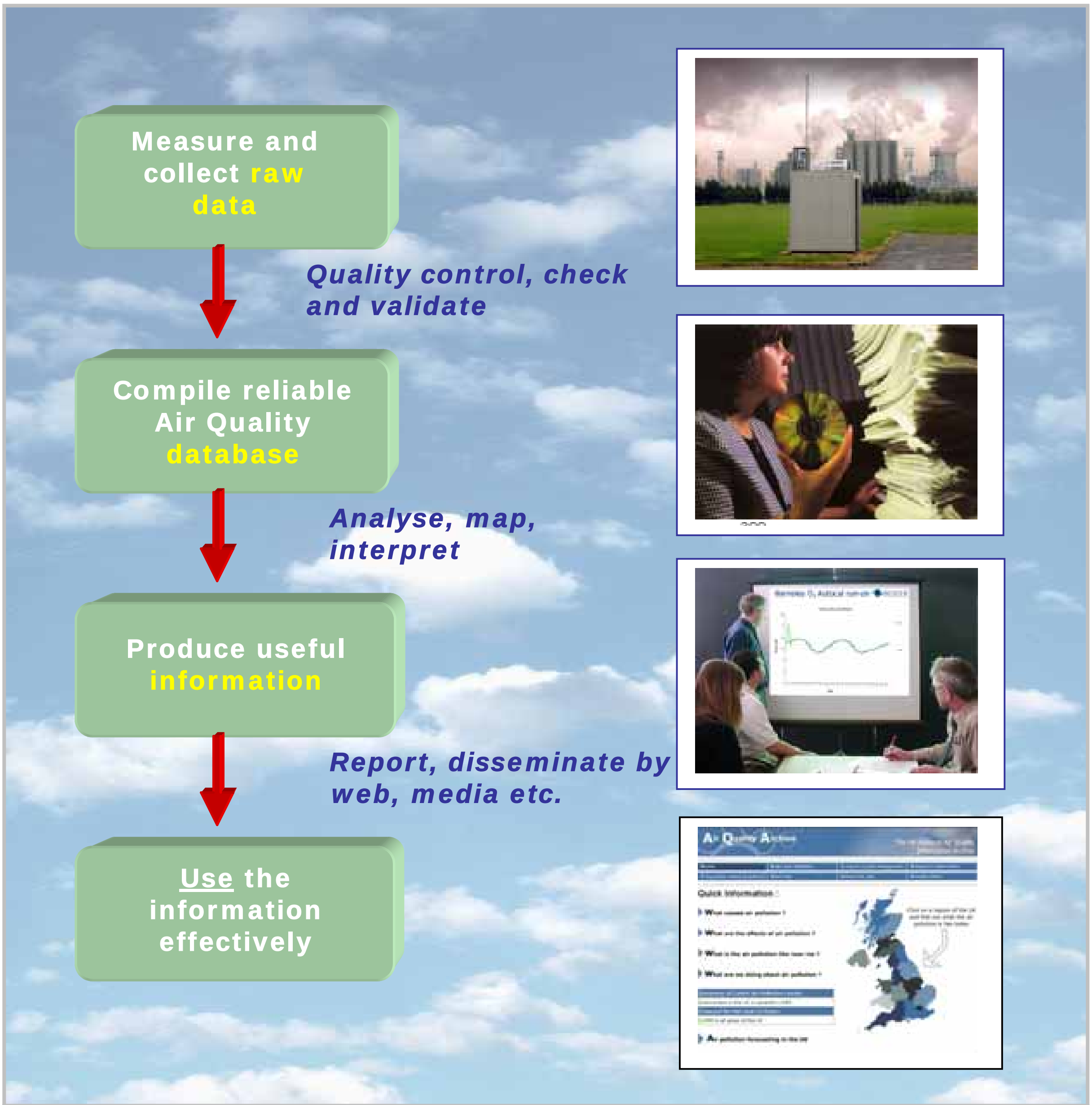


Figure 12. This report has been made possible by turning large quantities of raw air quality data into useful information

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 (Figure 13, Box 2). 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 also the national repository for ambient air quality measurement and emissions data. It contains measurements from automatic measurement programmes dating back to 1972, together with sampler measurements dating back to the 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 16 for a map of the site. Box 4 provides details of a new information resource that has recently introduced specifically to meet the needs of Local Government at www.laqmsupport.org.uk.

The UK's national air quality web site records over 4,000 hits each day and over 1.5 million every year. It also responds rapidly in providing data and reassurance during pollution events such as the Buncefield fires (discussed in Section 5). During this period, access to the website tripled. As well as its primary role in public information and awareness raising, the Archive has become a key resource for UK education and research. It has received wide praise, both within the UK and internationally.

As part of an ongoing improvement programme, the UK air quality website is currently undergoing a range of upgrades to its user interface; these are designed to further improve intelligibility, user-friendliness and ease of navigation, as well as enhancing its accessibility to all communities. See Figure 14.

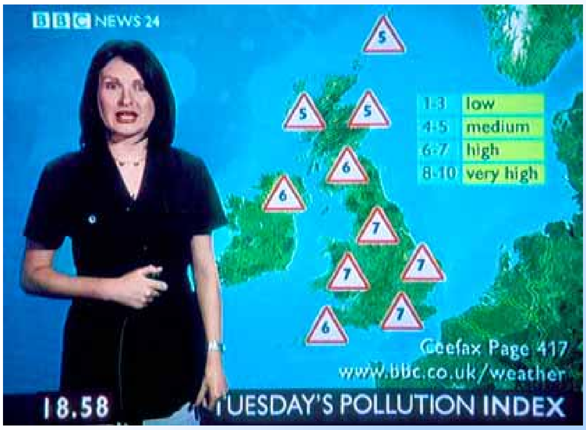
In 2004, a new air quality archive was established for Wales. Publicly available through its website at www.welshairquality.org.uk, this mirrors many of the services and functions of the UK National Archive. It provides for the first time a comprehensive one-stop resource for data and analyses covering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

During 2006, a similar air quality archive for Northern Ireland has gone live at www.airqualityni.co.uk (Figure 15). A further web-based facility is under development for Scotland at www.scottishairquality.co.uk. This is currently subject to consultation by a wide range of air quality stakeholders and end-users.

Figure 13. The UK Air Quality Information Service

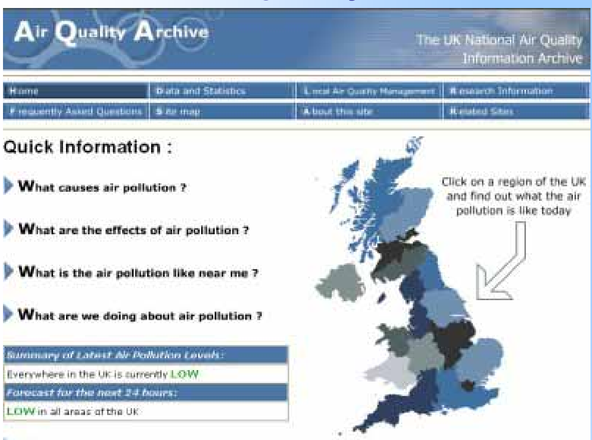
This utilises a wide variety of media, web and electronic resources to disseminate the latest air quality data and forecasts:

TV Weather Bulletins

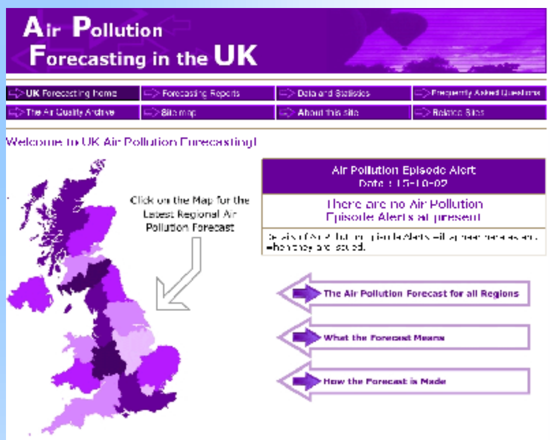


TV Teletext

The UK Air Quality Website



Twice daily web forecasts



A series of brochures & reports

Freephone 0800 556677

Figure 14. The new UK air quality website is more user-friendly

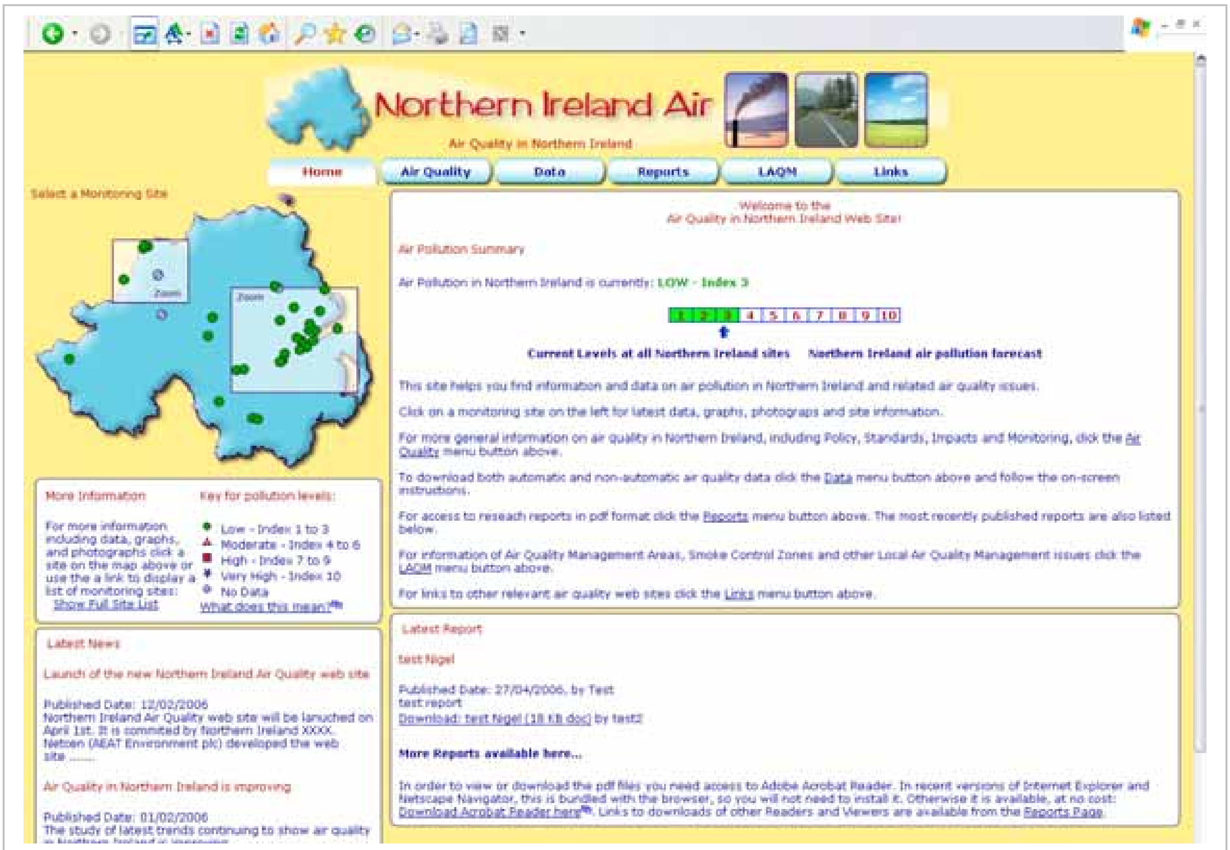


Figure 15. A new national archive for Northern Ireland has now gone live

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
- The Northern Ireland Archive at www.airqualityni.co.uk
- The Scottish Air quality Archive- coming soon at www.scottishairquality.co.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 DoE Environmental Policy Division website at http://www.doeni.gov.uk/epd
- 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@cambertown.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
http://www.airqualityni.co.uk/laqm_sca.php

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
- A **new** one-stop-shop describing the UK's air monitoring programmes and linking to many websites for the different networks
- 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

Box 4. Information for Local Government at www.laqmsupport.org.uk

This new site, provided on behalf of Defra and the Devolved Administrations, provides Local Authorities with access to advice and information on air quality monitoring, air quality modelling, and emissions inventories. It offers:

- Downloadable tools and guidance to assist with the entire Local Air Quality Management process
- The latest updates to Defra's Technical Guidance
- Guidance on use of NO_2 diffusion tubes, and a link to the NO_2 Web-Based Data Entry System, which provides Local Authorities with a convenient and reliable way of storing and sharing their diffusion tube data.
- Frequently Asked Questions
- Links to other useful websites, such as the Action Plan Appraisal Helpdesk and the Review and Assessment Helpdesk.

The Local Authority Air Quality Support Helpdesk can also be contacted by telephone on 0870 190 6050 and by e-mail on lasupport@aeat.co.uk.

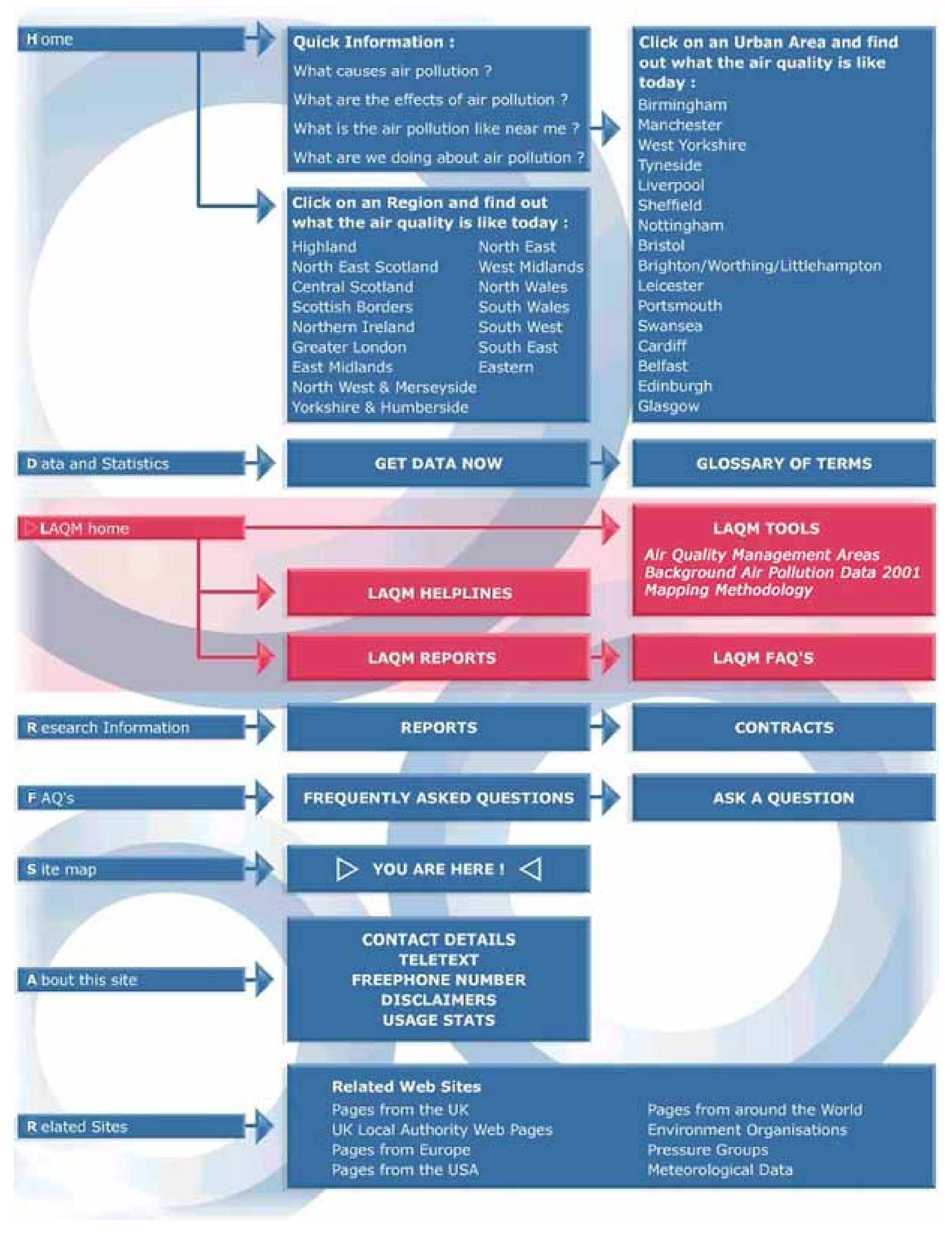


Figure 16. Map of the UK Air Quality Archive, showing the comprehensive range of available data and information from this resource

5. High Pollution Episodes

We focus in this section on periods when pollution levels during 2005 were unusually high, either locally or UK-wide. Through examining such episodes, we identify their causes and examine possible impacts.

5.1 Causes and types of air pollution episode

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.

Another type of pollution episode can be caused by long-range transport of pollutants from Europe, or occasionally from North Africa or North America. 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 busy roads or 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, as we have seen throughout this long-running series of annual reports.

In this section, we review the most significant air pollution events in the UK during 2005.

5.2 Air Quality Impacts from the Buncefield Fires

We start, however, by examining a wholly exceptional event that does not fit readily into any of the pollution episode categories identified in the previous section.

On Sunday 11th December 2005, there was a major explosion at the Buncefield oil depot near Hemel Hempstead, north of London. Following the explosion, large stocks of refined petroleum product including petrol, aviation turbine fuel, diesel and gas oil stored at the depot remained on fire until Wednesday 14th December, when the last major fires were finally extinguished. A number of smaller fires continued until Thursday 15th December.

The large plume of particles and other pollutants produced by the fires could be seen from many kilometres away, and was also clearly identified in satellite images (figure 17).

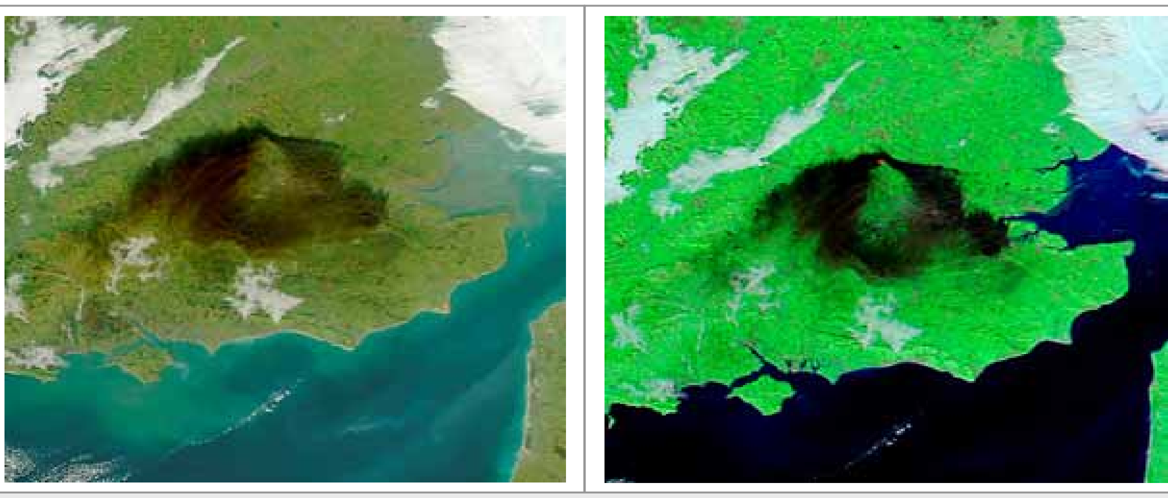


Figure 17 Visible and false colour MODIS satellite images of the Buncefield fires on 11 December- courtesy NASA and the Visible Earth Team

Due to the large scale of the fires and their dramatic visual impact, independent experts and the media expressed concerns about potential air quality effects on public health, both in the vicinity of the depot and throughout southern England.

This section is based on comprehensive initial analyses of those air quality impacts, presented in a report produced for Defra by Netcen, the Met Office and Health Protection Agency (HPA); this report was published in May 2006 and is now available from-
http://www.defra.gov.uk/environment/airquality/buncefield/index.htm

We have also had regard to wide–ranging analyses and presentations from Netcen, Met Office, HPA and Kings College ERG at a technical seminar on the Buncefield incident, held in Culham, Oxfordshire in June 2006. These may be accessed in full (in PDF format) at-
http://www.airquality.co.uk/archive/reports/reports.php?action=category&section_id=12

We thank all these contributing organisations for their insight and inputs to subsequent sections of this year's air quality report. In these, we examine:

- Likely emissions from the fires
- Monitoring undertaken
    - Around the plant
    - From an aircraft
    - In national and local monitoring networks
- Modelling of the plume
- Why ground level impacts were so low

Emissions

Buncefield was the largest industrial fire in Europe for over 50 years. Detailed estimates of the quantities of pollutants emitted have been undertaken in order to:

1) Enable improved modelling of the plume and
2) Understand the potential air quality impact of pollutants emitted during the fires.

The total amount of fuel at Buncefield Oil Depot was estimated from information about the terminal capacity provided by the UK Petroleum Industry Association (UKPIA) and Total Oil. Complete information on the actual quantities of fuel stored at the terminal during the event is not available at this time. These figures are therefore provisional and may need to be revised as more definitive information is made available.

Pollutant emission factors from the UK National Atmospheric Emission Inventory (NAEI at www.naei.org.uk), together with other published sources, were used to estimate the total emissions arising from the fires. The quantities of air pollutants emitted were estimated for four possible scenarios for the event:

1) 90% of fuel from BPA and 60% of fuel from HOSL depots combusted
2) LOW estimate (50% loss of fuel on site assumed)
3) MEDIUM estimate (75% loss of fuel on site assumed)
4) HIGH estimate (100% loss of fuel on site assumed)

These analyses attempt to give a picture of the different possible outcomes of the fire, including a more realistic scenario (1) as well as a possible worst-case scenario (4). The pollutants considered have air quality standards/objectives (or proposed standards/objectives), are greenhouse gas/global warming pollutants, or were considered to be most relevant for public health concern.

The results are shown below in Table 8. These demonstrate that the fires released 5% or more of annual UK air emissions of some pollutants – PM_{10}, $PM_{2.5}$ and benzo(a)pyrene. Emissions of other pollutants such as NO_2, CO and NMVOC were lower at < 0.1% of total annual emissions.

Table 8 – Estimates of total emissions of air pollutants emitted from the Buncefield oil fires

Pollutants	Scenario					UK Total (2003)		Scenario (%)			
	1	2	3	4	Units			1	2	3	4
NO_X	37.2	27.3	40.9	54.6	*Tonnes*	1570	*kTonne*	0.0024	0.0017	0.0026	0.0035
PM_{10}	8249.5	6054.8	9082.2	12109.6	*Tonnes*	141	*kTonne*	5.8507	4.2942	6.4413	8.5884
$PM_{2.5}$	4949.7	3632.9	5449.3	7265.7	*Tonnes*	86.9	*kTonne*	5.6958	4.1805	6.2708	8.3610
Dioxins	1.32	0.97	1.45	1.93	*g-TeQ g*	259	*g-TEQ g*	0.5087	0.3734	0.5601	0.7468
B[a]P	285.4	209.5	314.3	419.0	*kg*	4034	*kg*	7.0761	5.1936	7.7903	10.3871
CO	1712.7	1257.0	1885.6	2514.1	*Tonnes*	2768	*kTonne*	0.0619	0.0454	0.0681	0.0908
NMVOC	101.0	74.2	111.2	148.3	*Tonnes*	1089	*kTonne*	0.0093	0.0068	0.0102	0.0136
Benzene	58.3	42.8	64.2	85.6	*Tonnes*	13.6	*kTonne*	0.4290	0.3149	0.4723	0.6298
CO_2	0.144	0.105	0.158	0.211	*Mtonne*						
Carbon	39.2	28.7	43.1	57.5	*kTonne*	152324	*kTonne*	0.026	0.019	0.028	0.038

Figure 18 Inside the depot during the fires © Hertfordshire Constabulary

Figure 19 Devastated tanks after the fires © Hertfordshire Constabulary

Monitoring

1) Locally targeted monitoring

Rapid-response local monitoring was carried out around the oil depot and surrounding areas by i) Netcen on behalf of Defra and the DAs and ii) by the Fire Brigade's Scientific Advisors (Bureau Veritas) and HSL on behalf of the Health Protection Agency. These studies included:

- Particulate matter using a Grimm particulate sampler.
- Grab sampling for VOCs.
- Monitoring of CO, CO_2, SO_2, particulate matter, hydrocarbons and VOCs

This local air quality monitoring attempted to categorise both areas of maximum air quality impact (assessed on-the-spot visually) and nearby residential zones. Not surprisingly, the results obtained were highly variable in both space and time. The monitoring showed relatively high short-term concentrations of particulate matter and unburnt hydrocarbons close to the fire:

- Peak PM_{10} one-minute mean measurement - 985 μgm^{-3} on 12/12/05
- Peak PM_{10} 15-minute mean - 340 μgm^{-3} on 13/12/05
- Peak $PM_{2.5}$ 1m mean - 801 μgm^{-3} at on 13/12/05
- Peak $PM_{2.5}$ 15m mean - 318 μgm^{-3} on 13/12/05
- Peak PM_1 1m mean - 522 μgm^{-3} on 13/12/05
- Peak PM_1 15m mean -210 μgm^{-3} 13/12/05 a

To put these measurements made in the vicinity of the Buncefield depot in context, however, they are lower than those characteristic of near-roadside environments or during typical Bonfire Night. See subsequent sections and Figure 22 for further exploration of this point.

Parallel VOC sampling (meeting the requirement of the USEPA method TO-14A) showed that no measured VOC concentrations exceeded the short term Environmental Assessment Levels (EALs) for air for the protection of human health. For example, the highest recorded toluene grab-measurements around Buncefield were of the order of 700 μgm^{-3}. By way of comparison, the EAL for this species is 8000 μgm^{-3}.

2) Monitoring from the instrumented FAAM aircraft

The Facility for Airborne Atmospheric Measurements (FAAM) BAe146-301 aircraft, operated jointly by the Met Office and NERC, flew on the 12th and 13th December to study the position and composition of the plume (Figures 20, 21). These flights were made more complex by their proximity to several airports; this part of southern England has one of the highest air traffic densities on earth.

The aims of the flights – which included runs through, around and downwind of the plume were:

1) To provide real-time information on the position of the plume
2) To provide the *in-situ* data on its chemical composition and pollutant levels

Airborne measurements showed that the plume was mainly composed of black soot. The maximum particle level recorded was (only) 100 $\mu g/m^3$ (max of 30-sec averages) so instantaneous peaks may have been higher. Carbon monoxide (CO) and oxides of nitrogen (NO_x) were detected, but not in large quantities. Concentrations of PAHs and dioxins measured in the plume were also surprisingly small.

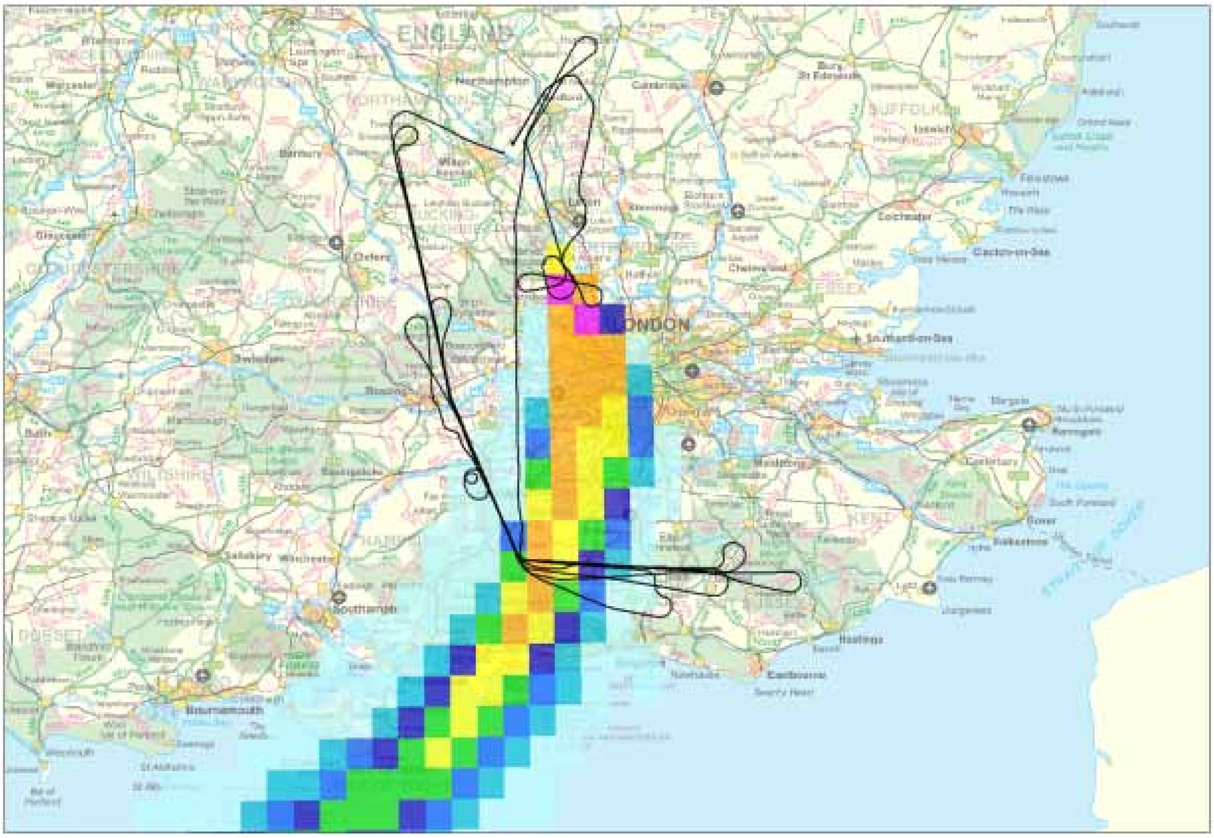


Figure 20- Flight paths of the FAAM aircraft sampling the plume on the 13th, together with Met Office NAME model predictions for that day.

Figure 21 The FAAM Aircraft used for plume monitoring

3) Observations from national networks

Hourly measurements continued throughout the fires in the UK national automatic monitoring networks (AURN and Hydrocarbon); data were disseminated in real-time, together with twice-daily forecasts, on the air quality website at www.airquality.co.uk, a range of media outlets and email bulletin services.

As noted in Section 3.2, the UK Air Quality Index (AQI) is used to report hourly air quality concentrations. This index provides a simple measure of how clean or polluted the air is, together with an indication of possible health impacts.

Analysed in detail, AURN measurements did not show any instance during the Buncefield incident with PM_{10} levels of MODERATE or above that were attributable to the fire. Although Bradford Centre exhibited levels into the HIGH AQI band (24hr average 50-75 $\mu g/m^3$ TEOM), this site was affected throughout this period and throughout the entire year by localised construction work; Camden Kerbside and London Marylebone recorded MODERATE PM_{10}, but these are located close to major roads (less than 1 metre from the kerb) and are therefore substantially affected by local transport sources.

In short, AURN PM_{10} measurements show no evidence of significant ground level air quality impacts from the Buncefield plume. It is interesting to note that similar analysis of national monitoring data from parts Northern France that could have been directly affected also showed no evidence of any ground-level impacts.

Figure 22 compares PM_{10} concentrations measured throughout the AURN during the Buncefield incident with those recorded during a range of recent Bonfire Night weeks. Bonfire Night particle concentrations depend critically on weather conditions and timing, and therefore vary markedly from year to year, The graphed Bonfire Night events (1995, 2001, 2005) have been selected as being typical of high, medium and low-intensity events of this type, respectively.

Please note that the running 24-hour average metric plotted here conforms to the Defra Health bandings for PM_{10}. Note, also, that the data graphed are network averages over the whole of the AURN (for sites with >75% data capture).

Although the different time series in Figure 22 are not strictly comparable, because they do not cover the same time periods or the same geographical scale (Bonfire Night being nationwide and Buncefield more localised), they nevertheless serve broadly to demonstrate the magnitude of the Buncefield event. It is clear that this was associated with UK-wide PM_{10} concentrations similar to those observed during Bonfire Night 2005. However, as the result of favourable meteorological factors, the 2005 event did not exhibit any significant increase in particle levels above background.

Briefly examining results from other national networks, London Marylebone is the closest automatic hydrocarbon network station to Hemel Hempstead. Levels here were unexceptional during the Buncefield week. However, ratios of individual species to benzene show a spike for toluene, xylene and trimethylbenzenes on the 12^{th}. This is the only unusual observation here, although absolute levels remain low. The observed ratios are broadly consistent with evaporative emissions of fuel, but different to those collected by grab sampling near to fires. It cannot be ruled out that this spike in hydrocarbon species was due to the Buncefield fires.

Levels of PAHs (Polyaromatic Hydrocarbons) rose in London during the week of the fire. However, we know very little about week-on-week variations of these species. Moreover, the lack of consistency in individual concentration of PAHs and dioxin profiles and ratios actually suggests a different causation at the three London sites; this may indicate local sources, or simply ‘noise’ in the week-on-week concentrations.

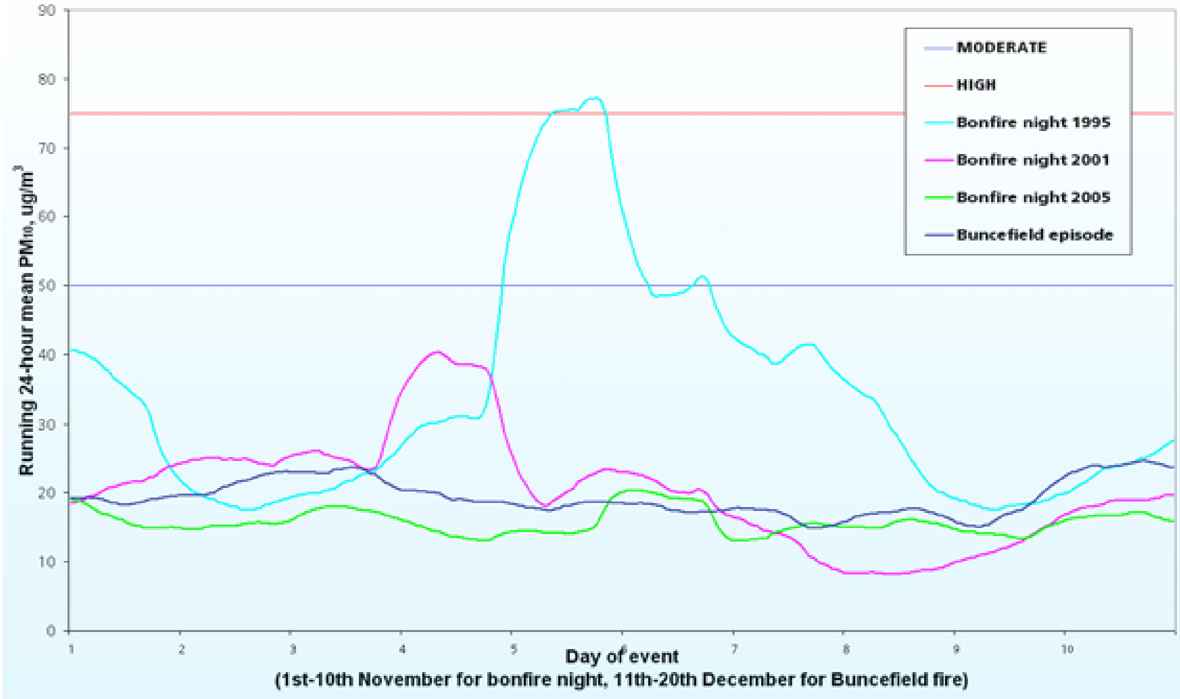


Figure 22 PM_{10} Concentrations averaged over the AURN- Buncefield week compared to typical Bonfire Nights

4) Local Network Monitoring

In addition to the national monitoring networks operating in the southeast of England, a number of local programmes – often with denser geographical spacing of monitoring sites - exist in this part of the country. These include:

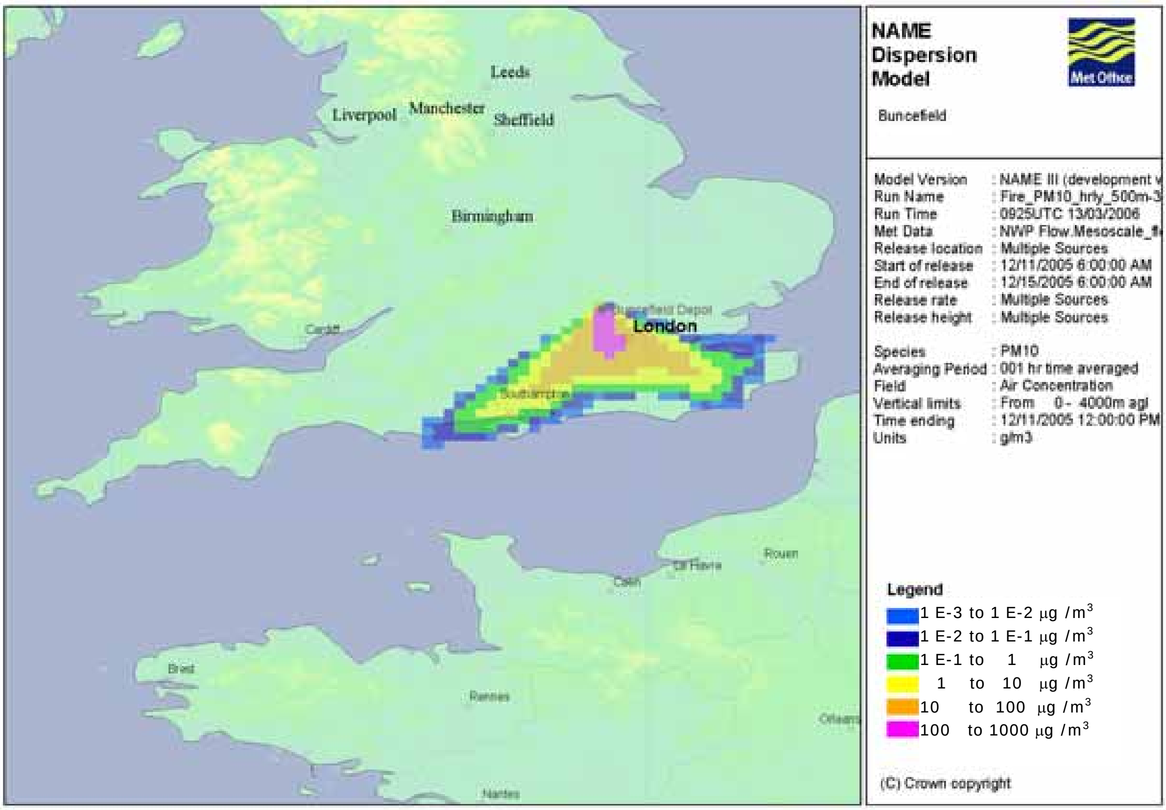
- Herts & Beds Air Pollution Monitoring Network (HBAPMN) www.hertsbedsair.org.uk
- London Air Quality Network (LAQN) www.londonair.org.uk
- Kent Air Quality Monitoring Network (KAQMN) www.kentair.org.uk
- Sussex Air www.sussex-air.net

Additional data available from these local and regional monitoring networks co-ordinated by King's College Environmental Research Group has shown some small and short-term (15-minute) PM_{10} peaks at a few sites in Hertfordshire, North London, Surrey and Sussex. Modelling by the Met Office using the advanced NAME III system (see next section) confirms that the air arriving at these sites at the times of the peaks could have come from the Buncefield area.

Despite these sporadic and transient events, comparison of ground-level air quality data with health-based air quality standards shows that pollution levels during the incident remained LOW or just into the MODERATE category at regional monitoring locations in the southeast,

Modelling

Using its well-established NAME dispersion model[42,43], the Met Office undertook detailed modelling of the plume, both before and after the event. This involved large uncertainties, especially in the early stages when the composition and amount of fuel burning was not known accurately. Observations by civilian aircraft helped to fine-tune the Met Office model results. Some typical NAME results are shown in Figure 23.



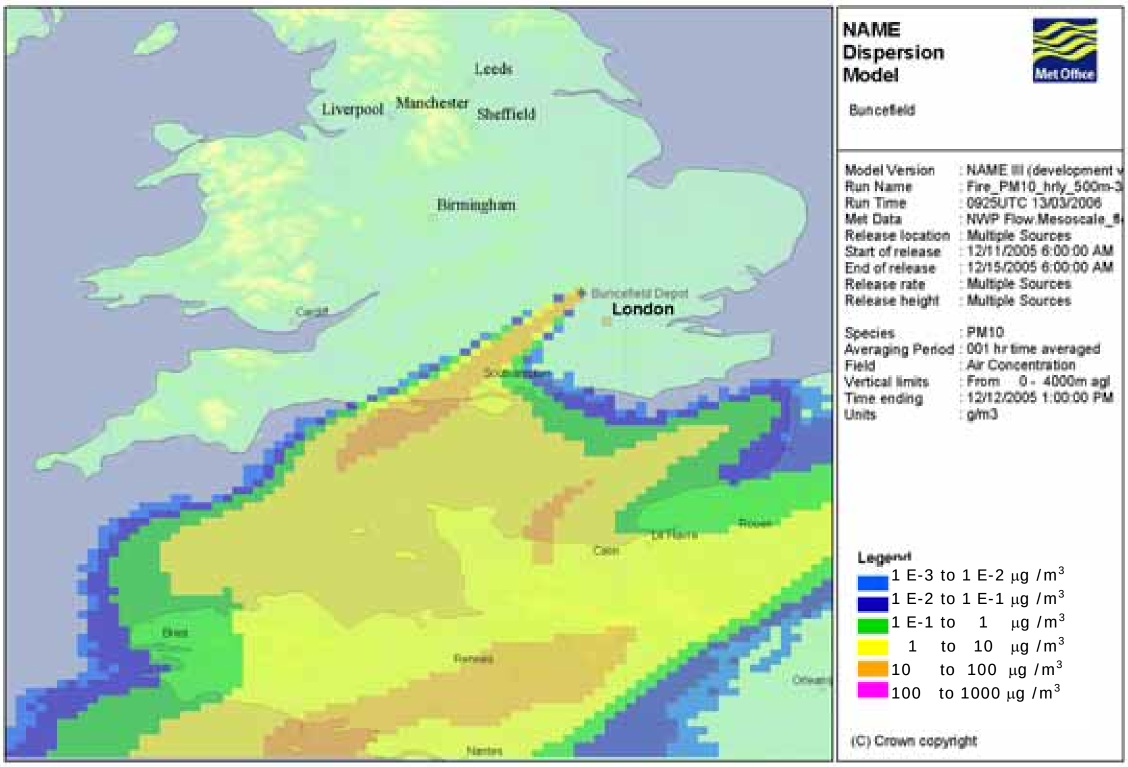


Figure 23 NAME predicted hourly averaged PM_{10} concentrations between 0 and 4000 m at 12:00 pm on 11/12/05 (top) and at 13:00 pm on 12/12/05 (bottom)

We have seen earlier that, despite the very large quantities of pollutants emitted, a wide range of air pollution monitoring undertaken before, during and after the event showed that UK ground-level concentrations of a wide range of pollutants remained LOW to MODERATE over local, regional and national scales. Although there was limited evidence of sporadic and episodic plume grounding on occasions, it appears – and the models confirm this - that the high plume buoyancy and favourable meteorological conditions resulted in the overwhelming bulk of the pollution rising high into the atmosphere, with minimal mixing to the ground. As a result, we saw little evidence of widespread or significant air quality impacts at ground level due to the pollutants emitted from the Buncefield fires.

Were we lucky? To answer this question, the Met Office has modelled several “what-if?” scenarios as follows:

- Windy conditions.
- Uncontrolled burning.
- Summer convective conditions.

The conclusion was that, even under this wide range of conditions, the model predicted ground-level pollution concentrations that would not have been significantly worse than those actually observed.

Health Impact Assessment

The Health Protection Agency has carried out three surveys to assess possible public health impacts of the incident:

1) Review of A&E case notes (acute effects)
2) Population survey (public concerns)
3) Occupational Health survey (‘high exposure’ group)

The Accident & Emergency case notes review discovered that 77% of those attending A&E due to the impact of Buncefield were from the emergency services. In most cases, this was because standard advice was issued suggesting that they should do so. Of the 244 cases reported, only 22 required further attention such as admission or referral to GP. This included the physical injuries from the explosion itself. There was an initial 65% increase in A&E workload but, after 24-hours, this returned to normal.

A random sample of 5,000 local people was also surveyed for their concerns following the explosion; a 40% response was obtained- typical for this kind of study. Almost half of the people surveyed were worried about potential long-term health impacts, whilst around a quarter were worried about short-term effects. Only 6% said they were specifically concerned about the smoke plume. Over 40% indicated that they were satisfied with the advice obtained.

A comprehensive survey of occupational health departments in the agencies directly involved in the incident is currently underway.

5.3 A photochemical smog episode: June/July 2005

HIGH levels of air pollution were measured across the Automatic Urban and Rural Network (AURN) during June 2005. This was the first – and only – extended photochemical episode of this type during the year.

Levels were highest in the South East area and Greater London. Ozone levels in index 7 of the Defra HIGH band (180-239 μgm^{-3}) were recorded at seven stations - see Table 9. The highest hourly concentration during June was 202 μgm^{-3} (index 7); this occurred at Weybourne at 19.00 on 24th June. High levels of ozone were measured during 5 consecutive hours at Weybourne between 18.00 and 23.00.

The 3rd Daughter Directive (Directive 2002/3/EC) on ozone in ambient air has established an alert threshold of 240 μgm^{-3} as an hourly average over three consecutive hours. However, this alert threshold was not exceeded during the episode.

Table 9. Number days of Moderate and High levels at each station across the AURN

Site	Number of Days		Max hourly if High (μgm^{-3})	Date of hourly max concentration
	Moderate	High		
Weybourne	18	2	202 & 192	24/06/05 & 19/06/05
Sibton	18	2	190	23/06/05 & 24/06/05
London Bexley	10	1	192	23/06/2005
St Osyth	17	1	186	19/06/2005
Bournemouth	16	0	180	19/06/2005
London Eltham	14	0	180	23/06/2005
Lullington Heath	16	0	180	23/06/2005

As can be seen in Figure 24, the episode started on 19th June, when more than 47 stations measured MODERATE levels of O_3 and 2 stations measured HIGH levels (index 7). The episode ended on 24th June, when only 23 stations measured levels in the MODERATE band and 2 stations measured HIGH levels (index 7).

There was a second period of elevated O_3 levels between 9th and 17th July. However, the levels rarely reached MODERATE index 5; the highest levels were measured in Wicken Fen at 172 μgm^{-3} (index 6) on the 14th July. This July period provides an illuminating contrast to the June episode, and is therefore investigated here.

Reasons for the episode

The June summer ozone episode was characterised by rising temperatures and air masses re-circulating over northern Europe and the UK. These conditions typically result in summer smog episodes as the ozone precursor chemicals react in the presence of sunlight. Similar summer episodes in the UK have previously been reported [44,45] and discussed in earlier annual reports in this series.

Comparisons between the contrasting June and July periods clearly show that both high temperatures and re-circulation of air masses over Europe and the UK were required to produce elevated ozone concentrations during the earlier period. High temperatures alone were insufficient to produce an episode in July.

1) Temperature

During June and July, there were two periods of high ambient temperatures in the UK:

- 18th to 24th June (the first period)
- 10th to 15th July (the second period)

During the first period, maximum temperatures reached *circa* 35ºC, with a daily average *circa* 26ºC a (Figure 24). These high temperatures were measured predominantly in the South East. During the second period, maximum temperatures reached 29ºC, with a daily average ~ 24ºC.

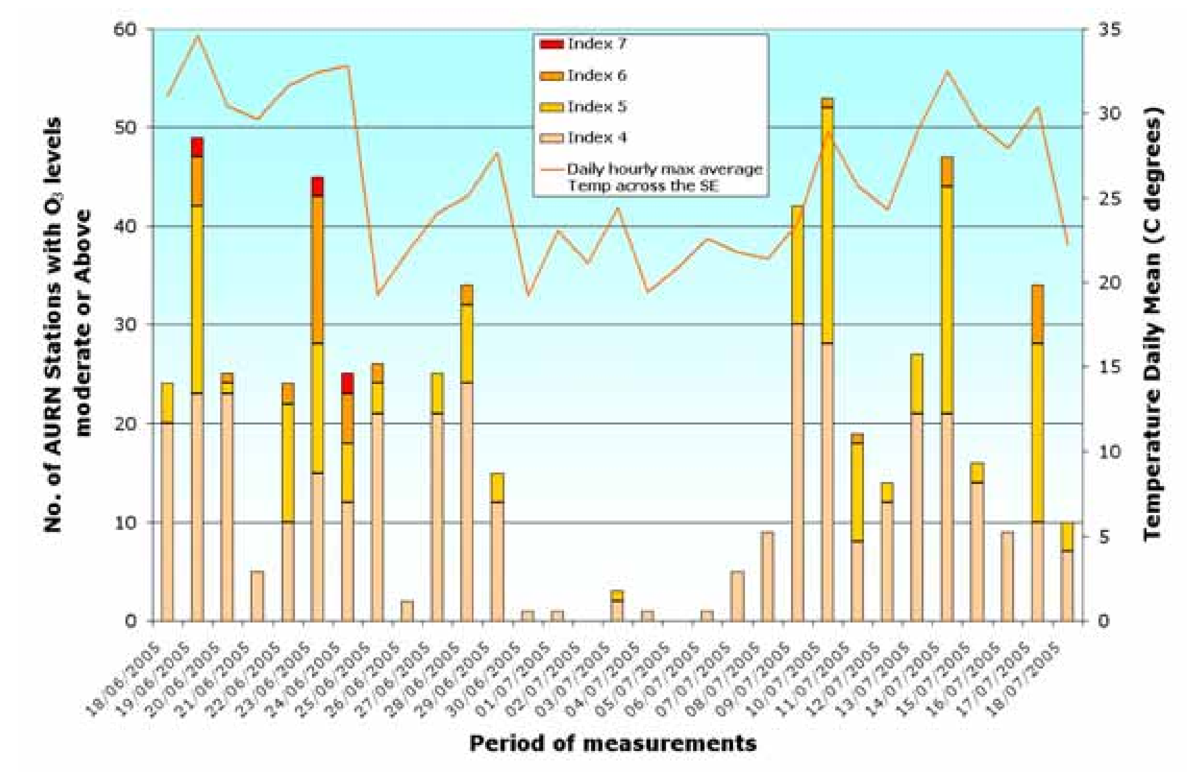


Figure 24. Ozone Episode Days – Number of Stations with MODERATE and HIGH levels between 18th June and 18th July 2005 with temperature profile across the South East.

As shown in Figure 24, however, only the first period of high temperatures resulted in HIGH levels of ozone. These were particularly noteworthy on 19th, 23rd and 24th June. Other factors were clearly necessary to bring about elevated ozone concentrations:

2) Re-circulation of air masses

96 hours airmass back-trajectories for the two periods of elevated temperatures in June and July were analysed. These clearly demonstrate the importance of air masses re-circulating over Europe and the UK. Figure 25 shows an example of the different back-trajectories prevailing during the two periods. During days of HIGH levels of ozone (19th, 23rd and 24th June), the re-circulation was over Europe and the UK. For the second period, despite the high temperatures, clean air masses originating in Ireland or in the Atlantic prevented ozone levels reaching HIGH.

Episode observed in local networks

The ozone episode was also measured across three local networks in the South East: Kent Air Quality Network, London Air Quality Network (LAQN) and the Hertfordshire & Bedfordshire Air Pollution Monitoring Network (HBAPMN).

As can be seen in Table 10, the highest hourly average was measured at Sevenoaks 2 Urban Background (UB) station at 195 on the 24th June. HIGH levels of O_3 were measured at Sevenoaks 2 UB and Greenwich 4 stations on the 23rd June, at Sevenoaks 2 UB, Bromley 4, Luton Background (UB) and Folkestone Suburban on the 24th June and at Mid Beds Silsoe (Rural) on the 14th July.

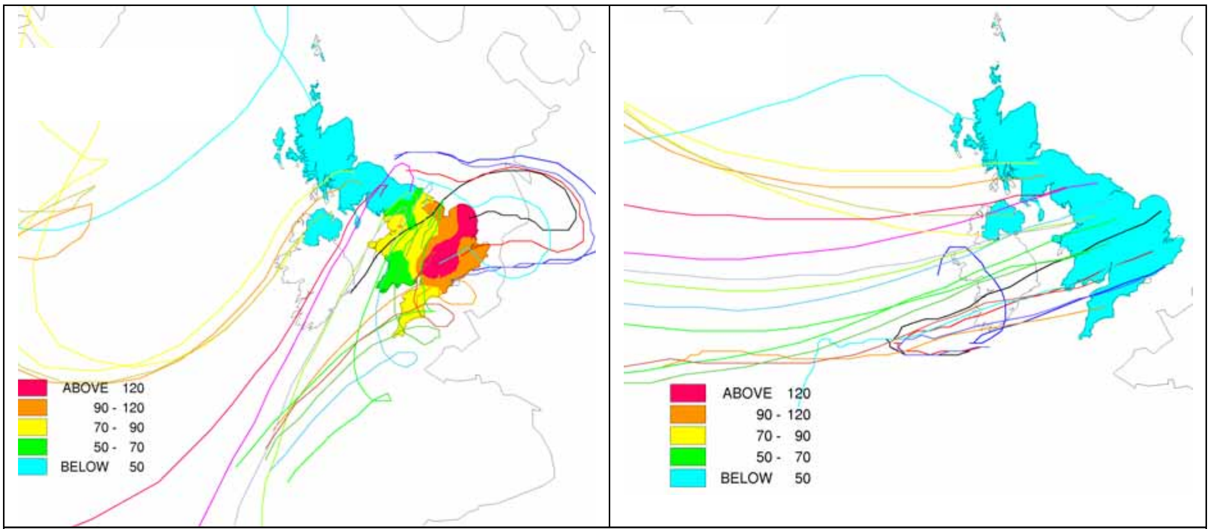


Figure 25. 96-hour air masses back trajectories

1st Period – 24/06/05 **2nd Period – 15/07/05**

Table 10. Defra's HIGH O_3 levels measured across Local Networks in the South East

Station Name	Type	Network	Date & hour	O_3 Hourly average (μgm^{-3})
Sevenoaks 2 - Greatness	Urban Background	Kent AQN	24/06/2005 11:00	195
Luton Background	Urban Background	Kent AQN	24/06/2005 11:00	189
Luton Background	Urban Background	Kent AQN	24/06/2005 10:00	187
Mid Beds Silsoe	Rural	HBAPMN	14/07/2005 16:00	185
Folkestone Suburban	Suburban	Kent AQN	24/06/2005 17:00	184
Bromley 5 – Biggin Hill	Suburban	LAQN	24/06/2005	184
Sevenoaks 2 - Greatness	Urban Background	Kent AQN	23/06/2005 16:00	183
Greenwich 4 – Eltham	Urban Background	LAQN	23/06/2005	180

Episode observed across Europe

The ozone episode on the 23rd and 24th of June was also observed in Belgium and the Netherlands. Figure 26 shows the following sequence of hourly ozone measurements in the UK, Belgium and the Netherlands on 23rd June between 12:00 and 23:00 (note that these data are provisional):

The episode on the 19th June was only measured in the UK (southeast England), while that on the 23rd and 24th affected both Europe and the UK.

The re-circulation of air masses between the UK and Europe, in conjunction with high temperatures across the UK and Europe, were clearly the dominant causes of this transboundary episode.

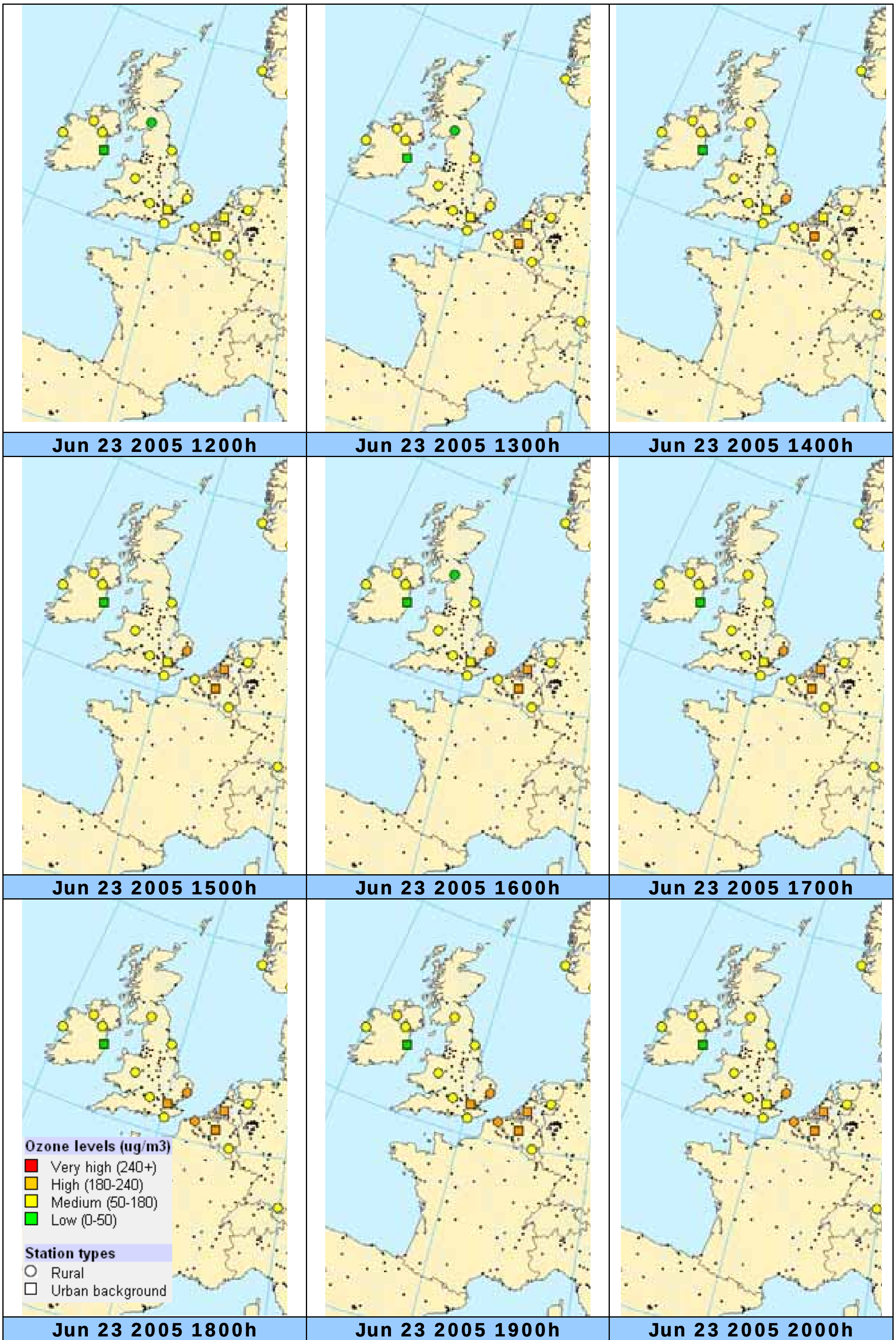


Figure 26. O_3 levels measured across Europe on 23rd of June between 12:00-20:00.

**** Data and maps from http://ozone.eionet.eu.int***

*****All data are provisional***

5.4 Near-road episodes and objective exceedences

On Friday May 26th 2005, the 36th day of the year with PM_{10} 24-hour averaged concentrations measured in excess of 50 $\mu g\ m^{-3}$ was recorded at London Marylebone Road. As the attainment date for the daily PM_{10} objective in the 1st European Daughter Directive was December 31st 2004, the air pollution episode measured at Marylebone Road on this day represented the first formal breach in the UK of the 35 days per year allowed under the Directive.

The PM_{10} problem at this location can be directly linked to the huge volume of motor vehicles on the road at that location each day. At the end of the year, a total of 118 days of exceedences were recorded at Marylebone Road. The only other roadside site in the UK with more than 35 days above 50 $\mu g\ m^{-3}$ in 2005 – and therefore in non-compliance with the Directive - was Camden Kerbside, with 52 such days. These two sites exceeded the objective, despite the fact that 2005 was a relatively unsettled year in terms of meteorology, and would therefore be expected to record lower numbers of pollution episodes than in years with cold, stable winter weather or heatwave summers.

The annual mean NO_2 objective of 40 $\mu g\ m^{-3}$ was also exceeded at 27 urban monitoring sites in 2005. These were mainly at roadside and background sites in London or at roadside sites elsewhere across the UK. Exceedences of this NO_2 objective are likely to continue to be a problem in the future, especially at roadside locations.

One of the main topics of discussion regarding near-road NO_2 concentrations at present is the increase in direct emissions from vehicle exhausts. Unfortunately, a side effect of the fitting of particulate traps to a many diesel vehicles is an increase in NO_2 emissions. Thus reducing PM_{10} concentrations at roadsides can have a knock-on effect of worsening the NO_2 situation. The relative lack of success of current emission control technologies in addressing the problem of NO_2 is discussed further in Section 7.4.

Figure 25 Gridlocked traffic in Central London © Jon Bower

5.5 Episodes around industrial locations

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 INEOS petrochemical and refinery complex situated 1km from the measurement point.

In 2005 at Grangemouth, there were only 4 exceedences of the 15-minute SO_2 concentration target level of 266 $\mu g\ m^{-3}$ on 2 days, compared to 60 over 18 days in 2004; this large decrease is most likely to have been caused by different meteorological conditions. The figures vary considerably from one year to the next, depending on how many incidents of plume grounding are caused by the meteorology in the vicinity of the monitoring site. Across the UK, there were generally fewer exceedences of the 15-minute SO_2 concentration target level in 2005 compared to 2004, and the Air Quality Objective of 35 or fewer exceedences was achieved at all locations.

Figure 26 Grangemouth refinery after heavy rainstorm © Jon Bower

An Air Quality Management Area (AQMA) has now been established for the region encompassing Grangemouth petrochemical complex and adjacent areas; this is one of the few to have been declared in the UK due to sulphur dioxide (Table 3).

Port Talbot PM_{10}

Another example of short-range transport of industrial pollutants causing local problems may be seen in Port Talbot, Wales, although here the problem pollutant is PM_{10} rather than SO_2. 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.

29 exceedences of the PM_{10} daily mean of 50 $\mu g\ m^{-3}$ were recorded here during 2005, just below the permitted number of 35 exceedences allowed by the UK Air Quality Objective. This Objective was not met in 2003 or 2004, when there were 43 and 38 such exceedences respectively. As mentioned earlier, it is likely that the relatively unsettled weather in 2005 led to the improvement in air quality at this location compared to previous years.

There continues to be much debate about the cause of the high levels in this area; this is being investigated by the Environment Agency. The discussions 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. We also assess how UK-wide levels of air pollution are predicted to change in the coming decades.

6.1 Introduction

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.

Motor vehicles are a major source of primary pollution in many large cities. In particular, traffic is an important source of carbon monoxide, nitrogen dioxide and volatile hydrocarbons (VOCs) such as benzene and 1,3-butadiene; it also emits 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 and some fine aerosols- 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.

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.

6.2 Mapping methods

We use two different approaches for modelling and mapping levels of air pollution across the UK for 2005 and future years.

For SO_2, NO_2 and PM_{10}, maps have been estimated using a combination of atmospheric dispersion models, the UK's National Atmospheric Emissions Inventory (NAEI) and data from the UK monitoring networks. Together, these provide the basis for robust, 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, Stedman et al (http://www.airquality.co.uk/archive/reports/cat16/0604041050_scenarioprojectionsreport8.pdf).

An important feature of these models is that they are directly related to the real-world measurements. Unlike monitoring, however, modelling can help predict future concentrations by taking into account the projected changes in emissions over the coming years.

The maps produced by the modelling enable the UK to fulfil its European commitments to assess nationwide pollution patterns as part of 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.

For ozone, the Ozone Source-Receptor Model (OSRM) is used to create detailed maps of current and future ozone concentrations. This model (see Hayman et al http://www.airquality.co.uk/archive/reports/cat16/0604031524_ED47154_OSRM_Modelling_for_AQS_Issue1.pdf) explicitly represents the photochemical processes occurring in the atmosphere in the formation of ozone. This means it can be used to predict future ozone concentrations; this would not be possible using an empirical modelling approach.

The mapped air pollutant concentrations presented in this section are clearly subject to greater uncertainty than corresponding values derived directly from measurements made at monitoring sites. This is due to a number of factors including:

- Uncertainties surrounding the emission inventories
- Uncertainties relating to the atmospheric dispersion model
- Complexities of the atmospheric chemistry
- Uncertainties relating to the source apportionment of ambient concentrations; this is particularly important for PM_{10}, for which a number of the sources are not well characterised.

The mapped concentrations in Figures 27 to 30 have been verified by comparison with automatic monitoring data, including data from non-national network sites that are of known high quality.

All predictions of future concentrations are subject to additional uncertainty, including that associated with economic and energy forecasts, political policy decisions and possible changes in the behaviour of the atmosphere.

6.3 Maps of current and future levels

Maps showing current and projected concentrations for the future years of 2010 and 2020 for SO_2, NO_2 and PM_{10} are presented in figures 27-30. The projected maps have been calculated from a 2004 base year, rather than from 2005. These are the most up to date projections available. This means that the projected maps are not directly comparable with the 2005 maps, but they do give an indication of how concentrations are likely to change in the future.

SO_2

A map showing average SO_2 levels across the country in 2005 is shown in Figure 27a. 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.

Figures 27b and 27c show a similar geographical distribution of predicted average SO_2 levels for 2010 and 2020, with the impact of power station and industrial emissions still evident. These figures show a progressive decline in overall levels of this pollutant, due primarily to the expected reduced emissions from power stations and industry.

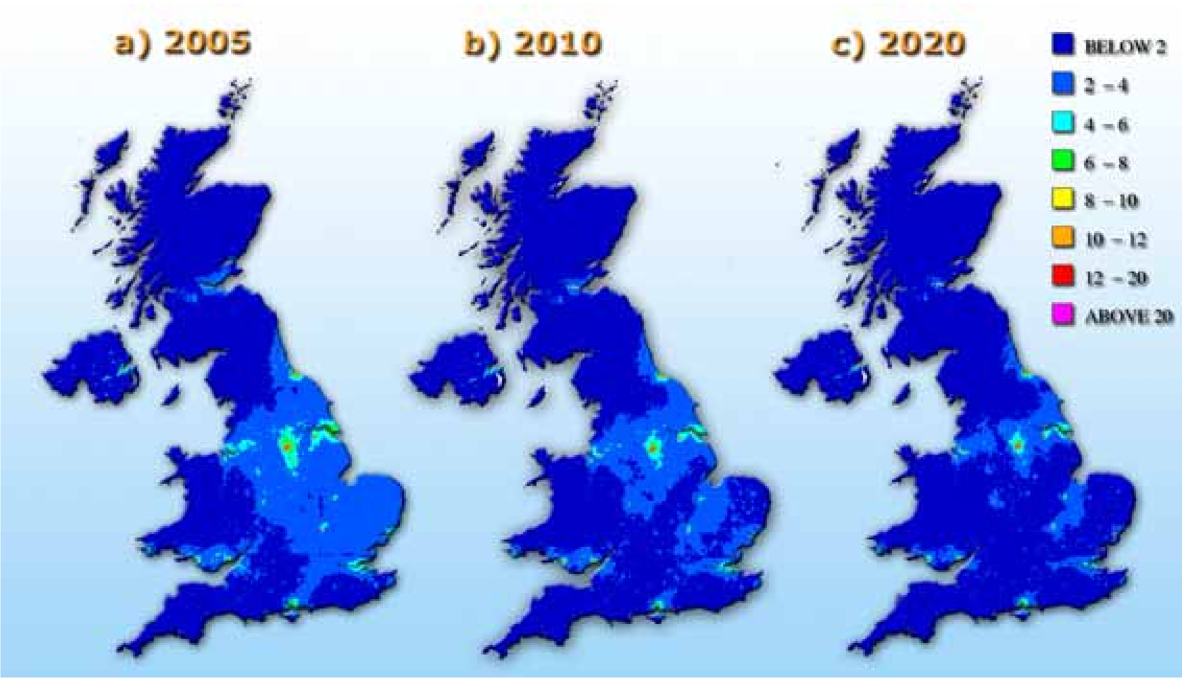


Figure 27 Background SO_2, annual average concentrations (µgm^{-3}), 2005-20

NO_2

UK-wide patterns of nitrogen dioxide concentrations in 2005 and predicted concentrations in 2010 and 2020 are shown in Figures 28a-c. These are markedly different from those of sulphur dioxide; although some NO_2 is emitted directly from vehicles or other sources, most is formed by rapid chemical reaction (oxidation of emitted NO) in the atmosphere. This pollutant therefore has both primary and secondary characteristics. Concentrations of NO_2 tend to be highest in urban areas such as in London, where traffic levels are high.

Although the data mapped in these figures are for background rather than roadside pollution levels, they clearly follow closely the country's major motorways and road network infrastructure. Concentrations in future years are expected to have a similar geographical distribution to concentrations in 2005, but to decrease with time. This reflects the fact that emissions from traffic are expected to decline over time.

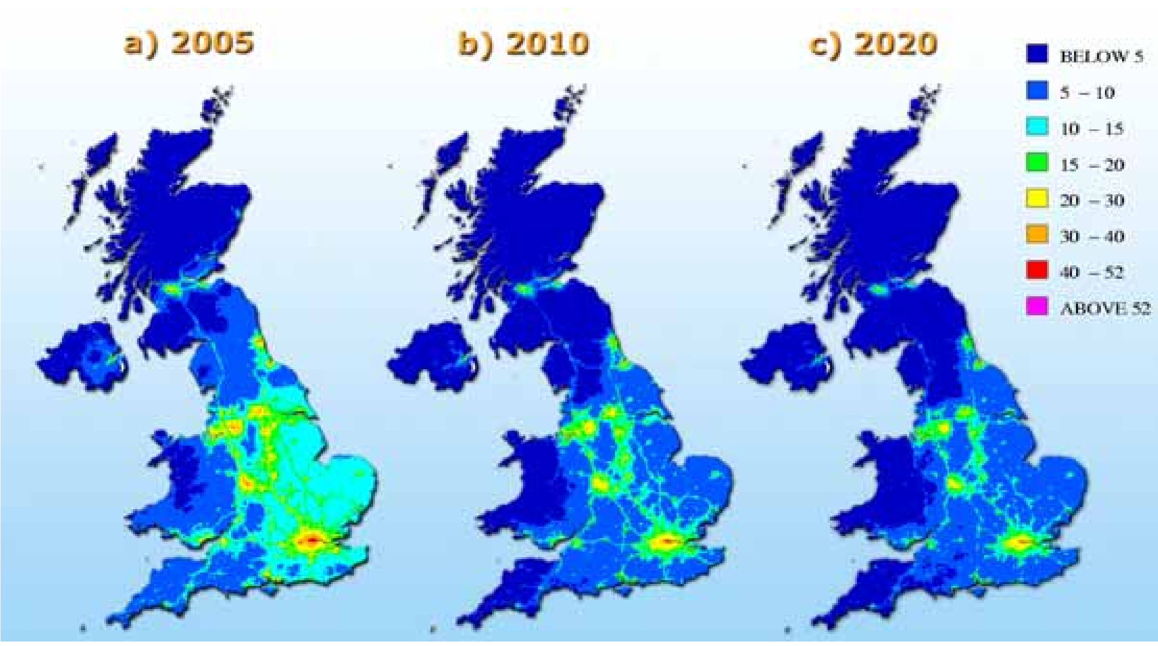


Figure 28 Nitrogen dioxide (NO_2) maps for 2005- 2020 (µgm^{-3})

PM_{10}

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 monitoring 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 primary 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. Sulphates and nitrates are formed by chemical reactions in the atmosphere from emissions of SO_2 and NO_x. Like ozone, secondary particles can therefore be produced considerable distances from the emission sources.

This diversity of PM_{10} source types and influences is reflected in the maps of average concentrations in Figure 29; these shows markedly less variation across the country than for the other pollutants assessed here. In terms of future PM_{10} levels, concentrations are predicted to decline in future years, reflecting declining emissions from the majority of significant sources of primary and secondary PM_{10}.

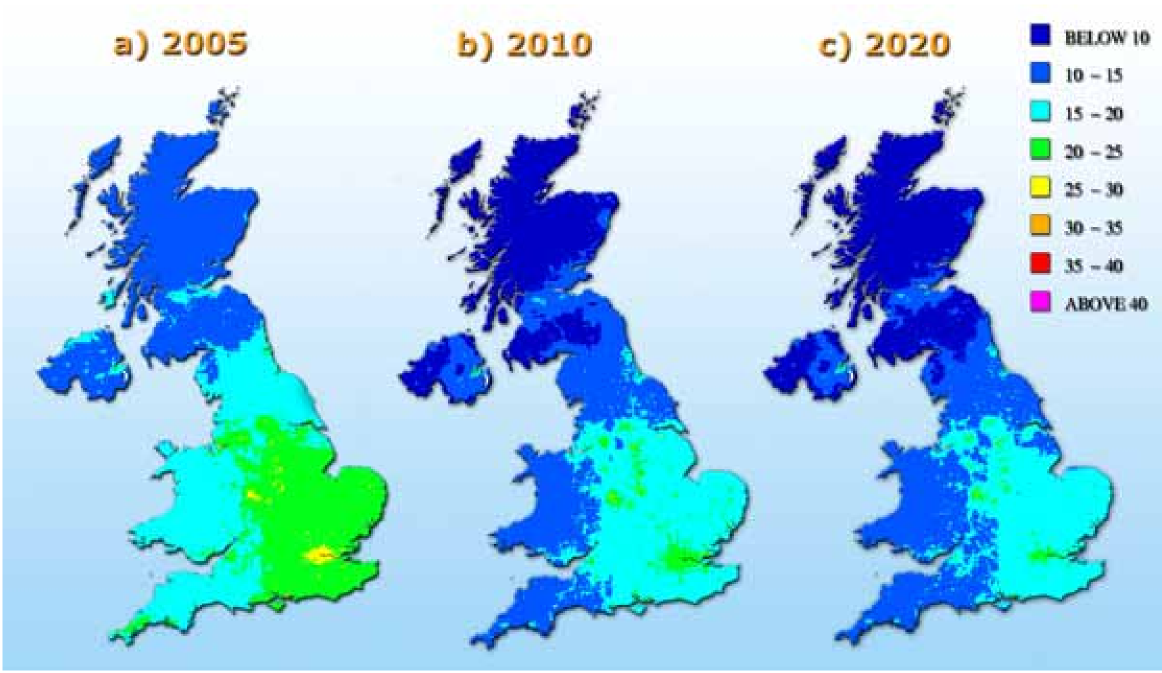


Figure 29: Background PM_{10} levels (μgm^{-3} gravimetric) for 2005- 2020

Ozone

UK-wide concentrations of ozone (expressed here as the accumulated hours above 80μg m^{-3}) in 2003 are shown in Figure 4. This way of expressing ozone has been chosen to represent the impact of this pollutant on vegetation. Values of this metric will be highest at locations with either higher average concentrations or where concentrations are elevated due to summer ozone episodes.

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 of NO react very quickly with ozone to generate NO_2.

The net result of these effects, acting together, is shown in Figure 30a, which shows ozone concentrations in 2003. 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.

Projected ozone concentrations, presented in Figures 30b and c, show that concentrations of this pollutant are generally expected to increase across the country in future years. By 2020, the highest concentrations are expected to remain in the South and southwest England, with lower concentrations in Scotland, Northern Ireland and more urban areas of England. This general projected increase in UK-wide ozone levels reflects a combination of i) predicted increases in hemispheric background ozone levels and ii) the continuing control of NO_x emissions from traffic.

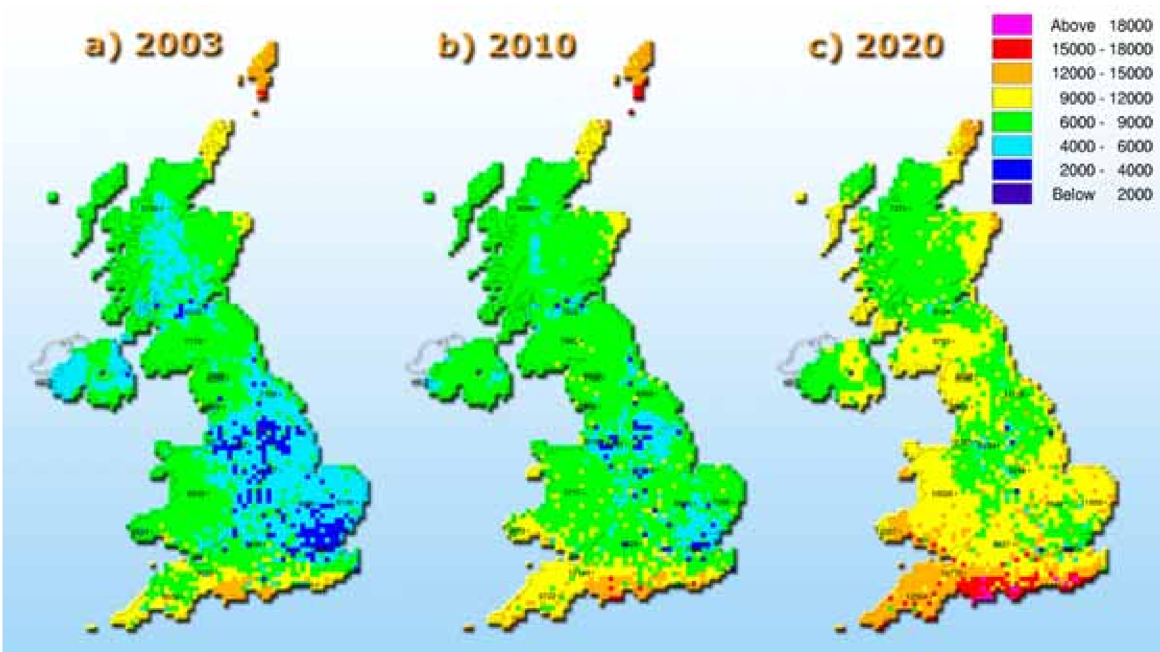


Figure 30. Accumulated ozone hours over 80 μgm^{-3} (μgm^{-3}.hours), 2003-20

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 clear-cut.

7.1 Introduction

The concentrations of different pollutants can vary markedly over many different time scales. Concentrations of primary pollutants (those directly emitted into the atmosphere) such as sulphur dioxide can fluctuate considerably in the short-term; these changes depend primarily on the magnitude, timing and distribution of their emission sources. By contrast, secondary pollutants (those that are created in the atmosphere), such as ozone, may vary more slowly over time as the chemical reactions that control their formation vary.

Changing air pollution concentrations can have important human health and other impacts, both the short and the long-term. In the short-term, air pollution episodes can trigger asthma attacks or exacerbate respiratory conditions in sensitive individuals. In the long-term, exposure to air pollution affects our quality of life and overall life expectancy.

In this section, we focus on examining long-term trends in UK air quality; these show how our overall exposure to harmful air pollutants is changing over time. Changes in our pollution climate are also important in assessing whether current regulations and controls on emissions are effective, or if new measures are needed at local national, or international level (see Section 3).

In this section, we examine the changing levels of air pollutants over many years and seek to answer the question "*is air quality improving or declining and to what extent?*" This involves an examination of black smoke and sulphur dioxide monitoring data extending back as far as the 1950s and 1960s, when air quality legislation and monitoring networks were in their infancy. More recent trends are examined in the context of:

1. The UK Government's new air quality indicators (Section 3.2) and
2. Assessing compliance with UK Air Quality Objectives (Tables 1 and 2)

7.2 Historic trends in black smoke & sulphur dioxide

Air pollution in the UK has changed significantly since the middle of the last century. The 1950s and 1960s were eras of industrial and domestic smogs that were closely associated with the emissions of black smoke (very fine particles) and sulphur dioxide from coal burning. Figure 31 presents monitoring data from the UK black smoke and SO_2 network. This network, which ceased operation this year (Section 4.3), was originally established in response to these serious smogs. It was one of the earliest examples of a national monitoring network in the world, comprising at its peak over 1200 monitoring sites.

Figure 31 shows how levels of both black smoke and SO_2 ('net acidity concentration') have dramatically declined since the inception of the monitoring network to around 2000. Since the turn of the century this long-term decline has flattened out, with current background levels of around 15 $\mu g\ m^{-3}$ SO_2 and 6 $\mu g\ m^{-3}$ black smoke. The marked decline in measured ambient concentrations has closely accompanied falling emissions of these pollutants; these, in turn, were strongly influenced by a number of factors.

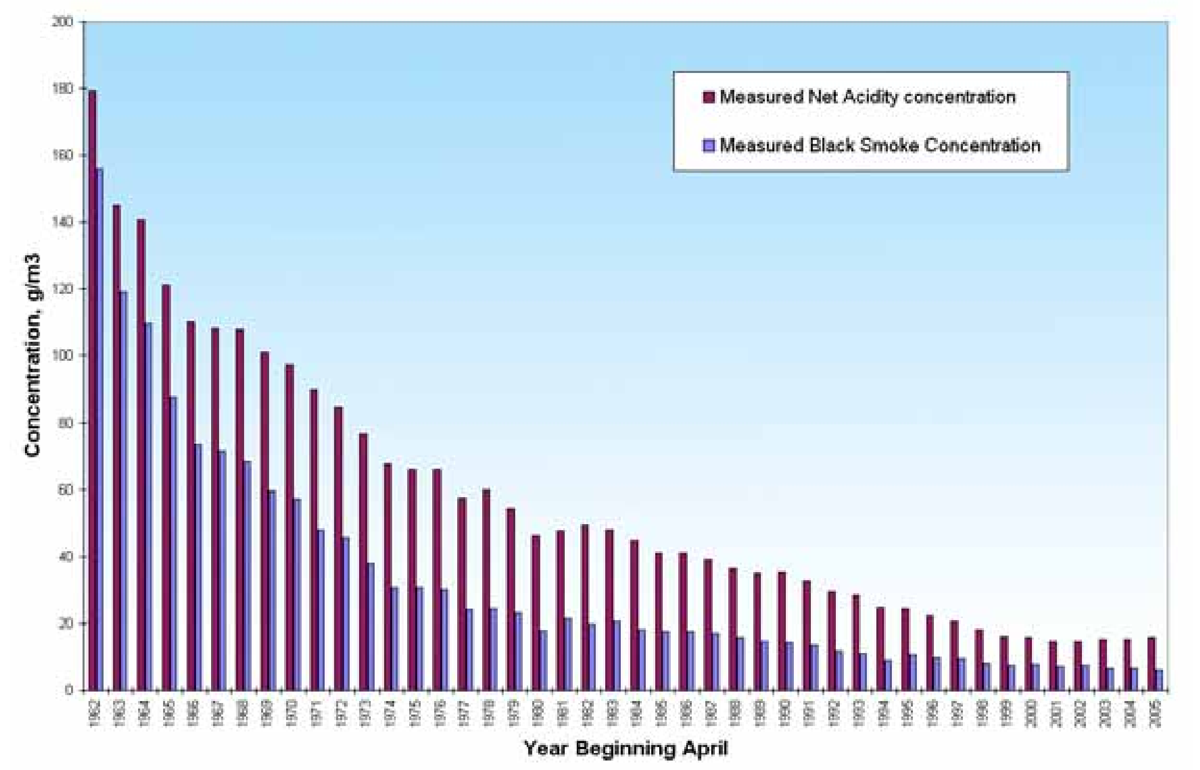


Figure 31 Trends in UK SO_2 and Black Smoke from the inception of the national monitoring network to 2005

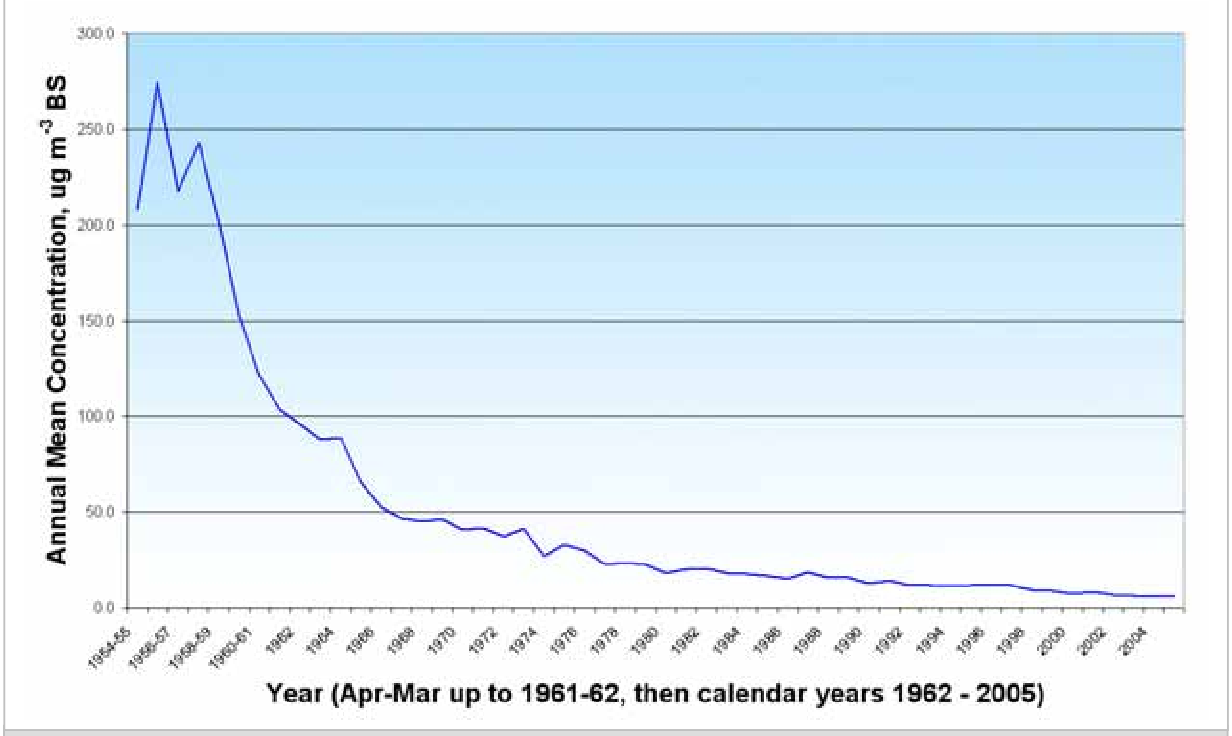


Figure 32 Decline in black smoke concentrations in London, including data from 1954 to 2005

These include:

- The move away from coal for domestic heating
- Tighter regulation of industrial emissions
- Adoption of cleaner fuels and improvements in fuel burning technologies.

Most notable among these controlling factors, however, has been the strict enforcement of smoke control measures in industry through a succession of Clean Air Acts from the early 1950s onwards.

The immediate impact of this legislation is shown in Figure 32. This may be viewed as broadly equivalent to Figure 31, but covering an even greater period of time; in fact, this includes black smoke monitoring data gathered before the formal establishment of the national black smoke and SO_2 network. It is important to realise that this graph is based on fewer monitoring sites than the network data from 1962 onwards; however, it shows even more clearly the precipitous fall in smoke levels in London from 1954 onwards. In fact, the steepest decline actually occurred from 1957 to 1960, before the network was even established.

Despite the success of legislative controls and the decline in SO_2 and black smoke, the UK has a broad range of air quality concerns that are still being addressed today. The establishment of automatic air quality monitoring networks in the early 1970s allowed us to track ambient levels of a much wider range of pollutants across the UK. The national networks have expanded substantially in the 1990s, and this extended monitoring has enabled us to:

- Analyse pollution trends in more detail
- Highlight important differences between rural and urban areas
- Assess variations in different pollutants across different regions of the UK (see Section 6)
- Determine key relationships between interrelated pollutants, particularly secondary pollutants.

Industrial pollutants are now extensively regulated throughout the UK. However, pollutants associated with traffic have typically increased as a result of rising numbers of road vehicles; these reached a maximum in the early 1990s. Concentrations of traffic-related pollutants have - since then - broadly declined as a result of the progressively tighter regulations (Euro Standards) applying to the emissions from road vehicles.

As medical research continues to identify and quantify the risks of air pollution to human health, increased importance is now being attached to pollutants such as NO_2, ozone and, especially, particulate matter. It is with these risks to health in mind that the Government has established a new range of air quality indicators (Section 3.2); these have been designed to simply present monitoring data from the national network and help assess resulting public health impacts over time.

The indicators for Air Quality and Health provide two measures of how the air quality has changed in the period from 1990-2005.

7.3 Pollution indicator 1- PM_{10} and ozone

The first of these indicators, graphed in Figure 33, is a new statistic that shows trends in the levels of two specific pollutants, ozone and particulate matter (PM_{10}). These pollutants have been given special prominence in this indicator because they are now believed to pose the most significant threats to public health through long-term exposure.

Figure 33 shows that annual average PM_{10} levels have been decreasing since the early 1990s, although the trend appears to be levelling off in more recent years. There is a very slight upward trend in background ozone levels. Ozone levels appear to be stable in rural areas while, at the same time, there has been a marked increase in urban ozone.

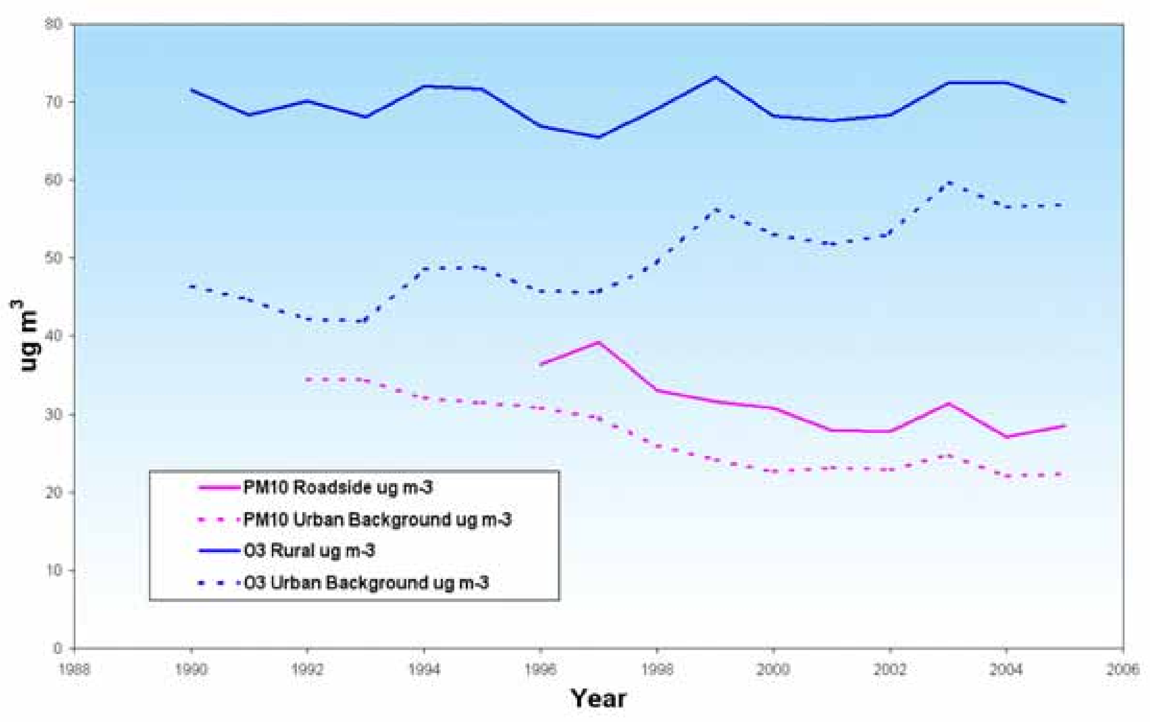


Figure 33 Trends in Air Pollution Indicator 1- gravimetric PM_{10} annual mean and ozone annual mean of the daily maximum running 8-hour mean, 1990-2005.

This rise of ozone levels in urban areas has been attributed to reductions in urban emissions of nitrogen oxides (NO_x) from road traffic leading to diminished 'scavenging' of ozone by chemical reaction. This, in turn, is a consequence of cleaner fuels and improved engine technologies. This shows that levels of pollutants - especially secondary pollutants formed in the atmosphere –can often be inter-related; as a result, measures to control one can sometimes have wider effects which are not always wholly desirable.

7.4 Pollution indicator 2- number of moderate or higher air pollution days

The second of the UK Government's air quality indicators has been established for several years and analysed in detail in earlier reports in this series. This is based on the average number of days per site on which pollution levels were above the UK's 'moderate' air quality band, as defined in Section 3.2 (Box 1). These bands represent defined levels associated with different levels of health risk. When air pollution is 'moderate', sensitive people may notice mild effects, but these are unlikely to need action. When levels enter the high band, sensitive people may notice significant effects and may need to take action.

Figure 34 shows how the number of moderate or greater air pollution days in the UK has changed over the period 1990 - 2005. The number of such days at urban sites has declined significantly since 1993, with the exception of a notable peak in 2003. The weather can cause significant variation from year to year in the number of days of moderate or higher air pollution. 2003 stands out in this analysis because of its unusual weather conditions, which were discussed in detail in our 2003 report.

During the spring of 2003, there were regular easterly winds bringing continental air pollution to the UK. This was followed during the summer months by exceptionally hot weather; this in turn led to series of photochemical ozone episodes and the high number of pollution days shown in Figure 34.

The number of rural high pollution days in Figure 34 shows no clear trend; this is mainly because the pollutant causing most problems here is ozone. As highlighted earlier, this is a secondary pollutant which is a much more difficult to control because it has no direct emissions sources to regulate. Although we cannot control the weather- the main influence on this pollutant - the Government is working at international level to reduce emissions of the pollutants that lead to ozone formation.

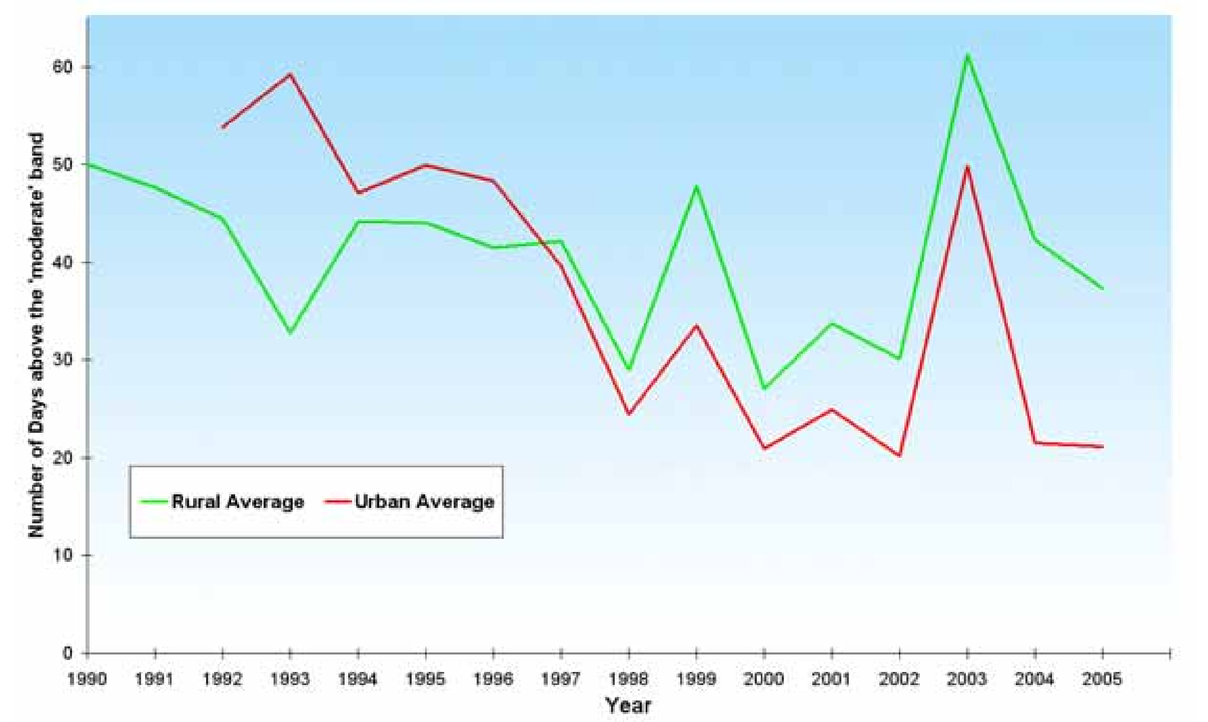


Figure 34 Trends in the number of days exceeding the 'moderate' air quality band from 1990- 2005.

7.5 Nitrogen dioxide trends

Excepting particulate matter and ozone, the pollutant of most concern in urban areas is now nitrogen dioxide (NO_2). This is both a primary pollutant (directly emitted from road vehicle exhausts) and a secondary pollutant (created by the same chemical reactions that are responsible for ozone formation). Unfortunately, the controls put in place to limit pollutants from road vehicles do not appear to be controlling levels of NO_2 as much as expected; this issue is one that is currently occupying the minds of scientists and policy-makers worldwide. For much more on this see, for example, the recent AQEG report at www.defra.gov.uk/environment/airquality/aqeg/reports.htm.

Legislation applied to vehicle manufacturers has targeted emissions of nitrogen oxides (NO_x), of which NO_2 is a component part; however, there have been no specific controls on NO_2 emitted from vehicles. Recent evidence from roadside monitoring sites in the UK suggests that, although NO_x levels have been declining, NO_2 levels remain either stable or may even be increasing in recent years. Figure 35 illustrates trends in annual mean NO_x and NO_2 between 1998 and 2005 at a selection of roadside and kerbside monitoring sites. While most of the sites show a decline in NO_x, NO_2 concentrations exhibit for the most part little change or even – in the case of the extremely traffic-intensive London Marylebone Road - an increase over time.

Figure 36 shows this trend even more clearly, by illustrating that the NO_2/NO_x ratio has increased at some sites by more than would be expected due to the decrease in NO_x on its own. At Glasgow Kerbside, the proportion of NO_2 in NO_x is relatively flat whilst, at other sites, the NO_2 to NO_x ratio is increasing. Recent emissions inventory calculations are consistent with these observations; these suggest that the proportion of NO_x emitted as NO_2 has increased from 11% to 14% between 2002 and 2005 across the UK and from 15% to 20% in Central London. These changes are thought to have resulted from the increase in the proportion of diesel vehicles on the roads, together with the exhaust after-treatment technologies employed.

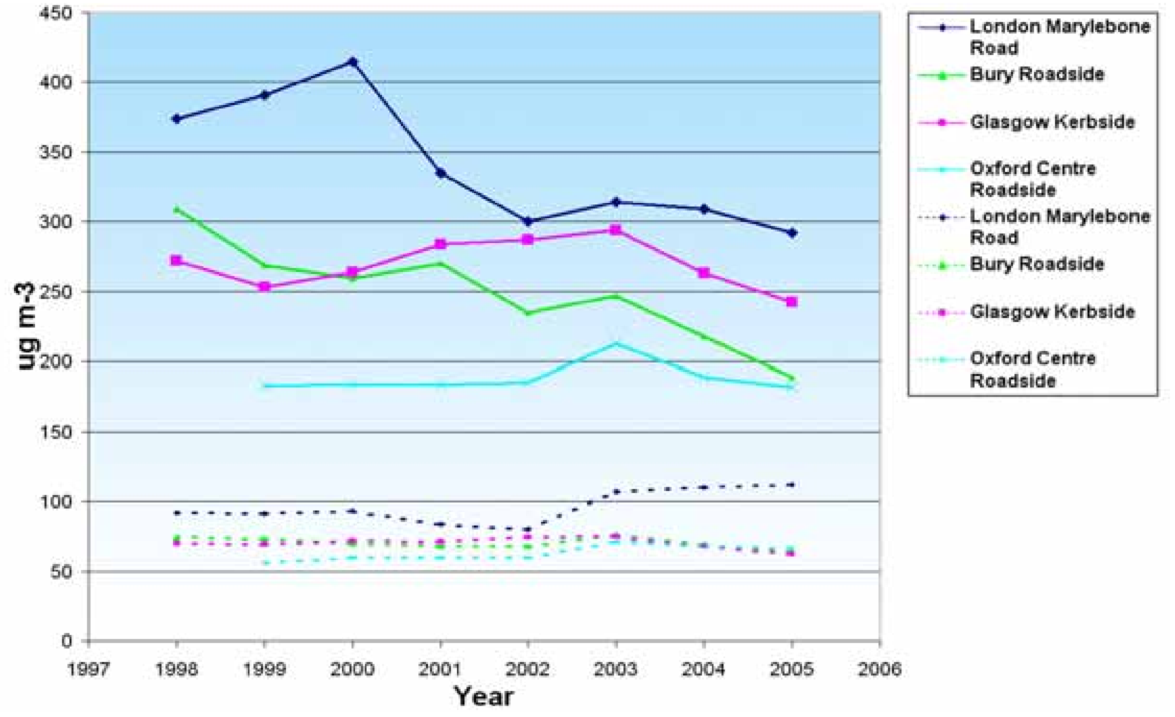


Figure 35 Annual mean NO_x (solid lines) and NO_2 (broken lines) at selected national network roadside and kerbside monitoring sites ($\mu g\ m^{-3}$).

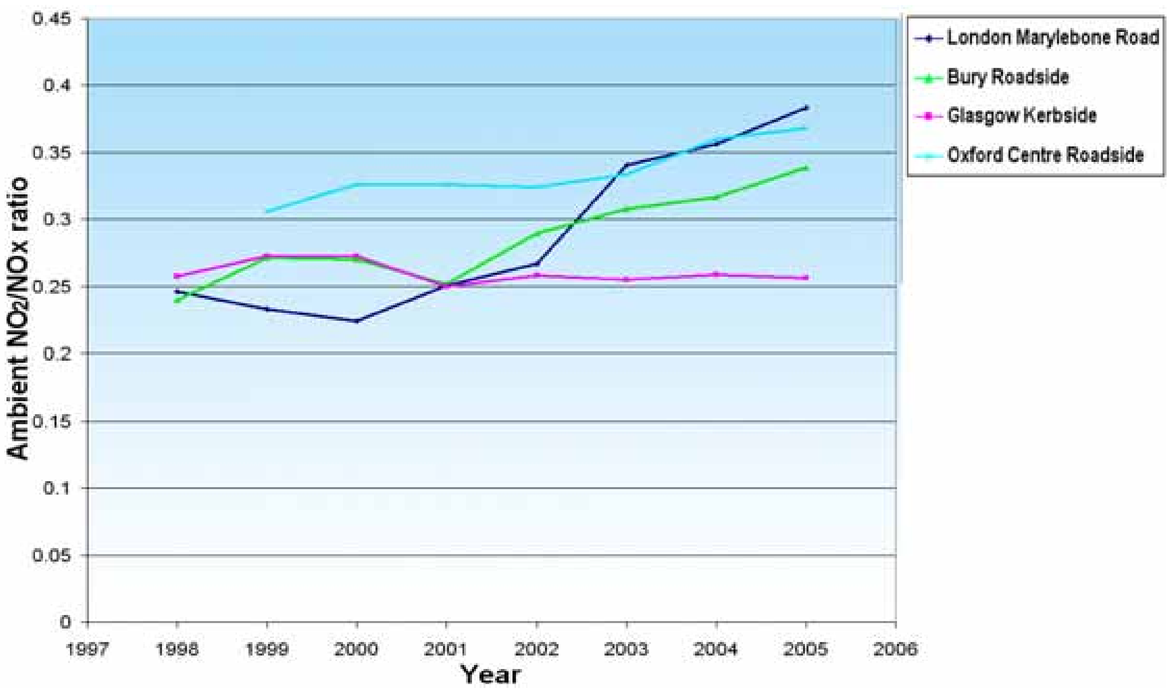


Figure 36 Ambient annual mean NO_2 / NO_x concentration ratios at selected national network roadside and kerbside monitoring sites.

7.6 Comparison with UK Objectives

Each 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 for 2005 are summarised in Figures 37 and 38.

In Figure 37 (a so-called ‘box and whisker plot’) 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 2005 compares with the relevant national objective, whilst the blue line show how the ‘worst’ site compares with that objective. The methodologies utilised to produce Figure 37 are discussed in greater details in Appendix 6.

Figure 37 shows clearly that some pollutants – notably benzene, carbon monoxide and sulphur dioxide - are largely under control. By contrast, levels of other pollutants - Benzo-a-Pyrene [BaP] NO_2, ozone and PM_{10}- currently exceed their respective objectives at some locations. Of particular concern is PM_{10}, because the average of the sites (rather than just the highest concentration) is above the 2010 provisional objectives.

Figure 38 presents time series analyses for specific examples of pollutant objectives including BaP, NO_2, ozone and PM_{10}. The average and maximum concentrations are presented in $\mu g\ m^{-3}$, not as percentages of the objective value. These graphs show how levels are changing over time in relation to each objective.

Figure 38a indicates that BaP concentrations are on average close to the objective; there may also be a slight downward trend. The maximum concentration measured for BaP is significantly above the objective value and does not show any indication of falling. The highest BaP concentration was recorded at Scunthorpe, where industrial emissions are known to make a substantial contribution.

The annual mean NO_2 objective is presented in Figure 38b. This shows that average concentrations across the network are declining slightly and are now below the objective; this trend looks set to continue. However, it is not all good news for this pollutant; as discussed earlier in this section, the highest concentrations are actually steadily increasing at several roadside monitoring sites.

Both maximum and average ozone concentrations (Figure 38c) have risen slightly over the last decade and it is likely that these will both exceed the objective value in the next few years. It has been suggested that background levels of ozone are increasing in the northern hemisphere; moreover, climatic change is predicted to result in longer summer seasons with increased sunshine intensity; this will further accelerate the chemical reactions that create ozone. It should be noted that the increase in average ozone concentration measured across the network also reflects the changes observed in urban areas as a result of tighter control of NO_x emissions, as discussed in Section 7.4.

Figure 38d shows corresponding trends in average and maximum PM_{10} when compared against the daily objective. It shows a slight decline in average levels; however, the highest levels remain above the objective and have not decreased significantly in recent years.

Both the time series plots for ozone and PM_{10} (Figures 38c and 38d) clearly show the unusually high concentrations of these pollutants measured in 2003.

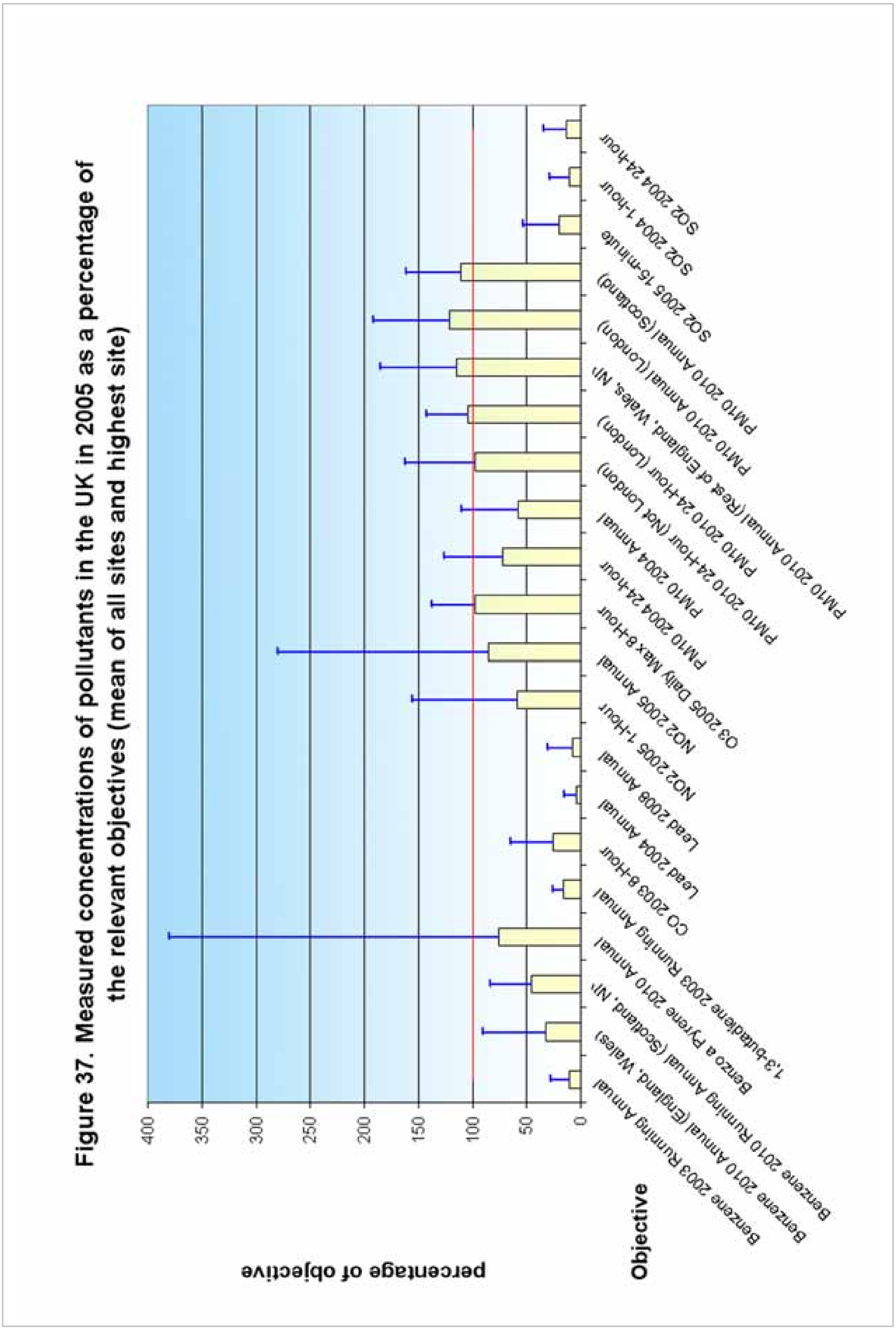


Figure 37. Measured concentrations of pollutants in the UK in 2005 as a percentage of the relevant objectives (mean of all sites and highest site)

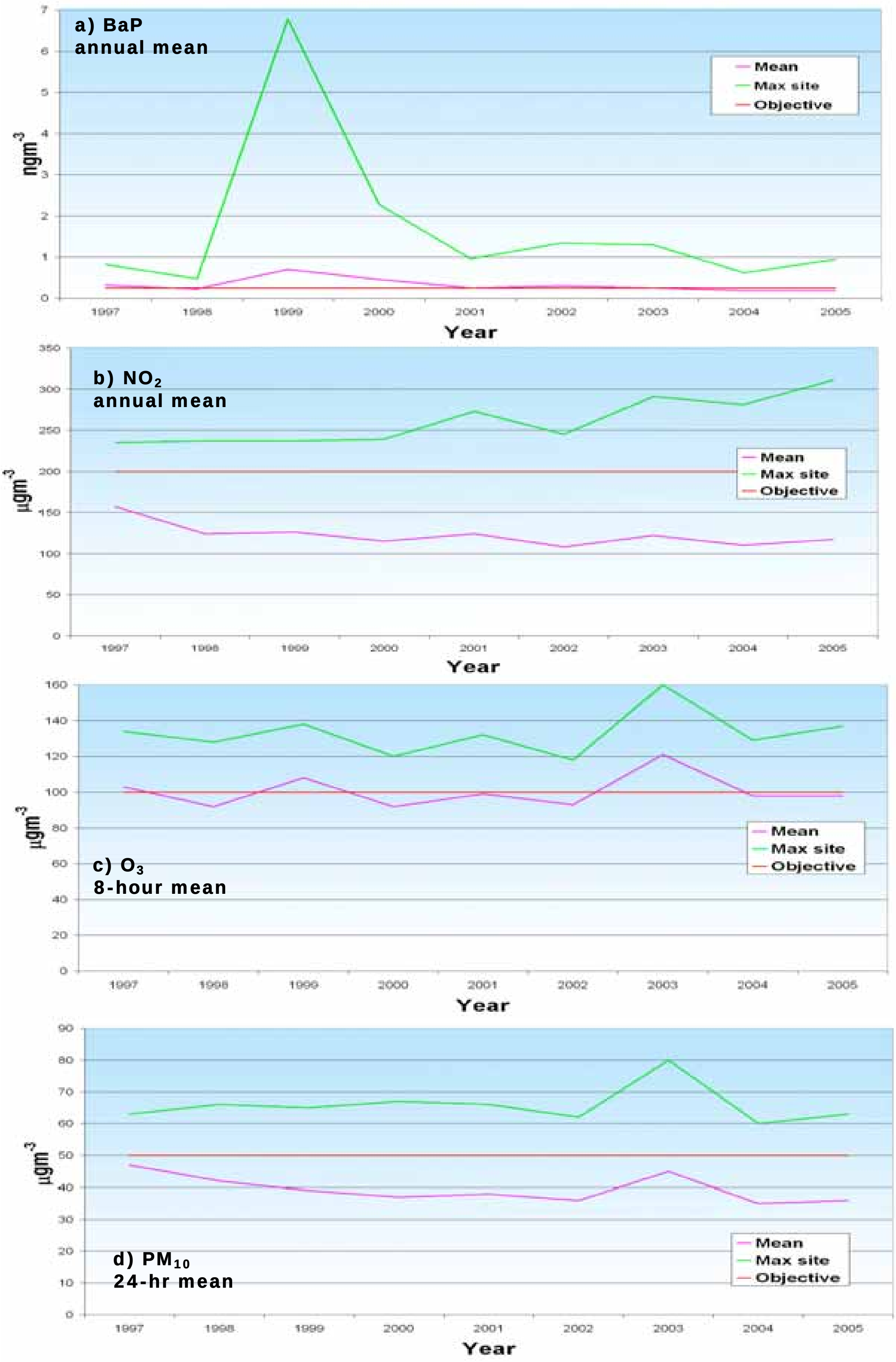


Figure 38 a) to d) Trends from 1997 to 2005 in mean and maximum measured site concentrations for four selected pollutants against corresponding UK AQS Objectives

8. Social aspects of UK air pollution

Which communities are most affected by air pollution? Here we examine the UK-wide distribution of air pollution, and assess whether more deprived of our communities experience the highest levels of pollution.

In recent years, there has been increasing recognition of the importance of identifying and tackling environmental inequalities. An environmental inequality arises where one community's access to a certain standard of environmental quality differs from another. This can be measured by assessing the different levels of air pollution, water quality, proximity to industrial facilities, noise levels or access to green spaces experienced by different communities.

A commonly held view is that it is the most deprived areas that tend to suffer the worst environmental quality; this may be due to such circumstances as:

- Living near areas with high levels of industrial pollution, or waste sites,
- Living in inner city areas close to major roads with high traffic densities
- Having limited access to areas of high environmental quality.

In this section, we examine whether this is true. In particular, we summarise the findings of a recent wide-ranging report prepared for Defra and the Devolved Administrations[46] to assess the issue of environmental inequalities associated with air quality. The main focus in the report is on assessing whether poorer communities live in areas of the UK with the highest levels of air pollution. We address the same key question in this section, together with a range of other issues associated with the linkage between air quality and social deprivation in Britain today.

8.1 Do the most deprived communities experience the worst air quality?

Our analysis has focussed on comparing the levels of air pollution across all part of the UK with levels of multiple deprivation experienced by different communities.[*] The objective of the analysis was to understand whether deprived communities experienced worse air pollution compared to other communities, and statistically examine that level of inequality.

Figure 39 shows the resulting comparison for each constituent country of the UK between the level of pollution, as measured in terms of NO_2, and the level of deprivation. Similar patterns are seen if we substitute PM_{10} for NO_2. Figure 39 shows that, across all countries, the most deprived communities (deciles 1-3, the 30% of the population that is most disadvantaged) experience higher than average pollution. In addition, in England, Northern Ireland, and Scotland, it is clearly the most deprived communities that experience the highest pollution levels. In Wales, by contrast, this is not the case; it is the least deprived communities that experience the highest pollution levels.

The main reason for these observations is that, for most of the UK, areas with the highest levels of deprivation tend to be urban. In those same areas, concentrations of most pollutants except ozone are highest (primarily as a result of emissions from road

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[*] *Deprivation here refers to unmet needs due to a lack of resources, whether that be in terms of income, employment, education or housing. Multiple deprivation is a combined measure of all of these different types of deprivation.*

transport and - in Northern Ireland - solid fuel burning). In Wales, a different pattern is observed. There tends to be a higher proportion of deprived communities in less densely urbanised locations (such as South Wales valleys), and relatively fewer deprived communities in the main urban centres of South Wales. The location of the most deprived areas (decile 1) in Wales are shown in Figure 40; it is clear that areas of highest pollution tend to be in the urban centres of the south.

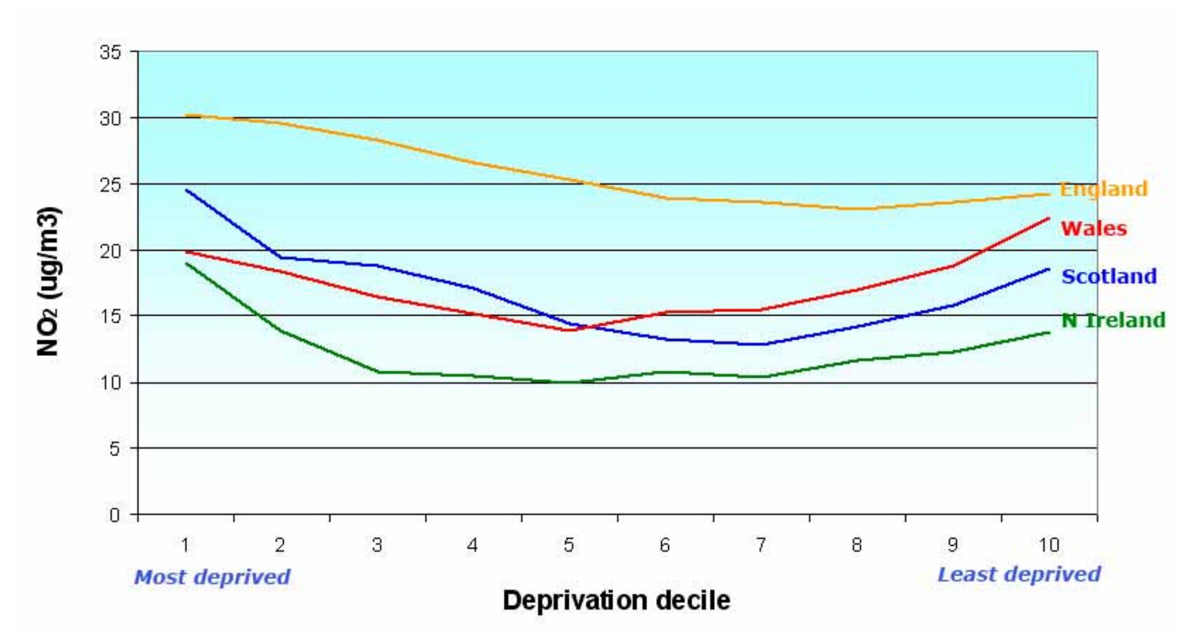


Figure 39. Mean concentrations of NO_2 by decile and country, 2003

Country	*England*	*Scotland*	*Wales*	*NI*
Average µg/m³	25.86	16.86	17.30	12.34

In all parts if the UK except Wales, the most deprived communities experience the highest average levels of air pollution (as measured both by NO_2 and PM_{10}). The pattern will be different for ozone, of course- see Section 6.3. However, Figure 39 also shows that the least deprived communities, often located in urban centres, also experience higher than average pollution levels. This suggests that inequalities can also be found even in areas of relatively low deprivation.

The inequalities experienced by the most deprived communities are even more pronounced if the most polluted areas of the UK are considered in isolation. Such an analysis helps us to understand which communities are located in areas of highest air pollution, and whether the population in such areas is disproportionately deprived. The analysis suggests that the most deprived communities account for the majority of the population living in the 10% most polluted areas (as measured by concentration levels of NO_2 and PM_{10}).

In England, over 70% of the population living in the most PM_{10} polluted areas is categorised as being in the most deprived deciles (1-4). In Scotland, the equivalent figure is over 60%. In Northern Ireland, it is the most deprived communities (decile 1) that account for almost half of the population living in these high pollution areas. A similar pattern can be seen for the NO_2 analysis. However, for the reasons already discussed, this pattern is not evidenced in Wales.

In summary, inequalities in access to a given standard of environmental quality, in this case measured by levels of air pollution, exist across many parts of the UK. The most deprived communities are more likely to experience higher levels of pollution than the rest of the population. The least deprived communities also experience above average pollution levels (except in England). In the most polluted areas, a disproportionate section of the community also experiences high levels of deprivation.

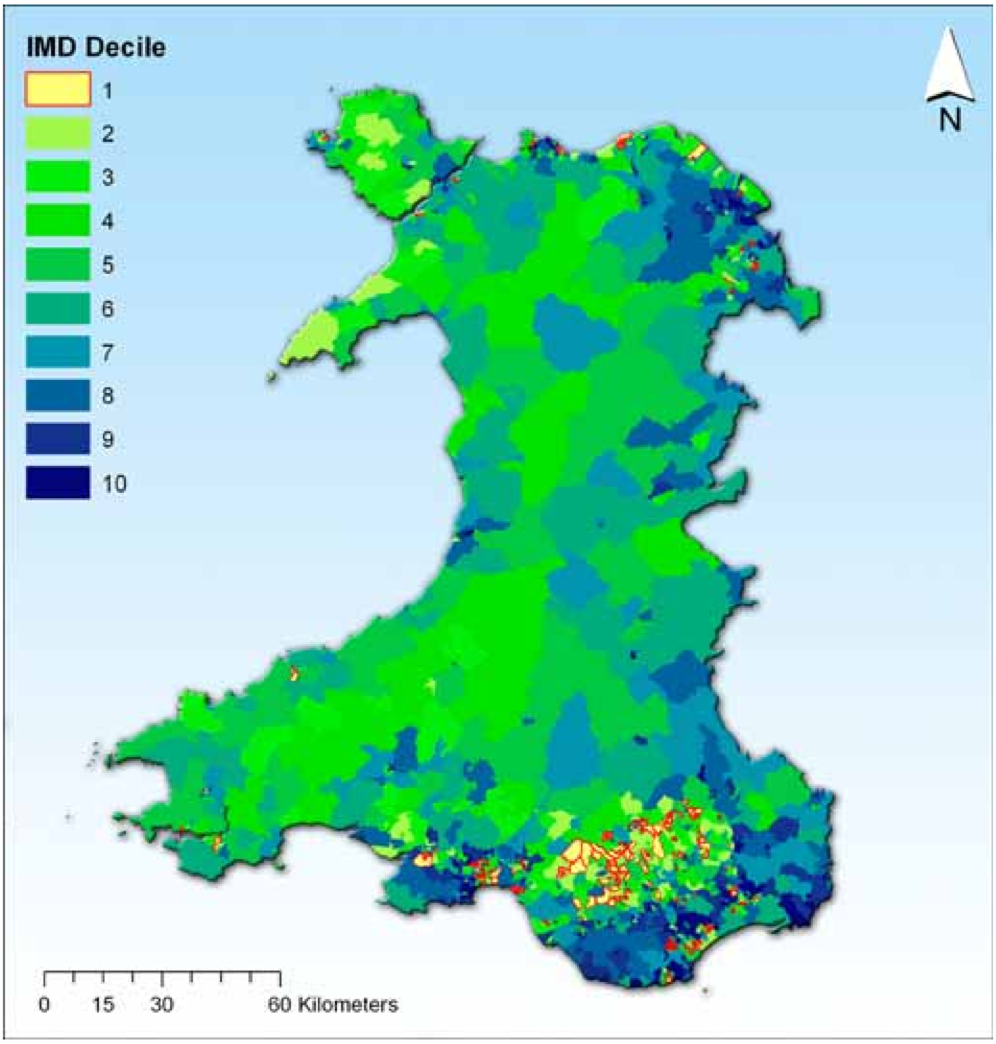


Figure 40. Levels of deprivation in Wales by super output area *(based on NAW (2005), Welsh Index of Multiple Deprivation 2005, National Assembly for Wales, Cardiff*

8.2 In future years, do the most deprived communities continue to experience the worst air quality?

For policy makers to address the issue of environmental inequalities, it is important to understand the current effectiveness of policies at the national and local level designed to reduce inequalities. We have therefore assessed the projected level of inequalities across the UK in 2010, relative to the modelling baseline year of 2003 [47]. This is a complex analysis, with some significant uncertainties associated with the modelled pollution data for 2010, together with the representation of current and future policy measures.

Nevertheless, Figure 41 shows the percentage of the population in areas of England where PM_{10} concentrations are predicted to be greater than 25 µg/m^3 in 2003 and 2010. The level of inequality is shown to be greater in 2010, with a steeper trend line observed; this suggests a higher proportion of more deprived communities in high pollution areas in future years. It also indicates that current inequalities – as shown in Figure 39 – may worsen in the future. The corresponding NO_2 trend shows a persistence of inequalities but not a worsening for that particular pollutant.

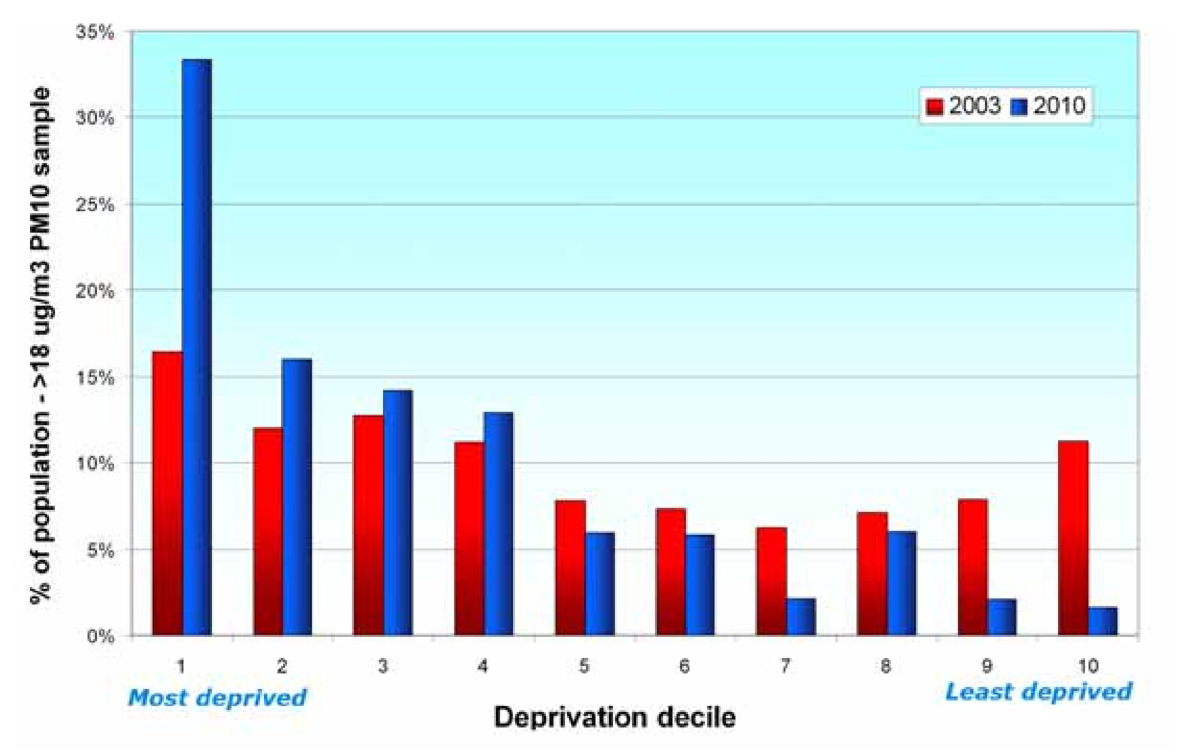


Figure 41. Distribution by decile of population in England in areas where PM_{10} >25 µg/m^3 in 2003 and 2010 (Population in sample - 11,808,185 in 2003 and 1,046,288 in 2010)

What is important to stress here is that the **total** population living in areas of high pollution significantly declines in future years, highlighting the predicted success of UK policy in reducing the number of people living in areas of high NO_2 and PM_{10} air pollution. However, while UK Government strives to improve air quality across the board, there is still an important issue to recognise over the coming years - continuing inequalities faced by the most deprived communities.

8.3 How important are AQMAs in addressing the inequalities faced by deprived communities?

As discussed in Section 3.3, Air Quality Management Areas (AQMAs) are an important local measure for tackling areas of high pollution. These are often located in urban areas where both air pollution levels and levels of deprivation are high. The emission controls introduced in such areas may therefore be important in reducing air pollution, together with some of the inequalities described earlier.

An analysis has been undertaken to assess whether populations covered by AQMAs in England are more deprived than the UK population as a whole and, in particular, whether they cover high pollution-high deprivation areas where inequalities are greatest. Figure 42 shows the areas of deprivation in some of the major English urban areas relative to AQMA location.

The analysis concluded that English AQMAs have disproportionately more deprived communities than England as a whole. This adds to the weight of evidence that deprived communities are likely to be in areas of higher pollution. It also suggests that AQMAs may provide a powerful tool for helping to address inequalities, by disproportionately benefiting more deprived communities; this would be based on the assumption that they would successfully tackle the identified air quality problems across the entire AQMA.

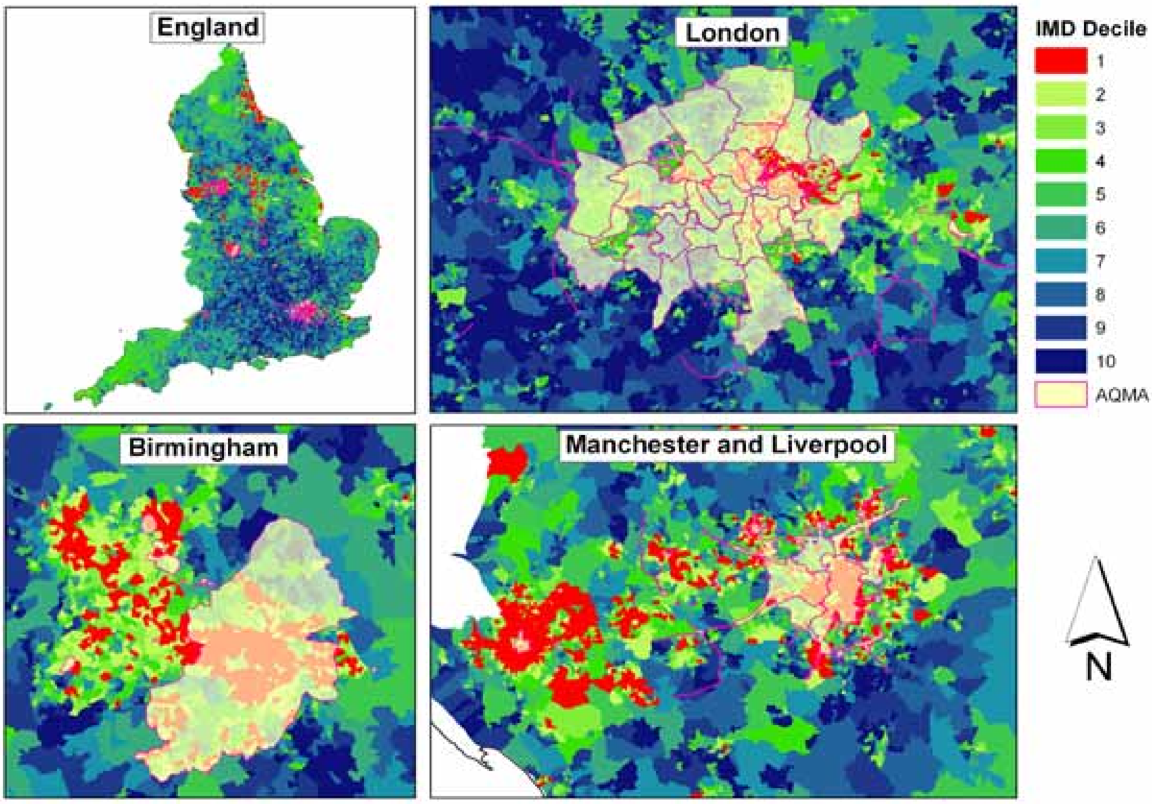


Figure 42. AQMA location in selected English urban areas classified by deprivation deciles

AQMAs may also be an important measure for addressing the high pollution-high deprivation areas, where inequalities are most significant. Almost 2000 distinct areas were identified in England that had both high pollution (as measured by NO_2) and deprivation levels. AQMAs are shown to cover or part cover approximately 80% of these areas.

This analysis indicates that AQMAs offer an important policy instrument, already in place in England, to reduce concentrations in urban areas where a significant number of deprived communities with high concentrations are located.

8.4 Are the inequalities experienced by deprived communities further compounded by their increased susceptibility to air pollution impacts?

This section has shown that air quality inequalities do exist in the UK, with the most deprived communities often experiencing the worst air pollution. A further issue is whether such inequalities may be made worse if deprived communities are more susceptible to health impacts associated with air pollution. If they are, for an equivalent level of pollution, the most deprived communities would then experience worse impacts than a less deprived community.

Understanding population susceptibility to health impacts associated with air pollution is extremely difficult, as this will be affected by many factors. These include the state of general health of the community (often determined in part by lifestyle factors such as diet, level of exercise, and smoking) and the daily exposure to different pollutants (influenced by factors such as daily patterns of movement, housing conditions, and work environments).

One important factor influencing susceptibility, that is easily measured using available data, is age. This is recognised in most health impact assessments as an important element in determining certain health impacts, with the young and elderly often considered the most susceptible. We have therefore assessed whether deprived communities had a higher proportion of elderly or young populations.

As shown in Figure 43, it is clear that a greater proportion of children live in areas of higher deprivation than in areas of lower deprivation. However, the opposite is true for the elderly. Therefore, based on age, it is not possible to say that one type of community is more susceptible than another, as the most deprived communities are likely to have a higher young but lower elderly population).

An important finding that does emerge from this analysis, however, is that the young are more likely to live in areas of high deprivation, and in areas of high pollution (as measured by NO_2 and PM_{10}). Therefore, as a population group, they experience higher levels of inequality than other population age groups.

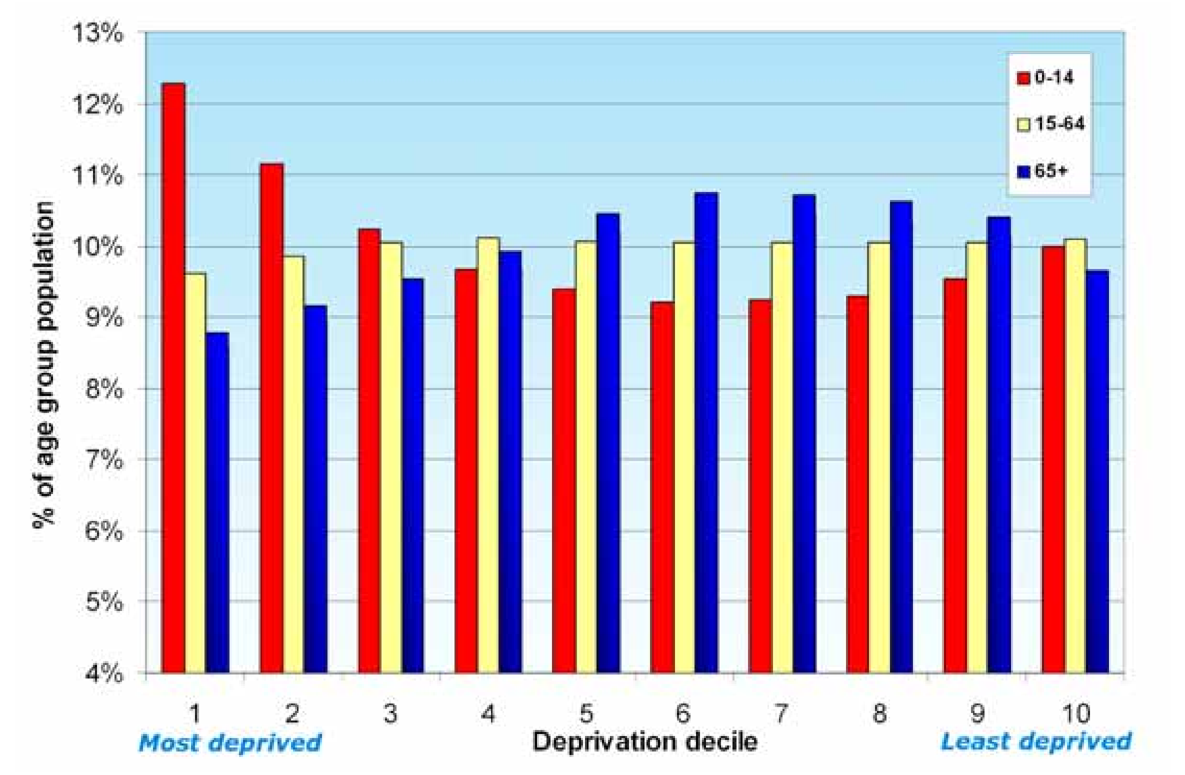


Figure 43. Percentage of age group by deprivation decile in England

The issue of susceptibility, and how it could result in increased inequalities, is very important. More research is needed in this area to better understand:

- Whether certain communities are more susceptible
- The complex issues surrounding exposure and different human responses to pollution levels
- The role of susceptibility in determining the level of inequalities.

8.5 How important do the Government consider the issue of environmental inequalities?

Over recent years, the issue of environmental inequalities has been seen as an increasingly important policy area across Government. The UK Sustainable Development Strategy[48] has identified the issue of environmental inequalities as a priority area for attention. The importance of the issue is highlighted by the following quote in the Strategy, taken from a report by the Sustainable Development Research Network:

> *'Poor local and environmental quality and differing ease of access to environmental goods and services have a detrimental effect on the quality of life experienced by the deprived communities and socially excluded groups and can reinforce deprivation if not tackled alongside access to employment, health and tackling crime[49].'*

In other words, the environmental quality we all experience contributes to our quality of life, and can have an important impact on deprivation levels. In recognition of this problem, the Strategy goes on to state that

> *'The Government will fund further research on the causes of environmental inequality and the effectiveness of measures to tackle it in order to establish the best ways to tackle these issues in communities.'*

The analyses presented in this section[46], funded by the Office for National Statistics (ONS) and the Department for Communities and Local Government (DCLG), add to the growing literature in the UK on environmental inequalities. Such an evidence-base will be vital in future:

- Firstly, in establishing whether or not inequalities exist and to what extent, and
- Secondly to enable us to develop effective policies and regulations designed to reduce inequalities

Air Pollution in the UK: 2005

Part 2

In this part of the report, we provide a detailed summary of the measurements made for each pollutant within the Automatic Urban and Rural Network (AURN) and Automatic Hydrocarbon Network. We also present information on measurement techniques, site locations and relevant UK, European and WHO pollutant criteria.

We then provide for each pollutant a table summarising measurements and exceedences of the UK Air Quality objectives during 2005. Finally, we include graphs to show variations in pollutant concentrations throughout the day and over the year as a whole, as well as time series showing long-term changes in concentrations over many years.

9. Benzene-Measurement Sites, Instrumentation and Statistics

9.1 Measurement Method

Benzene is measured using automated Gas Chromatograph or BTEX monitors; these measure concentrations of benzene, toluene, ethylbenzene and xylene isomers as well as 1,3-butadiene. This type of instrument uses an adsorption tube for sample collection.

9.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Environnement VOC 71M
- Perkin Elmer OPA

*Defra does not give approval or endorsement for any products or equipment

9.3 Data Quality Requirements of EC Directive 2000/69/EC

Uncertainty 15%
Minimum data capture 90%

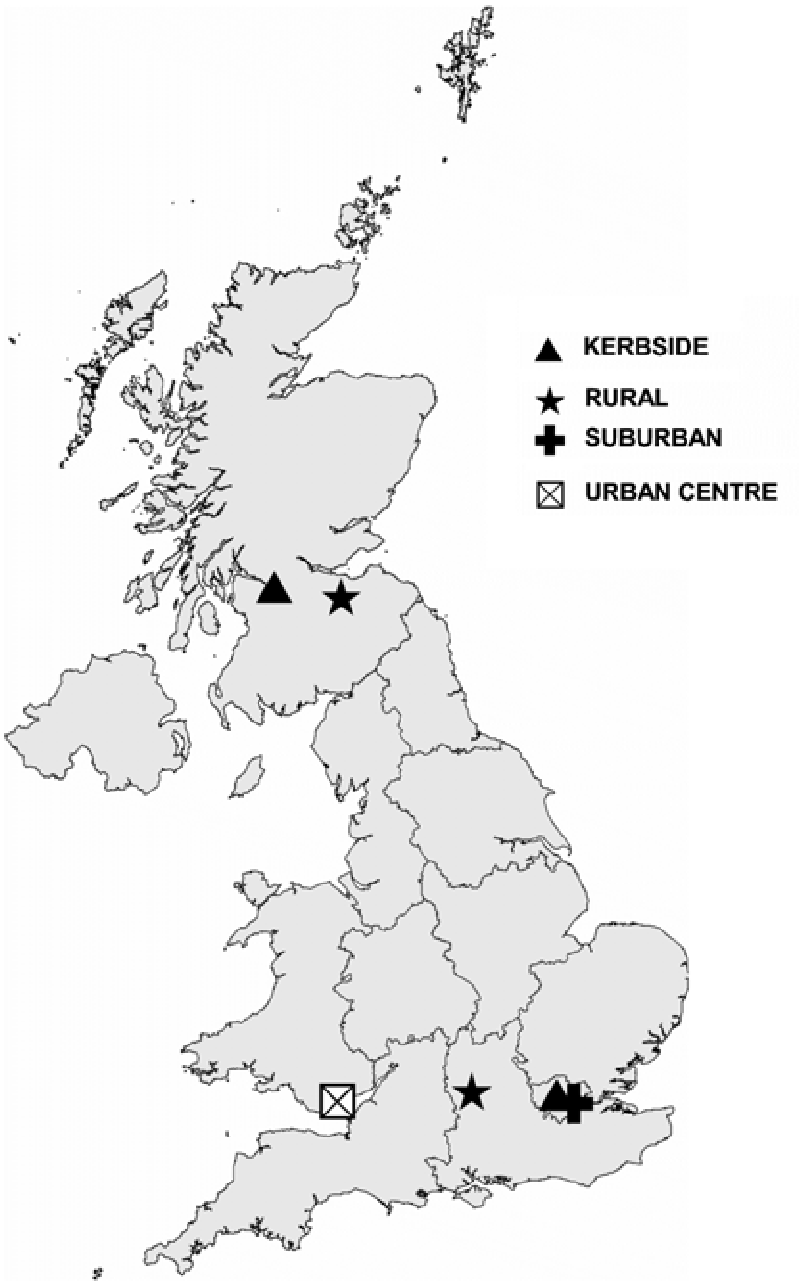
9.4 Objectives and Bandings

Summary of objectives of Air Quality Strategy			
	Objective*	**Measured as**	**To be achieved by**
Benzene	16.25 µg m^3	Running Annual Mean	31 December 2003
England and Wales only	5 µg m^{-3}	Annual Mean	31 December 2010
Scotland and Northern Ireland only	3.25 µg m^{-3}	Maximum Running Annual Mean	31 December 2010

No bandings are set for benzene, as there are no known short-term health effects for this pollutant.

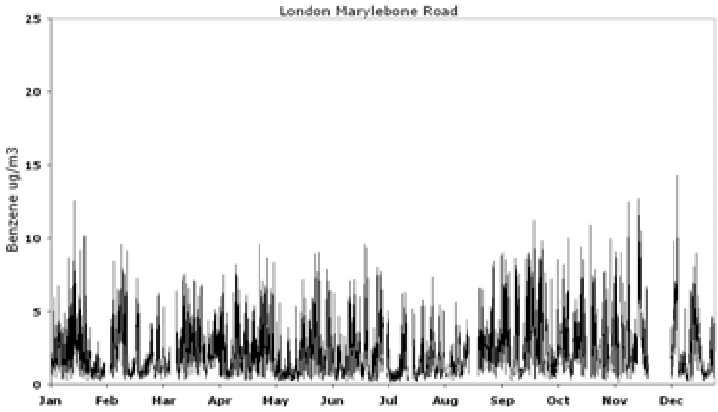
9.5 Site Locations

UK AUTOMATIC BENZENE MONITORING SITES 2005

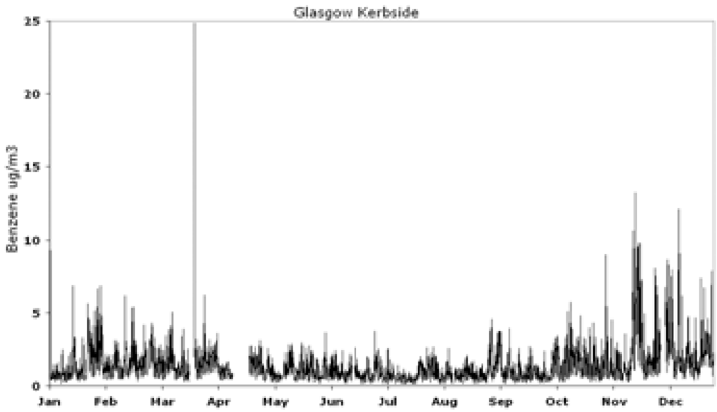


9.6 Hourly Average Concentrations

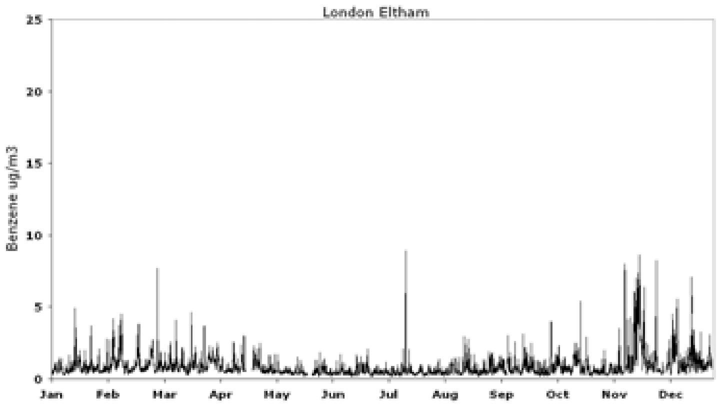
These figures show time series graphs of hourly average benzene concentrations at four *typical* site types for 2005.



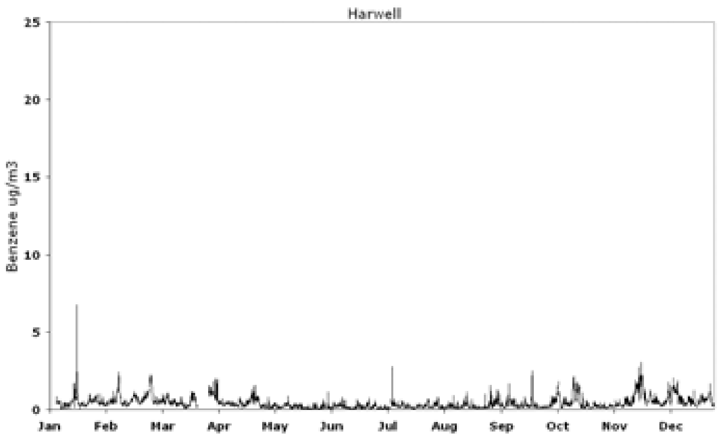
Kerbside Site
(Marylebone Road)



Roadside Site
(Glasgow)



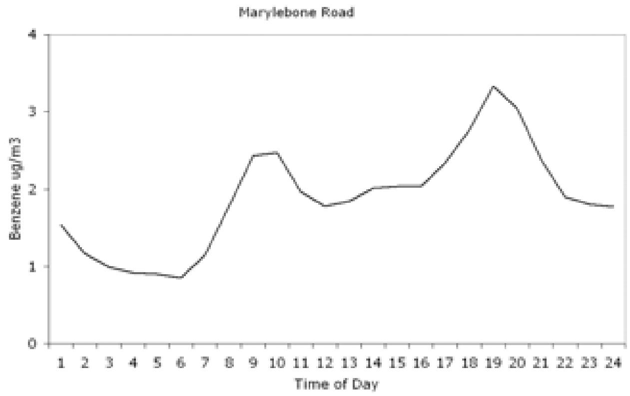
Suburban Site
(London Eltham)



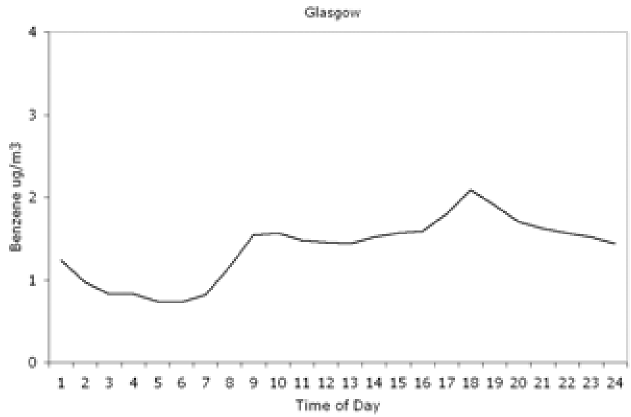
Rural Site
(Harwell)

9.7 Diurnal Variations

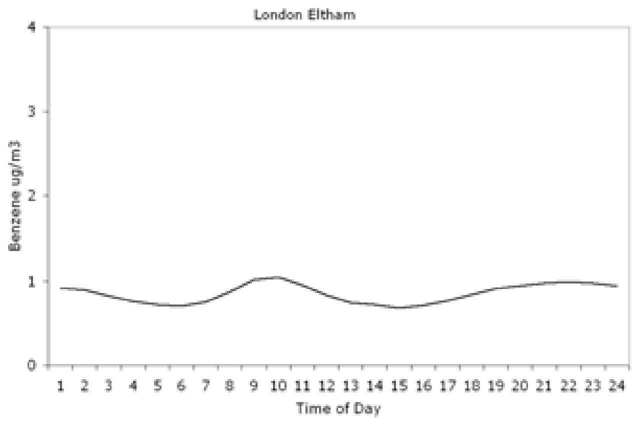
These figures show how benzene concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



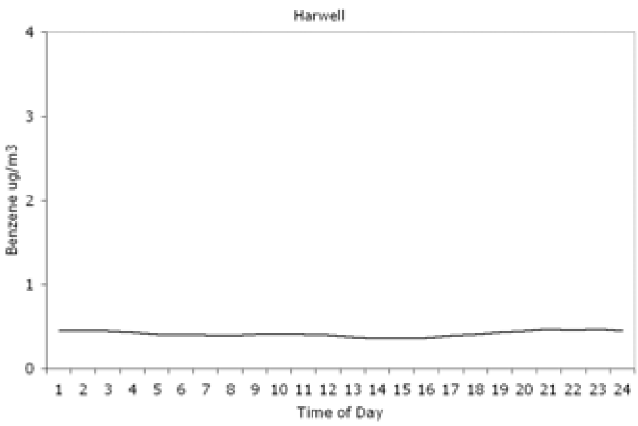
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Glasgow)*



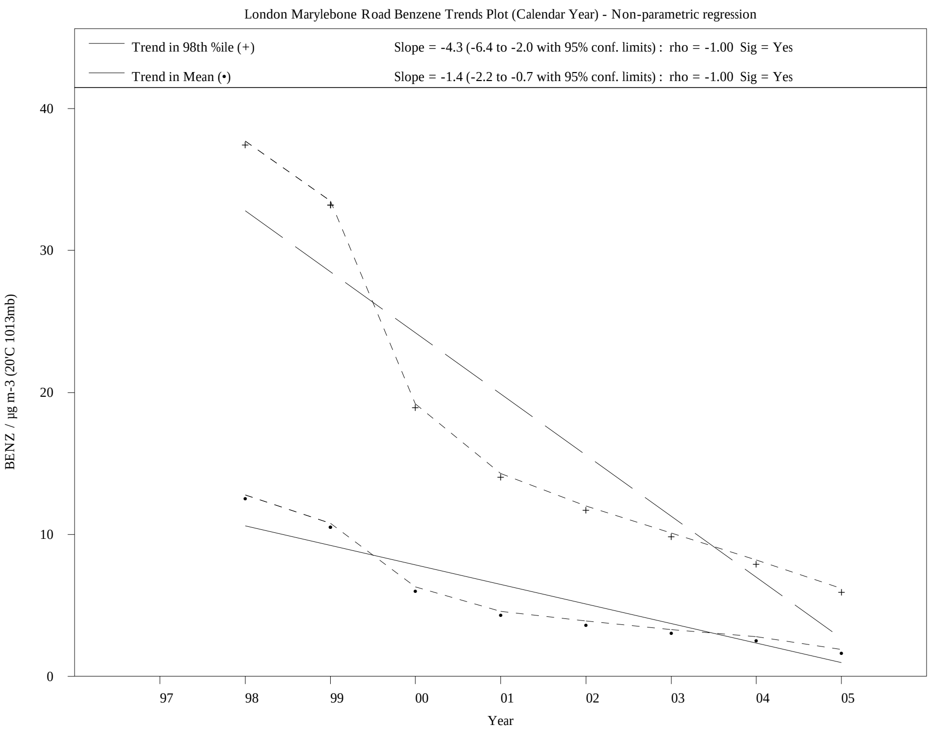
Suburban Site
(*London Eltham*)



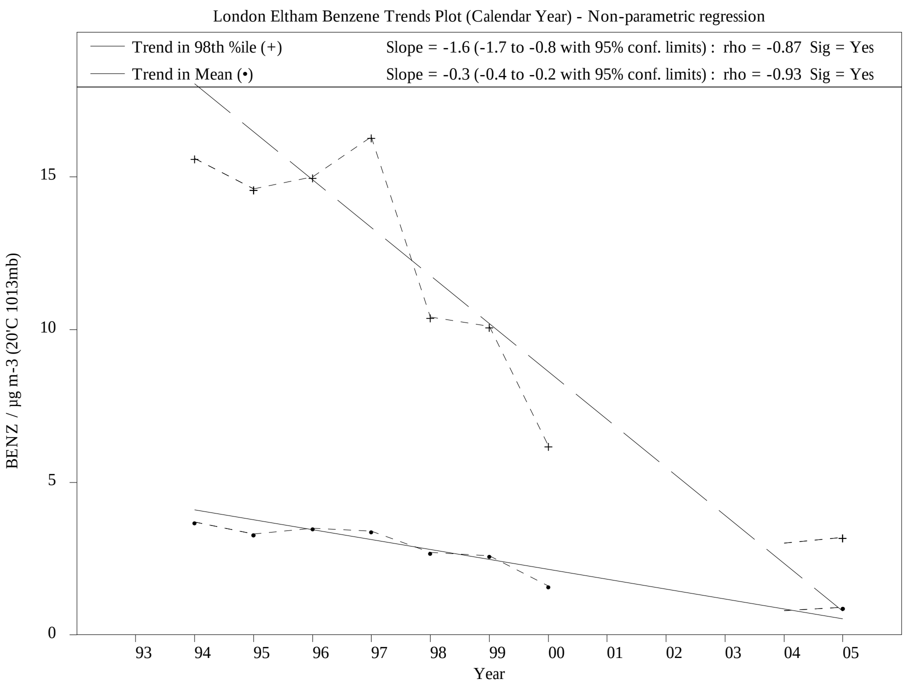
Rural Site
(*Harwell)*

9.8 Trends in annual concentrations

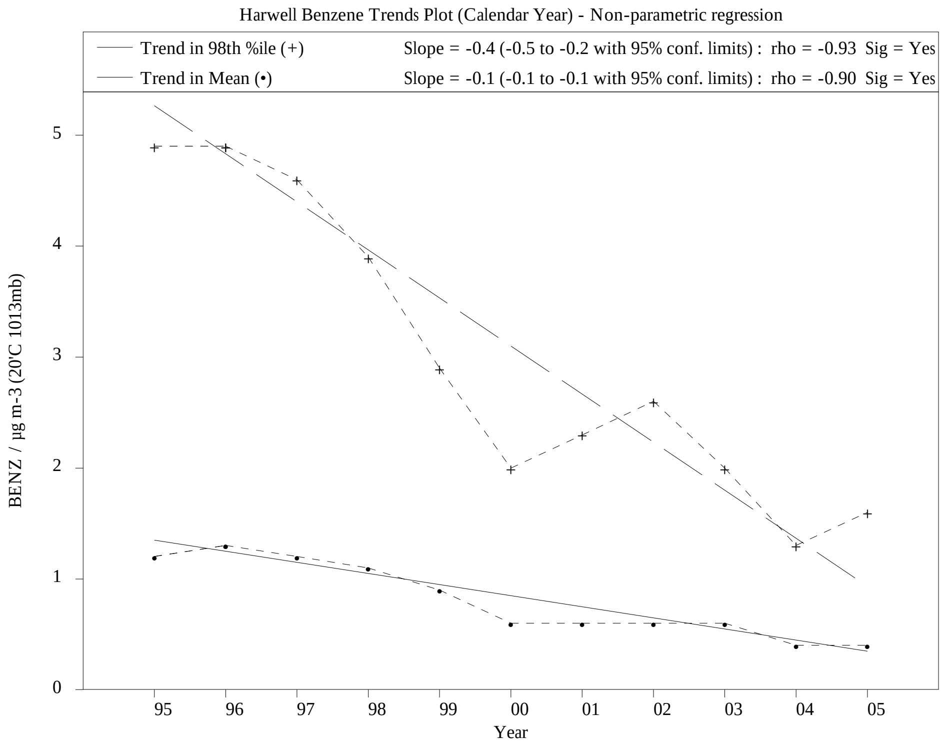
Statistically significant trends in concentrations are shown for sites with at least ≥5 years of measurement.



Kerbside Site
(*Marylebone Road)*



Suburban Site
(*London Eltham)*



Rural Site
(*Harwell***)**

9.9 Benzene Statistical Summary 2005

i) Annual Statistics

Site	Site Type	Annual Average of hourly means	Annual data capture of hourly means %	Maximum hourly mean
England				
Harwell	RU	0.42	95.2	6.76
London Eltham	SU	0.85	94.8	8.94
London Marylebone Road	KB	2.28	86.0	14.30
Scotland				
Glasgow Kerbside	KB	1.38	93.4	24.86
Wales				
Cardiff Centre	UC	0.91	51.1	8.78

ii) Exceedence Statistics

Site	Air Quality Standard	Days	Daughter Directive and Air Quality Standard (England and Wales)	Annual Mean Standard Scotland
England				
Harwell	0	0	0	0
London Eltham	0	0	0	0
London Marylebone Road	0	0	0	0
Scotland				
Glasgow Kerbside	0	0	0	0
Wales				
Cardiff Centre	0	0	0	0

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10. 1,3-Butadiene- Measurement Sites, Instrumentation and Statistics

10.1 Measurement Method

1,3-Butadiene is measured using automated GC or BTEX monitors; these measure concentrations of benzene, toluene, ethylbenzene and xylene isomers as well as 1,3-butadiene. This type of instrument uses an adsorption tube for sample collection.

10.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Environnement VOC 71M
- Perkin Elmer OPA

*Defra does not give approval or endorsement for any products or equipment

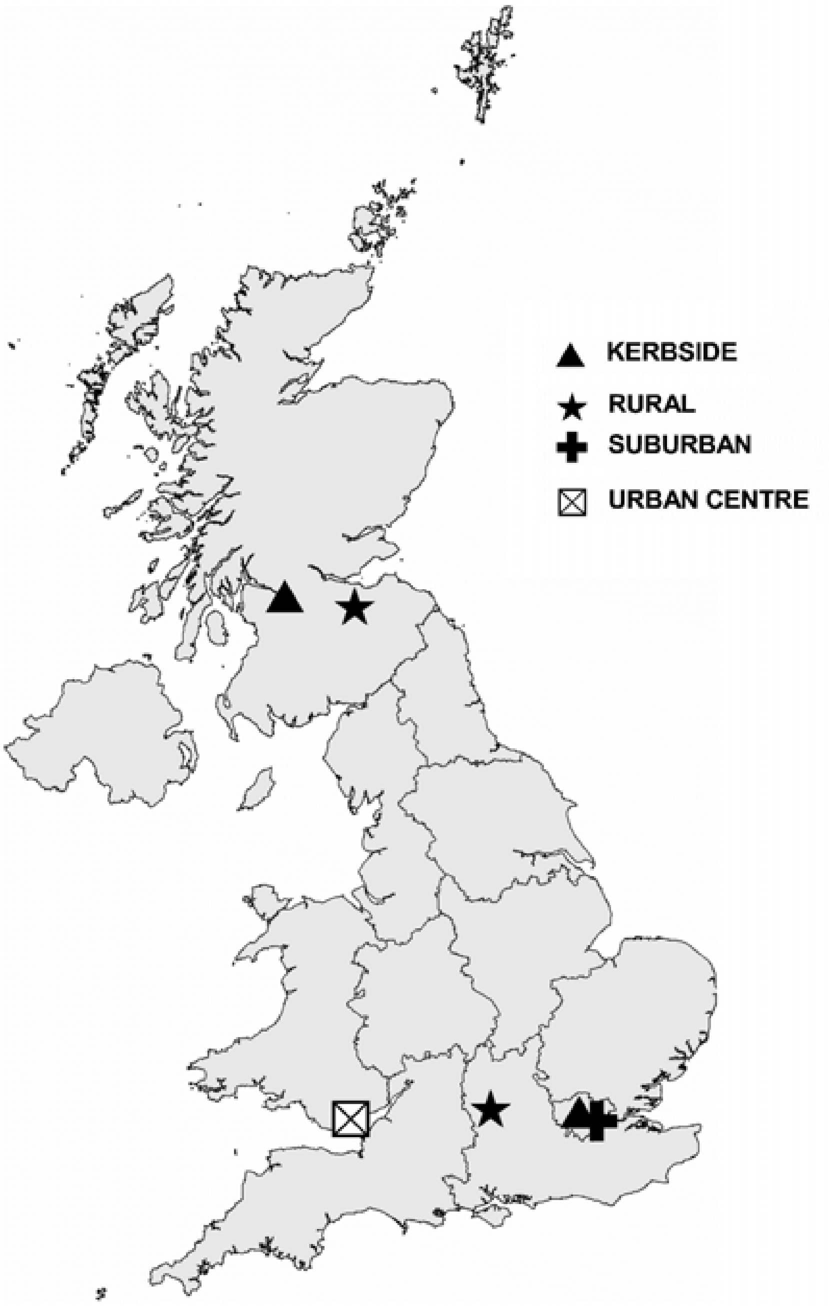
10.3 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
1,3-Butadiene	2.25 µg m^{-3}	Maximum Running Annual Mean	31 December 2003

No bandings are set for 1,3-Butadine, as there are no known short-term effects of this pollutant.

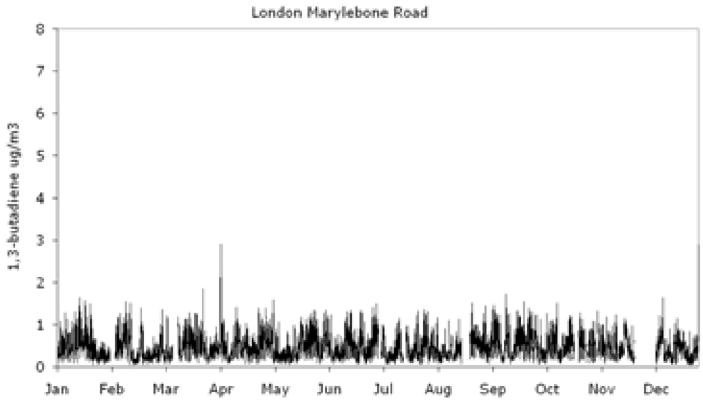
10.4 Site Locations

UK Automatic 1,3-Butadiene Monitoring Sites 2005

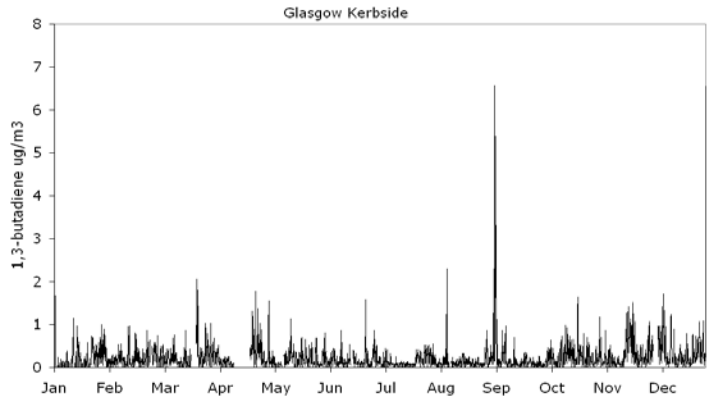


10.5 Hourly Average Concentrations

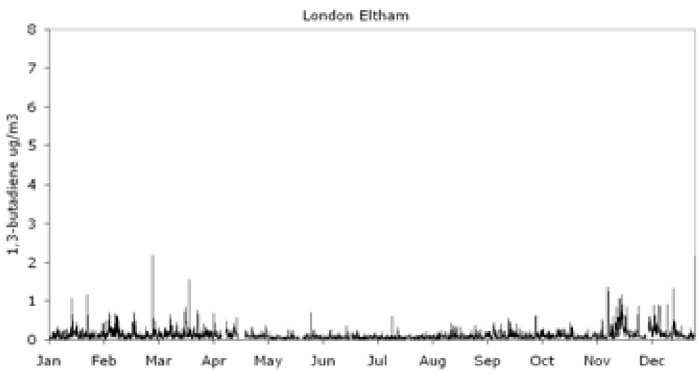
These figures show time series graphs of hourly average 1,3-Butadiene concentrations at four *typical* site types for 2005.



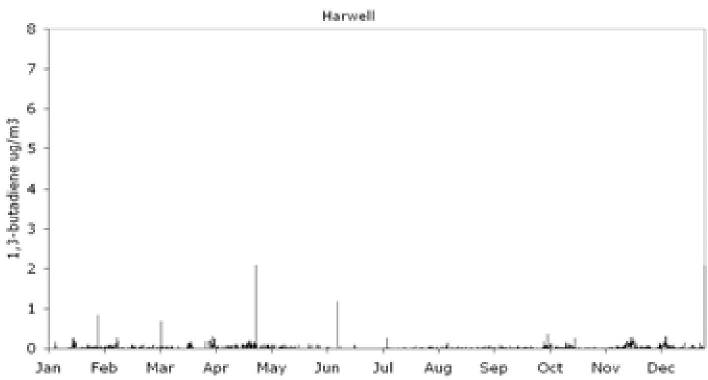
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Glasgow)*



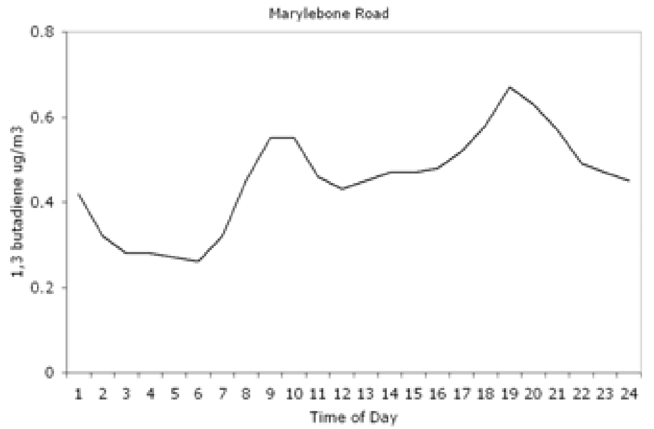
Suburban Site
(London Eltham)



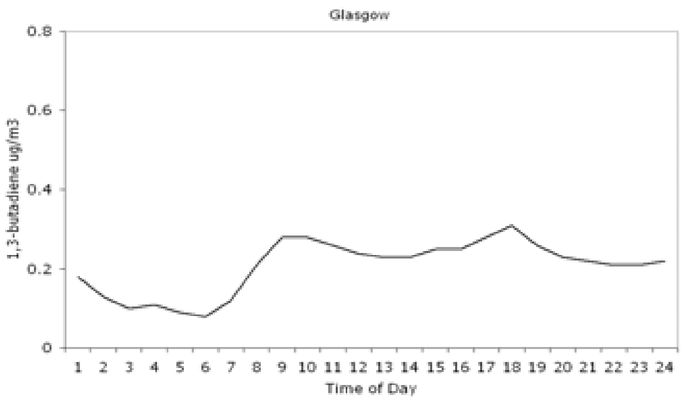
Rural Site
(Harwell)

10.6 Diurnal Variations

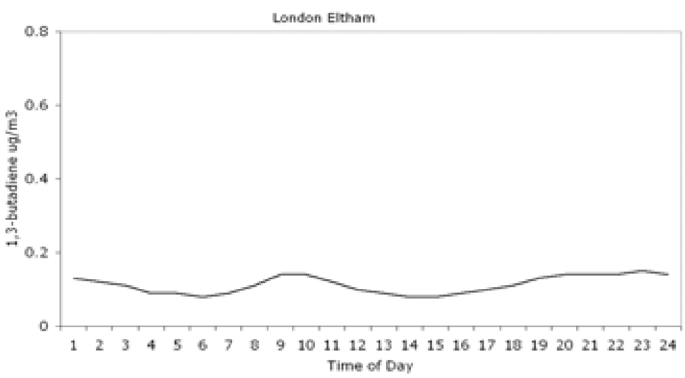
These figures show how 1,3-Butadiene concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



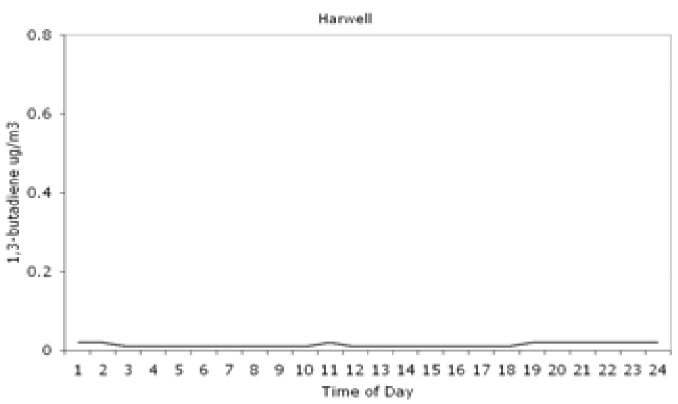
Kerbside Site
(*Marylebone Road)*



Kerbside Site
(Glasgow)



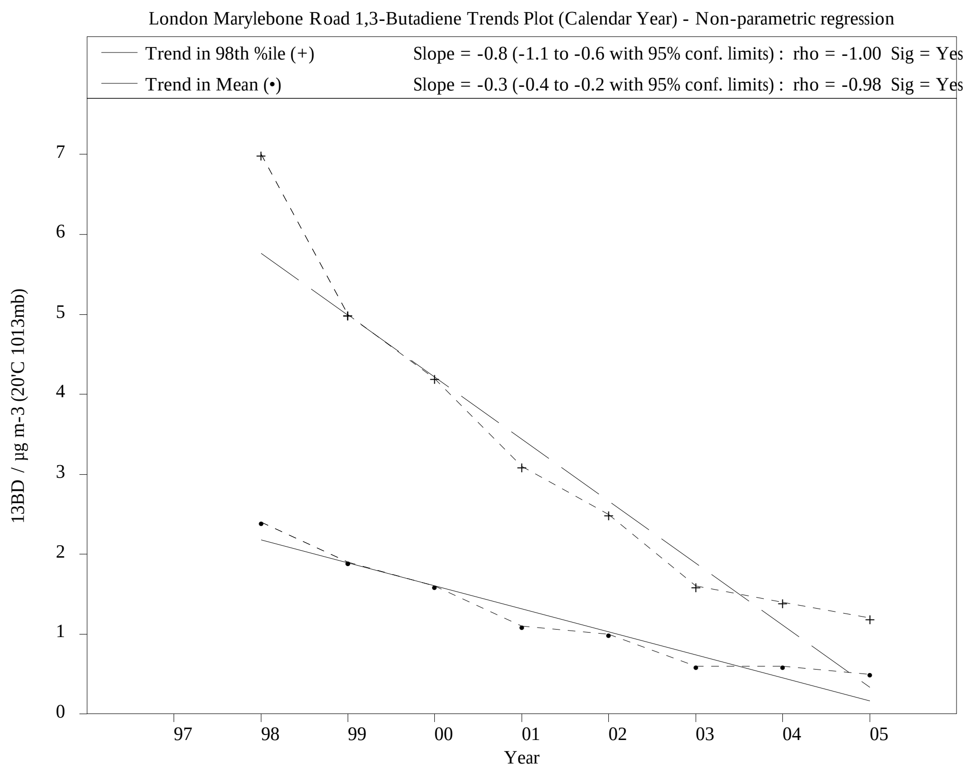
Urban Centre Site
(*Cardiff)*



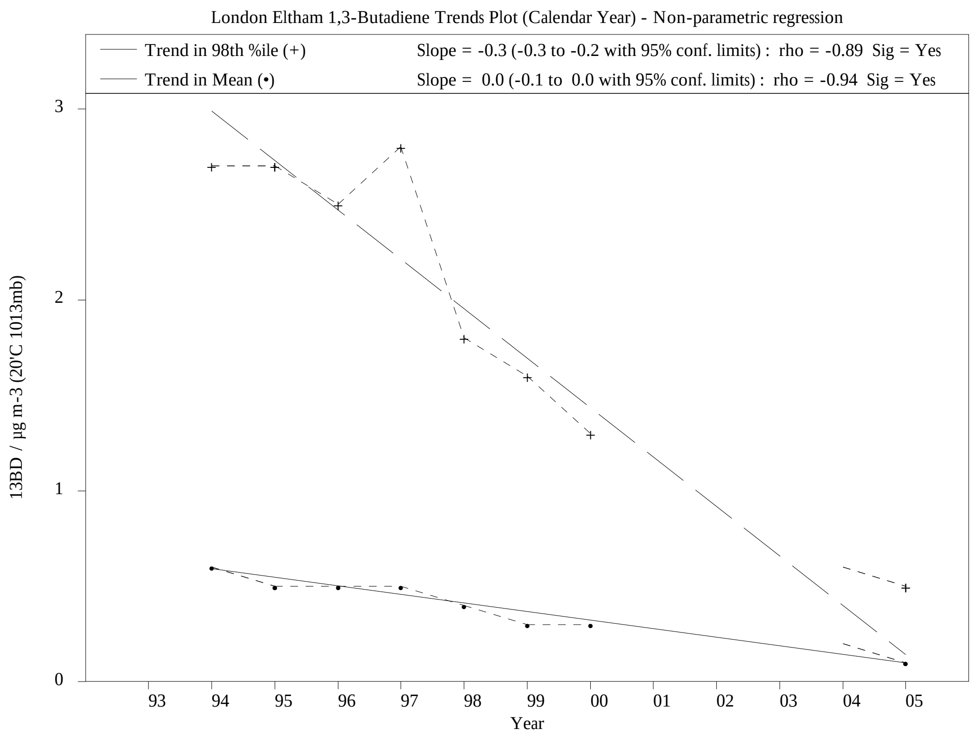
Rural Site
(Harwell)

10.7 Trends in annual concentrations

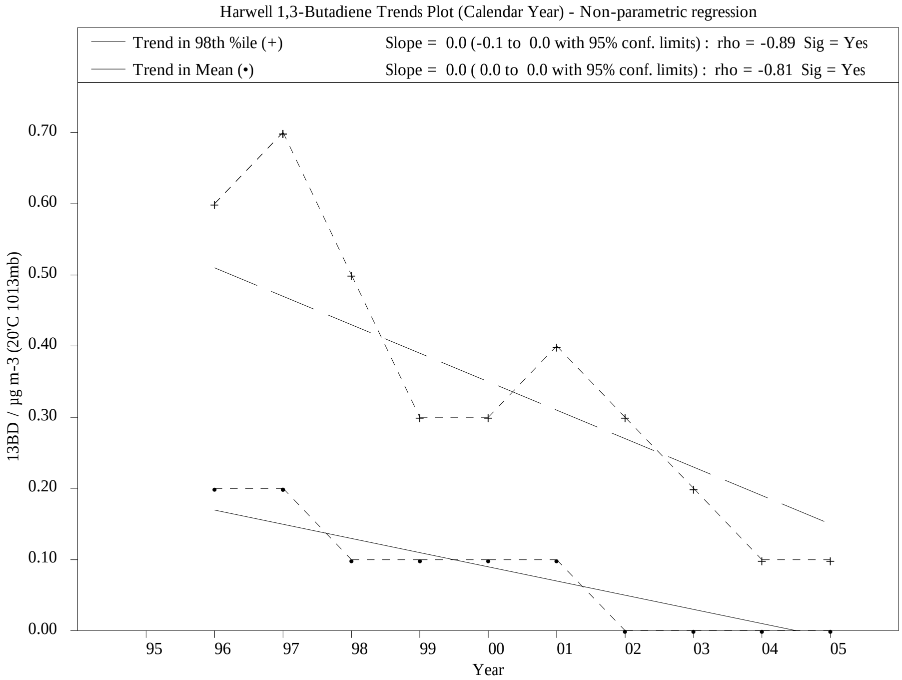
Statistically significant trends in concentrations are shown for sites with at least ≥5 years of measurement.



Kerbside Site
(Marylebone Road)



Suburban Site
(London Eltham)



Rural Site
(Harwell)

10.8 1,3-Butadiene Statistical Summary 2005

i) Annual Statistics

Site	Site Type	Annual Average of hourly means	Annual data capture of hourly means %	Maximum hourly mean
England				
Harwell	RU	0.01	95.2	2.09
London Eltham	SU	0.11	93.5	2.18
London Marylebone Road	KB	0.45	89.1	2.90
Scotland				
Glasgow Kerbside	KB	0.21	93.4	6.57
Wales				
Cardiff Centre	UC	0.14	51.1	6.98

ii) Exceedence Statistics

Site	Air Quality Standard	Days
England		
Harwell	0	0
London Eltham	0	0
London Marylebone Road	0	0
Scotland	0	0
Glasgow Kerbside	0	0
Wales	0	0
Cardiff Centre	0	0

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11. CO - Measurement Sites, Instrumentation and Statistics

11.1 Measurement Method

CO concentrations in ambient air are measured by the absorption of infrared radiation at 4.5 to 4.9 μm wavelength. A reference detection system is used to alternately measure absorption due to CO in the sampled air stream and absorption by interfering species. An infrared detector and amplification system produces output voltages proportional to the CO concentration.

11.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak CO
- API M300
- Environnement SA 11M
- Horiba APMA 350E
- Horiba APMA 360
- Monitor Labs 9830
- Rotork 416
- Thermo Electron 48

*Defra does not give approval or endorsement for any products or equipment

11.3 Data Quality Requirements of EC Directive 2000/69/EC

Uncertainty 15%
Minimum data capture 90%

11.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Carbon Monoxide England and Wales	10.0 mg m^{-3}	Maximum daily running 8 Hour Mean	31 December 2003
Scotland only	10.0 mg m^{-3}	Running 8 Hour Mean[a]	31 December 2003
Northern Ireland only	10.0 mg m^{-3}	Maximum daily running 8 Hour Mean	1 January 2005

a. The Quality Objective in Scotland has been defined in Regulations as the running 8-hour mean, in practice this is equivalent to the maximum daily running 8-hour mean

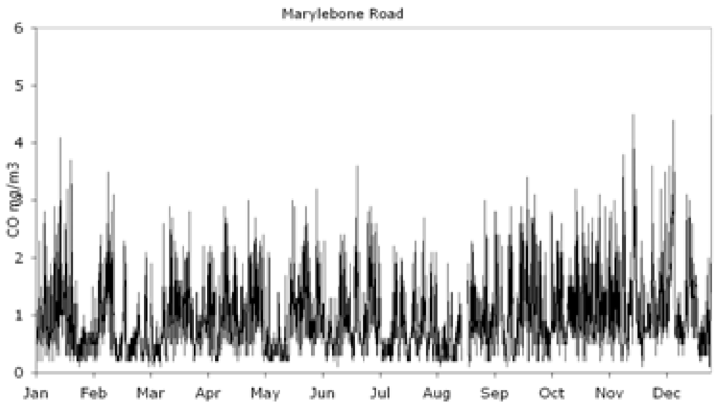
Air Quality Bands and Index Values		
Band	**Index**	**Carbon Monoxide mg m^{-3}**
Low	1	0-3.8
	2	3.9-7.6
	3	7.7-11.5
Moderate	4	11.6-13.4
	5	13.5-15.4
	6	15.5-17.3
High	7	17.4-19.2
	8	19.3-21.2
	9	21.3-23.1
Very High	10	23.2 or more

11.5 Site Locations

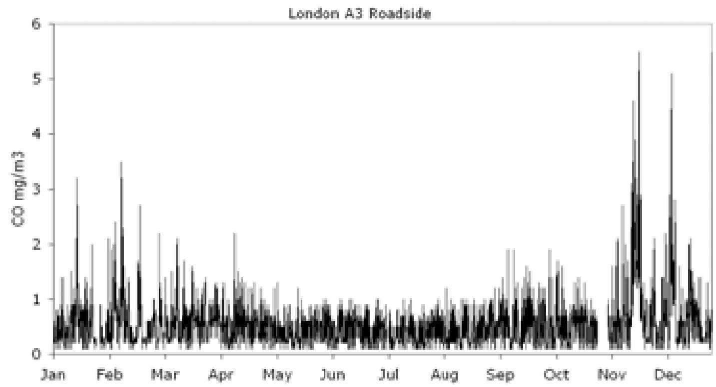
UK AUTOMATIC CARBON MONOXIDE MONITORING SITES 2005

11.6 Hourly Average Concentrations

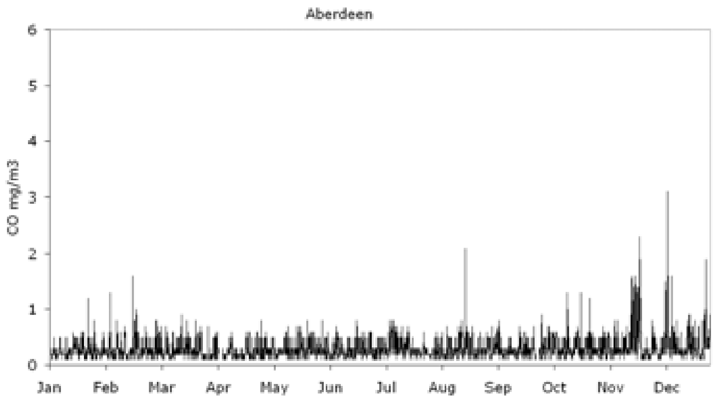
These figures show time series graphs of hourly average carbon monoxide concentrations at four *typical* site types for 2005.



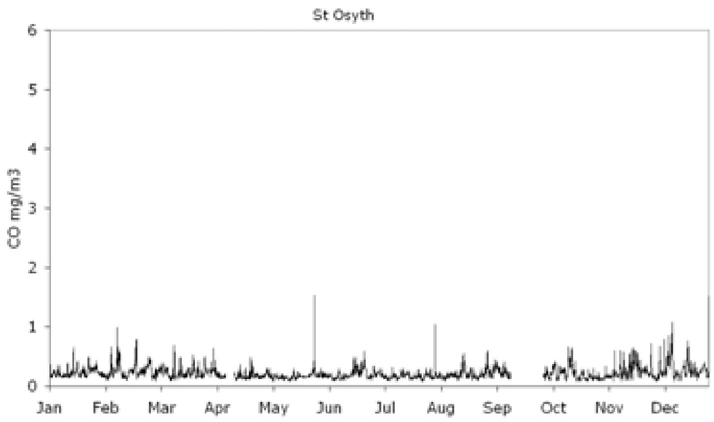
Kerbside Site
(Marylebone Road)



Roadside Site
(London A3)



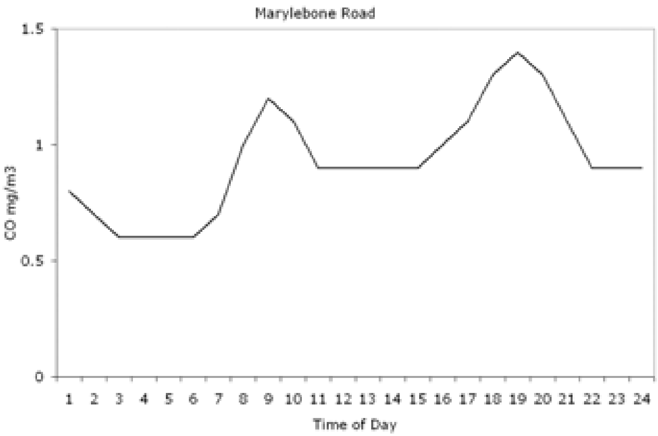
Urban Background Site
(Aberdeen)



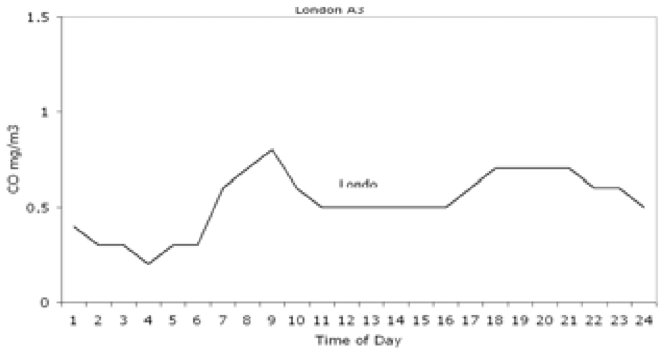
Rural Site
(Harwell)

11.7 Diurnal Variations

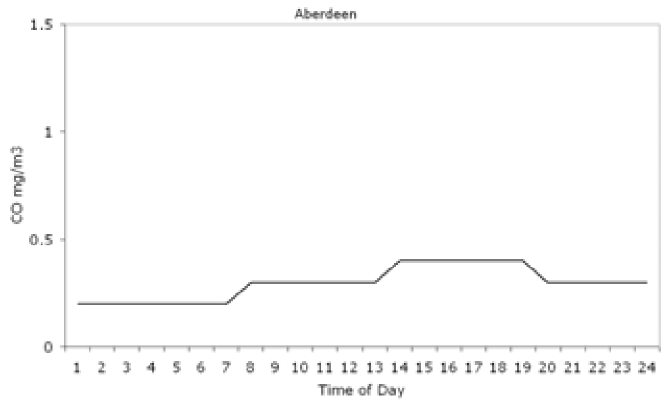
These figures show how carbon monoxide concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



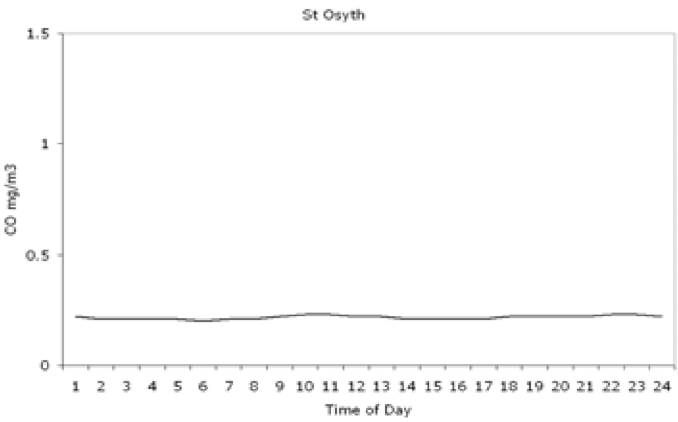
Kerbside Site
(Marylebone Road)



Roadside Site
(London A3)



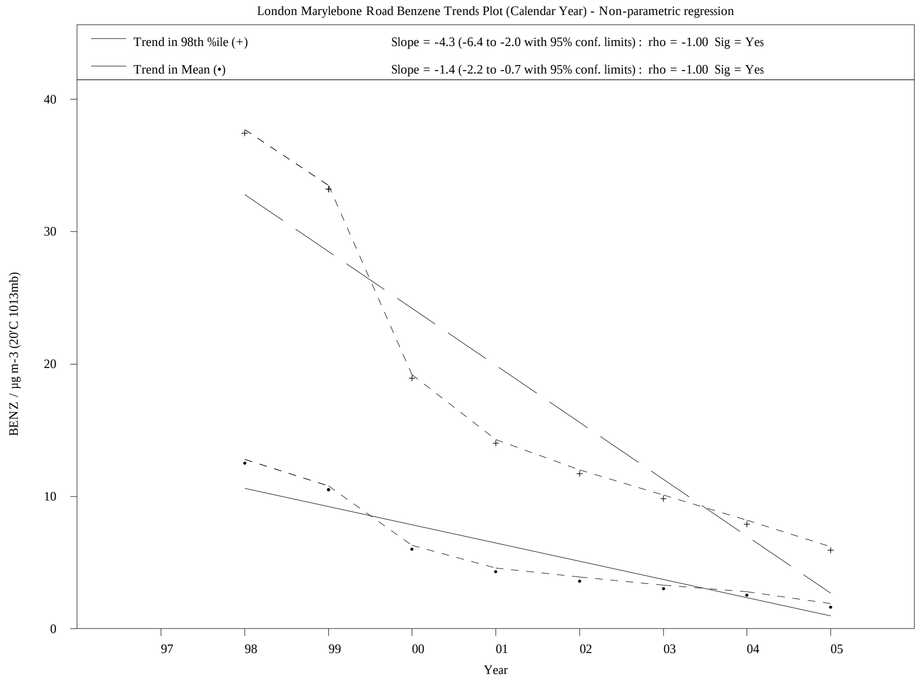
Urban Background Site
(Aberdeen)



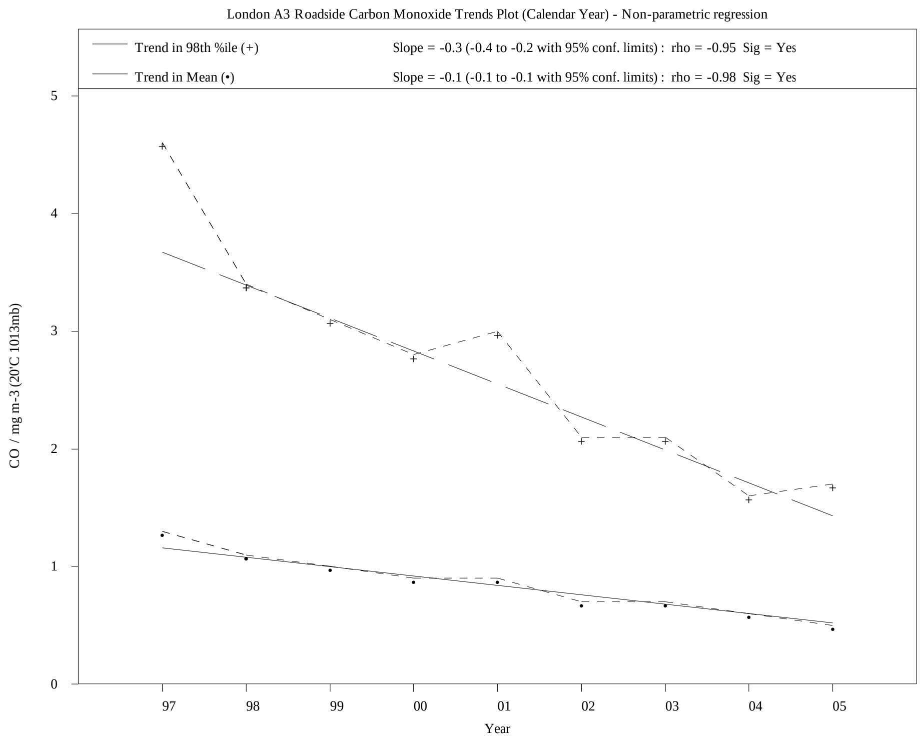
Rural Site
(Harwell)

11.8 Trends in annual concentrations

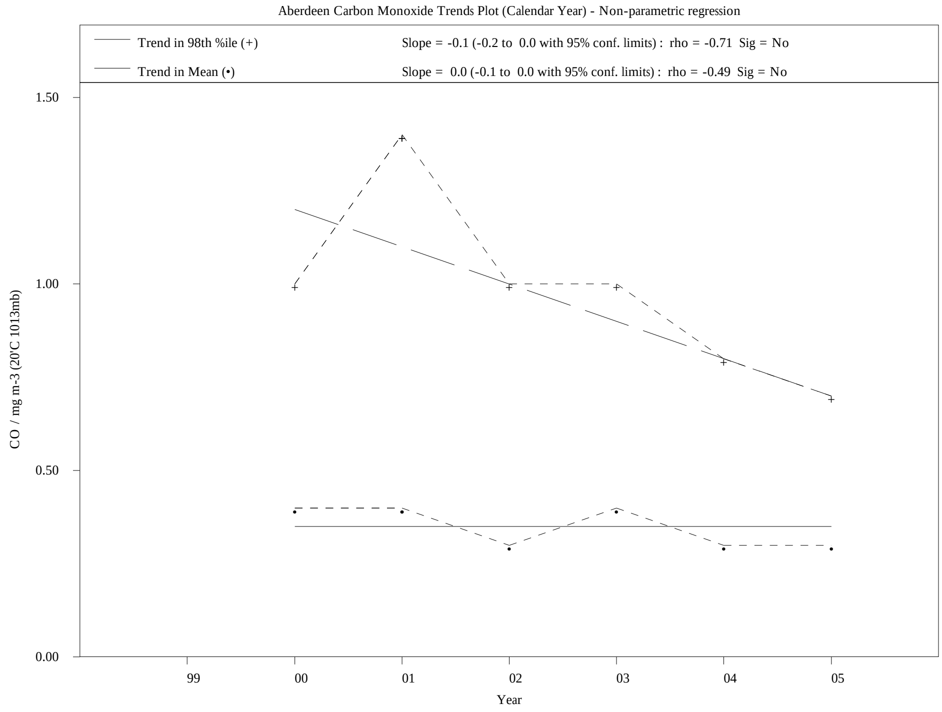
Statistically significant trends in concentrations are shown for sites with at least ≥5 years of measurement.



Kerbside Site
(*Marylebone Road*)



Roadside Site
(*London A3*)



Urban Background Site
(*Aberdeen)*

There are no rural CO measurement sites
with sufficient data to determine annual trends

11.9 Carbon Monoxide Statistical Summary 2005

i) ANNUAL STATISTICS I

Site	Site Type	Annual average of hourly means mg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean mg m^{-3}	Maximum running 8-hour mean mg m^{-3}	Date of maximum running 8-hour mean
England						
Barnsley Gawber	UB	0.2	56.8	2.8	1.6	21/11/2005
Bath Roadside	RD	0.8	93.8	4.5	3.3	30/11/2005
gham Centre	UC	0.3	85.0	2.4	1.4	08/12/2005
Birmingham Tyburn	UB	0.3	99.2	3.8	3.4	20/11/2005
Blackpool Marton	UB	---	49.2	2.0	1.3	20/11/2005
Bolton	UB	0.3	97.8	4.1	2.6	14/01/2005
Bournemouth	UB	0.3	98.4	3.6	2.4	29/11/2005
Bradford Centre	UC	0.4	90.2	4.8	4.1	09/12/2005
Brentford Roadside	RD	0.8	83.6	4.6	4.0	19/11/2005
Brighton Roadside	RD	0.5	90.3	4.5	2.7	21/12/2005
Bristol Centre	UC	0.4	67.8	3.0	1.5	07/02/2005
Bristol Old Market	RD	0.6	99.2	4.6	3.2	17/11/2005
Bury Roadside	RD	0.6	78.0	4.2	3.3	29/11/2005
Coventry Memorial Park	UB	0.2	98.7	2.4	1.7	21/11/2005
Exeter Roadside	RD	0.7	76.9	5.3	2.8	13/01/2005
Hove Roadside	RD	0.4	97.1	3.9	2.1	13/01/2005
Hull Freetown	UC	0.2	62.9	3.0	2.5	21/11/2005
Leamington Spa	UB	0.3	74.6	3.2	2.2	18/11/2005
Leeds Centre	UC	0.3	92.2	3.6	2.8	22/11/2005
Leicester Centre	UC	0.2	97.2	2.9	1.9	19/11/2005
Liverpool Speke	UB	0.2	96.1	3.2	2.1	21/11/2005
London A3 Roadside	RD	0.5	97.0	5.5	4.1	21/11/2005
London Bexley	SU	0.3	97.1	3.1	2.2	09/12/2005
London Bloomsbury	UC	0.5	91.9	3.6	2.9	20/11/2005
London Brent	UB	0.3	56.3	5.1	3.2	10/12/2005
London Bromley	RD	---	46.3	2.7	2.0	13/01/2005
London Cromwell Road 2	RD	0.7	94.0	4.9	3.6	20/11/2005
London Hackney	UC	0.3	95.7	4.5	3.5	09/12/2005
London Harlington	A	0.3	99.3	2.9	2.4	10/12/2005
London Hillingdon	SU	0.5	89.2	4.8	3.0	10/12/2005
London Marylebone Road	KB	---	98.0	---	---	---
London N. Kensington	UB	0.4	96.2	3.7	2.9	20/11/2005
London Southwark	UC	0.4	95.9	3.9	3.2	20/11/2005
London Westminster	UB	0.5	52.0	4.2	3.6	20/11/2005
Manchester Piccadilly	UC	0.4	97.9	3.4	2.5	20/11/2005
Manchester Town Hall	UB	0.4	66.3	2.7	1.9	17/11/2005
Market Harborough	RU	0.2	98.8	1.2	1.1	20/11/2005
Middlesbrough	I	0.3	93.7	2.3	1.5	08/12/2005
Newcastle Centre	UC	0.2	97.4	3.7	2.4	08/12/2005
Northampton	UB	0.2	99.2	3.4	1.6	21/11/2005
Norwich Centre	UC	0.3	96.9	2.7	2.4	09/12/2005
Nottingham Centre	UC	0.4	86.5	4.2	3.1	22/11/2005
Oxford Centre Roadside	RD	0.2	95.7	5.9	2.6	21/11/2005
Plymouth Centre	UC	0.3	97.6	2.3	1.4	20/12/2005
Portsmouth	UB	0.3	94.4	4.2	2.8	30/11/2005
Preston	UB	0.3	79.8	4.5	2.1	20/11/2005
Reading New Town	UB	0.3	80.9	3.8	2.5	14/01/2005
Redcar	UB	0.3	88.2	2.7	1.4	21/11/2005
Salford Eccles	SU	0.2	95.4	4.5	2.9	29/11/2005
Sandwell West Bromwich	I	0.2	89.0	2.3	1.6	17/11/2005
Sheffield Centre	UB	0.4	96.9	3.8	3.0	23/11/2005
Sheffield Tinsley	UC	0.4	99.0	3.5	2.3	23/11/2005
Southampton Centre	I	0.3	87.8	5.0	3.2	20/12/2005
Southend-on-Sea	UC	0.3	94.6	3.0	1.4	04/02/2005
Southwark Roadside	UB	0.7	91.9	4.3	3.4	09/12/2005
St Osyth	RD	0.22	93.0	1.53	0.80	11/12/2005
Stockport Shaw Heath	RU	0.2	75.5	2.4	1.5	22/11/2005
Stockton-on-Tees Yarm	UB	0.4	97.9	3.8	2.2	23/11/2005
Stoke-on-Trent Centre	RD	0.4	93.3	4.9	3.0	20/11/2005

ii) EXCEEDENCE STATISTICS I

Site	Moderate band	Days	High band	Days	Very High band	Days	Daughter Directive and Air Quality Standard	Days	Air Quality Standard (Scotland)	Days
England										
Barnsley Gawber	0	0	0	0	0	0	0	0	0	0
Bath Roadside	0	0	0	0	0	0	0	0	0	0
Birmingham Centre	0	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	0	0	0
Blackpool Marton	0	0	0	0	0	0	0	0	0	0
Bolton	0	0	0	0	0	0	0	0	0	0
Bournemouth	0	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0	0
Brentford Roadside	0	0	0	0	0	0	0	0	0	0
Brighton Roadside	0	0	0	0	0	0	0	0	0	0
Bristol Centre	0	0	0	0	0	0	0	0	0	0
Bristol Old Market	0	0	0	0	0	0	0	0	0	0
Bury Roadside	0	0	0	0	0	0	0	0	0	0
Coventry Memorial Park	0	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	0	0	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	0	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0	0
London A3 Roadside	0	0	0	0	0	0	0	0	0	0
London Bexley	0	0	0	0	0	0	0	0	0	0
London Bloomsbury	0	0	0	0	0	0	0	0	0	0
London Brent	0	0	0	0	0	0	0	0	0	0
London Bromley	0	0	0	0	0	0	0	0	0	0
London Cromwell Road	0	0	0	0	0	0	0	0	0	0
London Hackney	0	0	0	0	0	0	0	0	0	0
London Harlington	0	0	0	0	0	0	0	0	0	0
London Hillingdon	0	0	0	0	0	0	0	0	0	0
London Marylebone	0	0	0	0	0	0	0	0	0	0
London N. Kensington	0	0	0	0	0	0	0	0	0	0
London Southwark	0	0	0	0	0	0	0	0	0	0
London Westminster	0	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	0	0	0	0
Manchester Town Hall	0	0	0	0	0	0	0	0	0	0
Market Harborough	0	0	0	0	0	0	0	0	0	0
Middlesbrough	0	0	0	0	0	0	0	0	0	0
Newcastle Centre	0	0	0	0	0	0	0	0	0	0
Northampton	0	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0	0
Nottingham Centre	0	0	0	0	0	0	0	0	0	0
Oxford Centre Roadside	0	0	0	0	0	0	0	0	0	0
Plymouth Centre	0	0	0	0	0	0	0	0	0	0
Portsmouth	0	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	0	0	0
Redcar	0	0	0	0	0	0	0	0	0	0
Salford Eccles	0	0	0	0	0	0	0	0	0	0
Sandwell West	0	0	0	0	0	0	0	0	0	0
Sheffield Centre	0	0	0	0	0	0	0	0	0	0
Sheffield Tinsley	0	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0	0
Southwark Roadside	0	0	0	0	0	0	0	0	0	0
St Osyth	0	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0	0
Stockton-on-Tees Yarm	0	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0	0

iii) ANNUAL STATISTICS II

Site	Site Type	Annual average of hourly means mg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean mg m^{-3}	Maximum running 8-hour mean mg m^{-3}	Date of Maximum running 8-hour mean
Thurrock	UC	0.3	93.9	3.8	2.3	09/12/2005
Tower Hamlets Roadside	UB	0.6	88.3	14.6	6.4	30/06/2005
West London	RD	0.4	93.7	1.9	1.6	13/11/2005
Wigan Centre	UC	0.3	98.3	3.5	2.9	18/11/2005
Wirral Tranmere	UB	0.2	61.3	2.1	1.7	08/12/2005
Wolverhampton Centre	UC	0.4	96.2	4.2	3.0	21/11/2005
N Ireland						
Belfast Centre	UC	0.2	94.4	4.4	3.5	22/11/2005
Derry	UB	0.3	96.3	3.4	2.3	21/11/2005
Scotland						
Aberdeen	UB	0.3	98.9	3.1	1.7	08/12/2005
Dumfries	RD	0.6	97.2	4.6	2.7	08/12/2005
Edinburgh St Leonards	UB	0.3	98.8	2.7	1.7	18/11/2005
Glasgow Centre	UC	0.3	94.6	3.5	2.3	18/11/2005
Glasgow City Chambers	UB	0.4	79.4	2.7	2.0	20/11/2005
Glasgow Kerbside	KB	0.4	91.3	3.9	3.0	13/12/2005
Grangemouth	I	0.3	99.3	2.1	1.4	17/11/2005
Inverness	RD	0.5	97.3	3.9	2.4	18/11/2005
Wales						
Cardiff Centre	UC	0.4	58.3	2.6	1.7	30/11/2005
Cwmbran	UB	---	29.4	3.1	2.1	14/01/2005
Swansea	UC	0.3	97.3	3.8	1.8	21/03/2005
Wrexham	UC	0.6	98.6	4.6	2.3	21/11/2005

iv) EXCEEDENCE STATISTICS- II

Site	Moderate band	Days	High band	Days	Very High band	Days	Daughter Directive and Air Quality Standard	Days	Air Quality Standard (Scotland)	Days
Thurrock	0	0	0	0	0	0	0	0	0	0
Tower Hamlets Roadside	0	0	0	0	0	0	0	0	0	0
West London	0	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0	0
Wirral Tranmere	0	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	0	0	0	0	0	0	0	0	0	0
N Ireland										
Belfast Centre	0	0	0	0	0	0	0	0	0	0
Derry	0	0	0	0	0	0	0	0	0	0
Scotland										
Aberdeen	0	0	0	0	0	0	0	0	0	0
Dumfries	0	0	0	0	0	0	0	0	0	0
Edinburgh St Leonards	0	0	0	0	0	0	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	0	0	0
Glasgow City Chambers	0	0	0	0	0	0	0	0	0	0
Glasgow Kerbside	0	0	0	0	0	0	0	0	0	0
Grangemouth	0	0	0	0	0	0	0	0	0	0
Inverness	0	0	0	0	0	0	0	0	0	0
Wales										
Cardiff Centre	0	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0	0
Swansea	0	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0	0

12. NO_2 - Measurement Sites, Instrumentation and Statistics

12.1 Measurement Method

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide (NO_2).

12.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak NO2
- API M200
- Environnement AC 31M
- Horiba APNA 360
- Monitor Labs 9841
- Rotork 447
- Thermo Electron 42

*Defra does not give approval or endorsement for any products or equipment

12.3 Data Quality Requirements of EC Directive 1999/30/EC

Uncertainty 15%
Minimum data capture 90%

12.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Nitrogen Dioxide	200 µg m^{-3} Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 µg m^{-3}	Annual Mean	31 December 2005

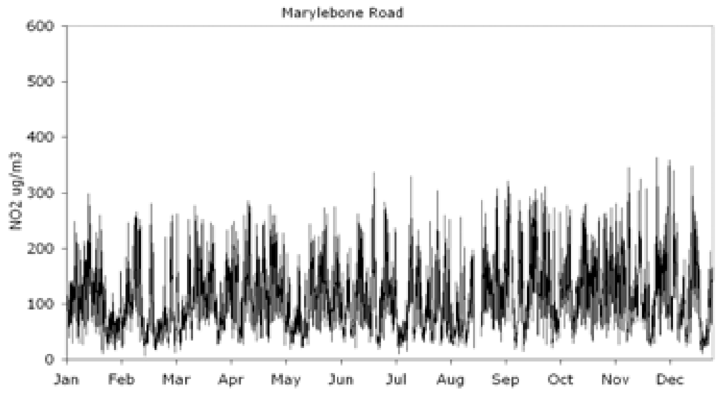
Air Quality Bands and Index Values		
Band	**Index**	**Nitrogen Dioxide µg m^{-3}**
Low	1	0-95
	2	96-190
	3	191-286
Moderate	4	287-381
	5	382-477
	6	478-572
High	7	573-635
	8	363-700
	9	701-763
Very High	10	764 or more

12.5 Site Locations

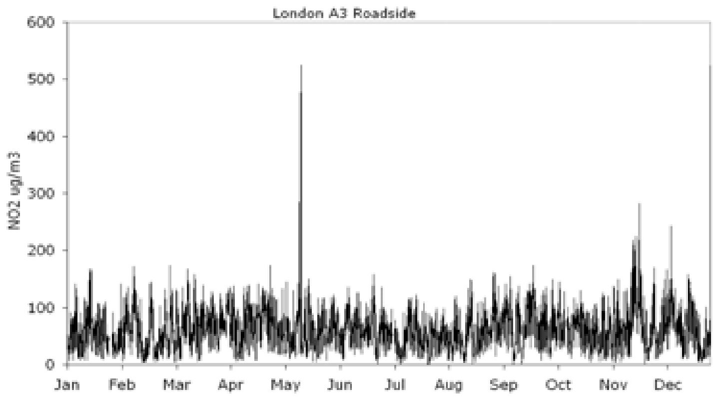
UK AUTOMATIC NITROGEN DIOXIDE MONITORING SITES 2005

12.6 Hourly Average Concentrations

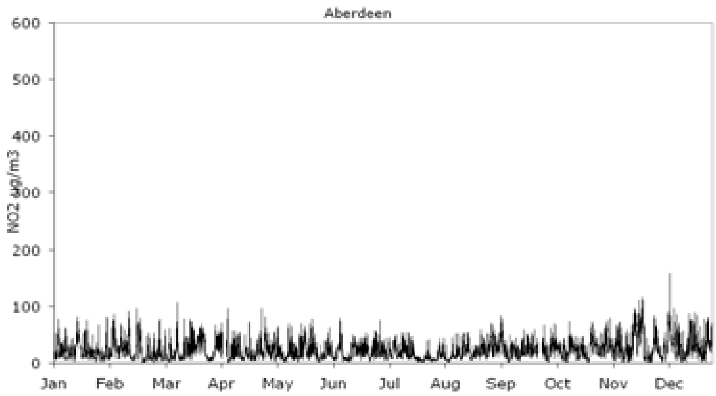
These figures show time series graphs of hourly average nitrogen dioxide concentrations at four *typical* site types for 2005.



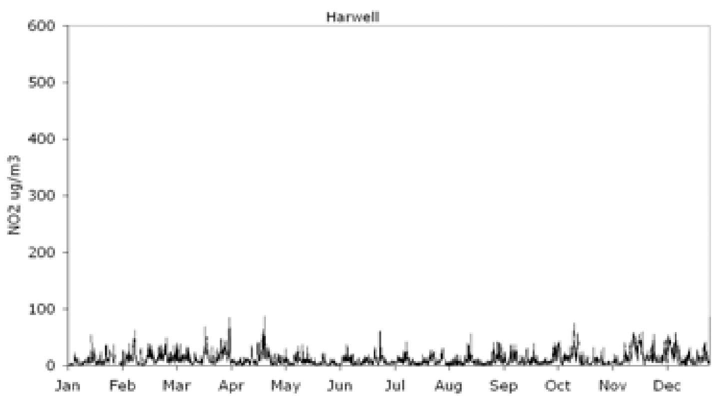
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*London A3)*



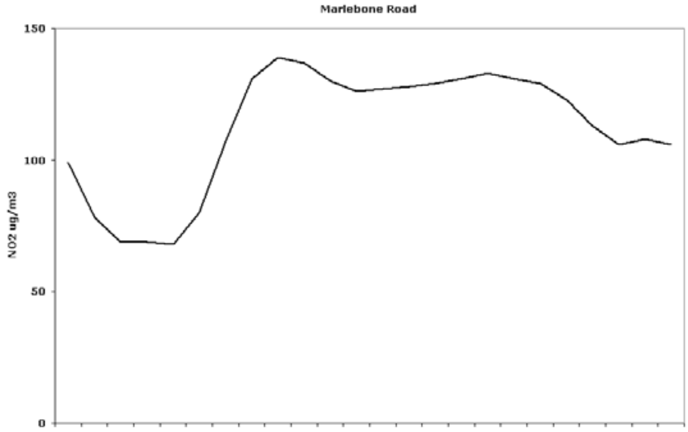
Urban Background Site
(*Aberdeen)*



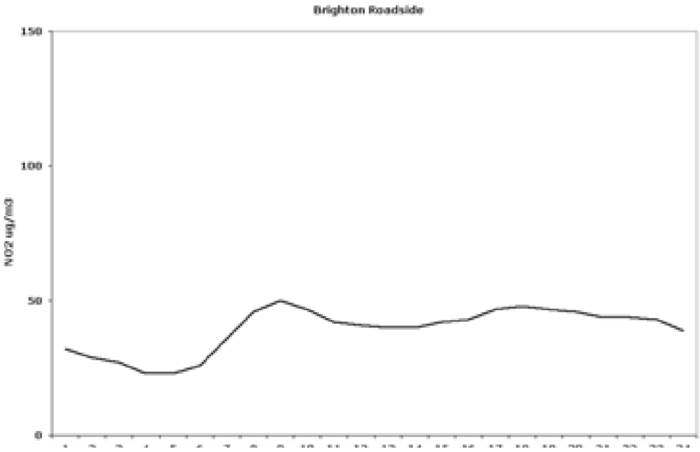
Rural Site
(Harwell)

12.7 Diurnal Variations

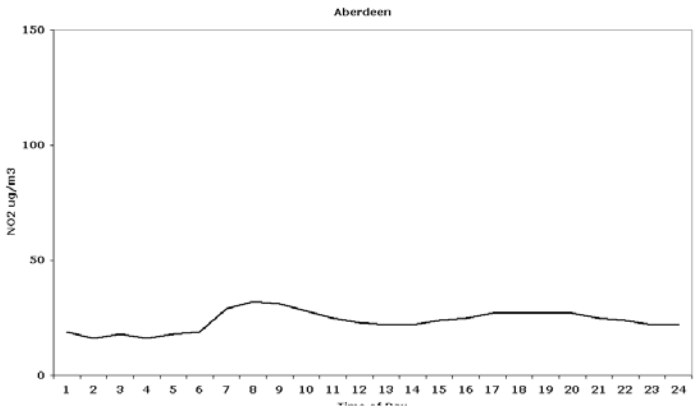
These figures show how nitrogen dioxide concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



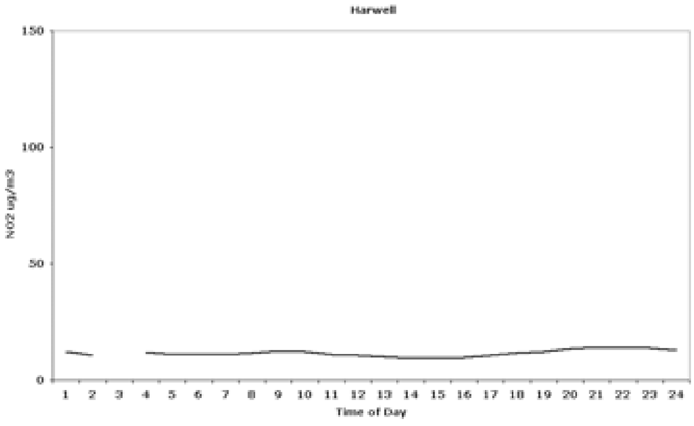
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Brighton)*



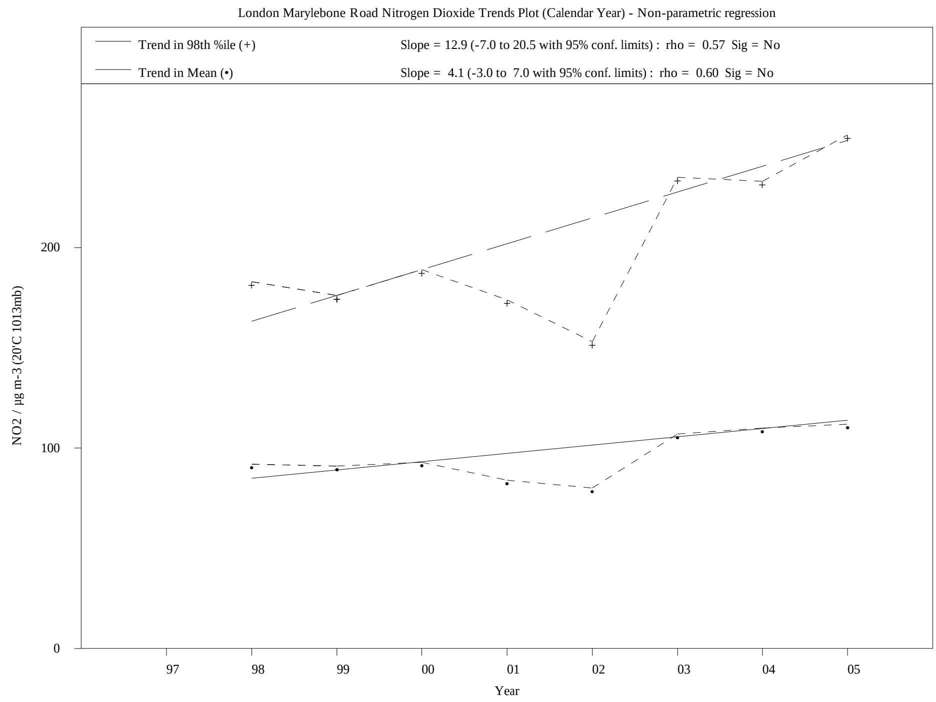
Urban Background Site
(*Aberdeen)*



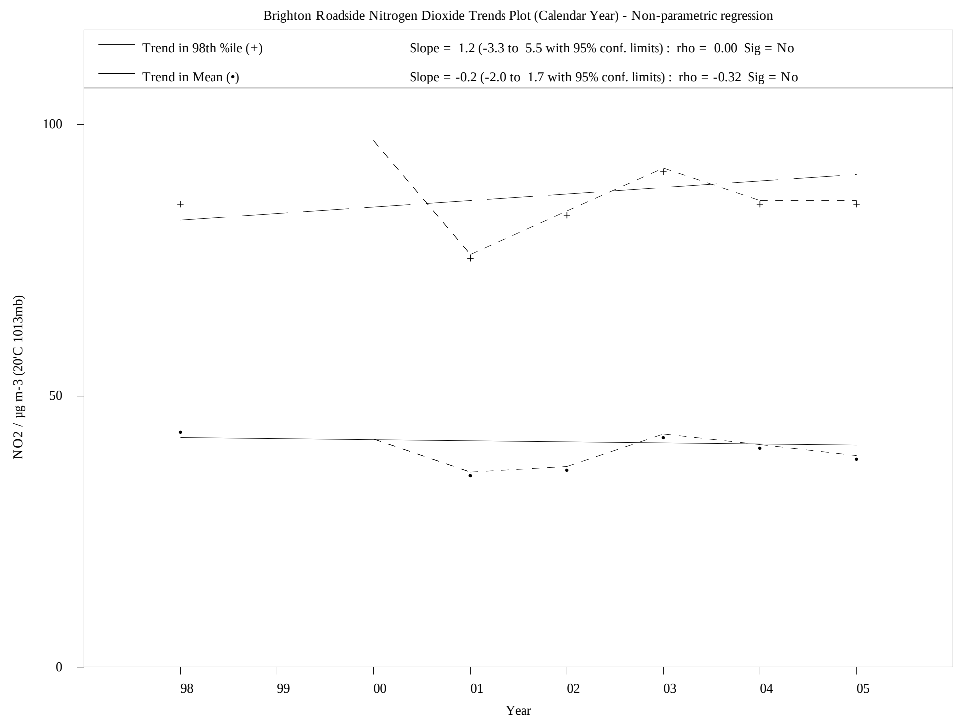
Rural Site
(Harwell)

12.8 Trends in annual concentrations

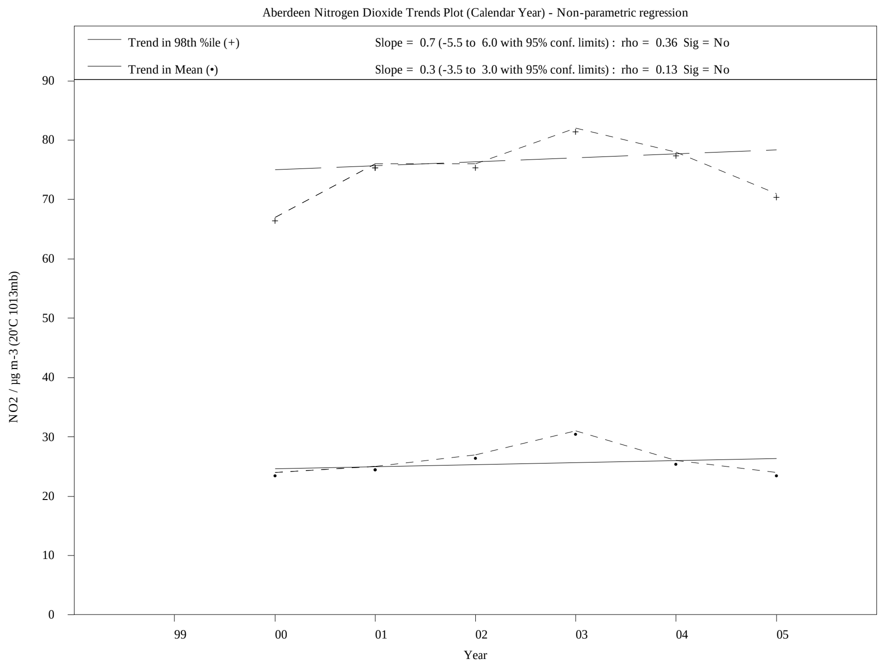
Statistically significant trends in concentrations are shown for sites with at ≥5 years of measurement.



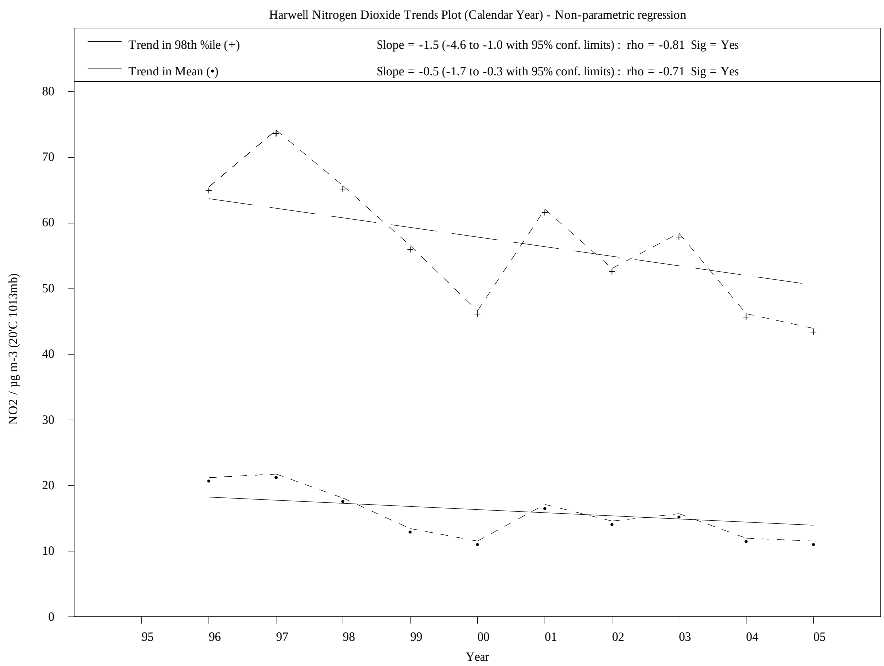
Kerbside Site
(*Marylebone Road)*



Roadside Site
(Brighton)



Urban Background
(Aberdeen)



Rural Site
(Harwell)

12.9 Nitrogen Dioxide Statistical Summary 2005

i) ANNUAL STATISTICS- I

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	99.8%ile of hourly means µg m^{-3}
England					
Barnsley Gawber	UB	20	81.0	132	94
Bath Roadside	RD	64	93.8	208	170
Billingham	I	27	97.5	252	147
Birmingham Centre	UC	33	81.1	128	99
Birmingham Tyburn	UB	34	99.0	212	147
Blackpool Marton	UB	19	52.1	105	90
Bolton	UB	25	58.9	111	90
Bournemouth	UB	18	94.4	118	82
Bradford Centre	UC	29	88.4	139	109
Brentford Roadside	RD	49	99.4	250	172
Brighton Preston Park	UB	22	96.3	134	94
Brighton Roadside	RD	39	99.0	164	118
Bristol Centre	UC	34	68.7	185	115
Bristol Old Market	RD	60	98.9	258	204
Bury Roadside	RD	64	90.4	183	162
Cambridge Roadside	RD	45	96.4	239	109
Camden Kerbside	KB	76	84.8	308	204
Canterbury	UB	17	95.5	118	71
Coventry Memorial Park	UB	22	98.9	134	101
Exeter Roadside	RD	43	83.4	189	155
Glazebury	SU	17.8	91.6	144.2	112.7
Haringey Roadside	RD	43	97.0	202	139
Harwell	RU	11.6	91.4	87.7	63.6
High Muffles	RU	7.5	88.7	61.1	54.6
Hove Roadside	RD	36	95.7	139	107
Hull Freetown	UC	21	66.2	97	82
Ladybower	RU	8.6	91.8	68.8	47.9
Leamington Spa	UB	25	69.8	118	88
Leeds Centre	UC	31	91.9	162	97
Leicester Centre	UC	33	97.0	201	136
Leominster	SU	---	42.4	90	---
Liverpool Speke	UB	24	98.2	149	113
London A3 Roadside	RD	61	98.0	525	212
London Bexley	SU	36	95.3	168	124
London Bloomsbury	UC	57	93.8	222	124
London Brent	UB	33	89.0	180	128
London Bromley	RD	49	94.9	202	141
London Cromwell Road 2	RD	79	93.7	246	183
London Eltham	SU	29	84.5	141	99
London Hackney	UC	49	97.2	260	191
London Harlington	A	38	99.0	202	113
London Hillingdon	SU	45	93.6	185	132
London Lewisham	UC	51	99.2	233	174
London Marylebone Road	KB	112	97.7	363	311
London N. Kensington	UB	40	95.8	237	185
London Southwark	UC	49	98.7	183	139
London Teddington	UB	25.5	94.6	125.5	97.6
London Wandsworth	UC	54	96.4	262	166
London Westminster	UB	48	82.6	183	130
Lullington Heath	RU	10.1	86.1	79.1	62.1
Manchester Piccadilly	UC	---	48.6	279	---
Manchester South	SU	---	6.5	59	---
Manchester Town Hall	UB	43	94.9	183	141
Market Harborough	RU	12.7	93.2	72.6	59.2
Middlesbrough	I	25	92.6	514	124
Newcastle Centre	UC	28	95.2	166	92

ii) EXCEEDENCE STATISTICS- I

Site	Moderate band	Days	High band	Days	Very High band	Days	Air Quality Standard (Annual Mean)	Daughter Directive Hourly Mean and Standard	Days
England									
Barnsley Gawber	0	0	0	0	0	0	0	0	0
Bath Roadside	0	0	0	0	0	0	**1**	**3**	**3**
Billingham	0	0	0	0	0	0	0	**3**	**3**
Birmingham Centre	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	**2**	**1**
Blackpool Marton	0	0	0	0	0	0	0	0	0
Bolton	0	0	0	0	0	0	0	0	0
Bournemouth	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0
Brentford Roadside	0	0	0	0	0	0	**1**	**3**	**3**
Brighton Preston Park	0	0	0	0	0	0	0	0	0
Brighton Roadside	0	0	0	0	0	0	0	0	0
Bristol Centre	0	0	0	0	0	0	0	0	0
Bristol Old Market	0	0	0	0	0	0	**1**	**22**	**8**
Bury Roadside	0	0	0	0	0	0	**1**	0	0
Cambridge Roadside	0	0	0	0	0	0	**1**	**1**	**1**
Camden Kerbside	1	1	0	0	0	0	**1**	**17**	**11**
Canterbury	0	0	0	0	0	0	0	0	0
Coventry Memorial Park	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	**1**	0	0
Glazebury	0	0	0	0	0	0	0	0	0
Haringey Roadside	0	0	0	0	0	0	**1**	**1**	**1**
Harwell	0	0	0	0	0	0	0	0	0
High Muffles	0	0	0	0	0	0	0	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0
Ladybower	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	**1**	**1**
Leominster	0	0	0	0	0	0	---	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0
London A3 Roadside	3	1	0	0	0	0	**1**	**23**	**6**
London Bexley	0	0	0	0	0	0	0	0	0
London Bloomsbury	0	0	0	0	0	0	**1**	**1**	**1**
London Brent	0	0	0	0	0	0	0	0	0
London Bromley	0	0	0	0	0	0	**1**	**1**	**1**
London Cromwell Road 2	0	0	0	0	0	0	**1**	**9**	**4**
London Eltham	0	0	0	0	0	0	0	0	0
London Hackney	0	0	0	0	0	0	**1**	**15**	**5**
London Harlington	0	0	0	0	0	0	0	**1**	**1**
London Hillingdon	0	0	0	0	0	0	**1**	0	0
London Lewisham	0	0	0	0	0	0	**1**	**3**	**2**
London Marylebone Road	51	25	0	0	0	0	**1**	**853**	**155**
London N. Kensington	0	0	0	0	0	0	0	**14**	**3**
London Southwark	0	0	0	0	0	0	**1**	0	0
London Teddington	0	0	0	0	0	0	0	0	0
London Wandsworth	0	0	0	0	0	0	**1**	**10**	**2**
London Westminster	0	0	0	0	0	0	**1**	0	0
Lullington Heath	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	---	**6**	**3**
Manchester South	0	0	0	0	0	0	---	0	0
Manchester Town Hall	0	0	0	0	0	0	**1**	0	0
Market Harborough	0	0	0	0	0	0	0	0	0
Middlesbrough	1	1	0	0	0	0	0	**4**	**4**
Newcastle Centre	0	0	0	0	0	0	0	0	0

iii) ANNUAL STATISTICS- II

Site	Site type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	99.8%ile of hourly means µg m^{-3}
Northampton	UB	23	52.0	101	80
Norwich Centre	UC	23	83.1	82	71
Norwich Forum Roadside		34	70.1	105	88
Norwich Roadside	RD	---	11.8	88	---
Nottingham Centre	UC	33	91.9	149	113
Oxford Centre Roadside	RD	67	97.7	246	191
Plymouth Centre	UC	25	98.0	287	94
Portsmouth	UB	23	98.0	136	88
Preston	UB	22	73.9	71	65
Reading New Town	UB	23	95.3	132	96
Redcar	SU	25	50.7	88	82
Rochester	RU	18.8	95.3	89.8	75.3
Rotherham Centre	UC	34	92.5	164	118
Salford Eccles	I	39	83.2	208	160
Sandwell West Bromwich	UB	27	96.2	136	101
Sheffield Centre	UC	35	66.0	88	82
Sheffield Tinsley	I	32	97.4	244	145
Somerton	RU	8.3	87.1	55.4	50.8
Southampton Centre	UC	31	87.2	113	88
Southend-on-Sea	UB	23	91.9	149	88
Southwark Roadside	RD	60	98.8	218	162
St Osyth	RU	16.2	93.0	86.1	72.4
Stockport Shaw Heath	UB	31	91.0	145	118
Stockton-on-Tees Yarm	RD	34	99.1	275	117
Stoke-on-Trent Centre	UC	33	95.6	166	132
Sunderland Silksworth	UB	16	92.7	124	84
Thurrock	UB	35	84.7	139	107
Tower Hamlets Roadside	RD	61	99.0	202	147
Walsall Alumwell	UB	42	99.0	311	145
Walsall Willenhall	SU	28	69.6	147	118
West London	UB	50	94.6	202	134
Wicken Fen	RU	10.6	98.7	75.4	57.1
Wigan Centre	UB	25	97.6	118	97
Wirral Tranmere	UB	17	63.9	120	84
Wolverhampton Centre	UC	28	91.6	267	117
Yarner Wood	RU	9.2	81.5	45.5	37.4
N Ireland					
Belfast Centre	UC	33	54.5	254	168
Derry	UB	12	92.0	107	61
Scotland					
Aberdeen	UB	24	96.6	159	94
Bush Estate	RU	---	45.7	66.1	---
Dumfries	RD	36	96.8	243	134
Edinburgh St Leonards	UC	25	96.0	134	94
Eskdalemuir	RU	3.8	92.8	47.0	25.2
Glasgow Centre	UC	33	95.6	225	143
Glasgow City Chambers	UB	46	94.6	187	136
Glasgow Kerbside	KB	62	98.3	269	189
Grangemouth	I	16	99.2	120	101
Inverness	RD	21	95.1	130	99
Wales					
Aston Hill	RU	4.7	97.8	75.6	44.7
Cardiff Centre	UC	35	56.3	117	109
Cwmbran	UB	17	99.3	94	80
Narberth	RU	5.0	92.2	57.7	41.4
Port Talbot	UB	19	97.1	101	74
Swansea	UC	34	94.7	138	105
Wrexham	RD	19	94.6	113	76

iv) EXCEEDENCE STATISTICS- II

Site	Moderate band	Days	High band	Days	Very High band	Days	Air Quality Standard (Annual Mean)	Daughter Directive Hourly Mean and Standard	Days
Northampton	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0
Norwich Forum Roadside	0	0	0	0	0	0	0	0	0
Norwich Roadside	0	0	0	0	0	0	---	0	0
Nottingham Centre	0	0	0	0	0	0	0	0	0
Oxford Centre Roadside	0	0	0	0	0	0	**1**	**12**	**7**
Plymouth Centre	1	1	0	0	0	0	0	**2**	**2**
Portsmouth	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	0	0
Redcar	0	0	0	0	0	0	0	0	0
Rochester	0	0	0	0	0	0	0	0	0
Rotherham Centre	0	0	0	0	0	0	0	0	0
Salford Eccles	0	0	0	0	0	0	0	**4**	**2**
Sandwell West Bromwich	0	0	0	0	0	0	0	0	0
Sheffield Centre	0	0	0	0	0	0	0	0	0
Sheffield Tinsley	0	0	0	0	0	0	0	**3**	**1**
Somerton	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0
Southwark Roadside	0	0	0	0	0	0	**1**	**2**	**2**
St Osyth	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0
Stockton-on-Tees Yarm	0	0	0	0	0	0	0	**1**	**1**
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0
Sunderland Silksworth	0	0	0	0	0	0	0	0	0
Thurrock	0	0	0	0	0	0	0	0	0
Tower Hamlets Roadside	0	0	0	0	0	0	**1**	**1**	**1**
Walsall Alumwell	2	1	0	0	0	0	**1**	**3**	**1**
Walsall Willenhall	0	0	0	0	0	0	0	0	0
West London	0	0	0	0	0	0	**1**	**1**	**1**
Wicken Fen	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0
Wirral Tranmere	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	0	0	0	0	0	0	0	**1**	**1**
Yarner Wood	0	0	0	0	0	0	0	0	0
N Ireland									
Belfast Centre	0	0	0	0	0	0	0	**4**	**3**
Derry	0	0	0	0	0	0	0	0	0
Scotland									
Aberdeen	0	0	0	0	0	0	0	0	0
Bush Estate	0	0	0	0	0	0	---	0	0
Dumfries	0	0	0	0	0	0	0	**1**	**1**
Edinburgh St Leonards	0	0	0	0	0	0	0	0	0
Eskdalemuir	0	0	0	0	0	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	**1**	**1**
Glasgow City Chambers	0	0	0	0	0	0	**1**	0	0
Glasgow Kerbside	0	0	0	0	0	0	**1**	**9**	**5**
Grangemouth	0	0	0	0	0	0	0	0	0
Inverness	0	0	0	0	0	0	0	0	0
Wales									
Aston Hill	0	0	0	0	0	0	0	0	0
Cardiff Centre	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0
Narberth	0	0	0	0	0	0	0	0	0
Port Talbot	0	0	0	0	0	0	0	0	0
Swansea	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0

13. NO_x- Measurement Sites, Instrumentation and Statistics

13.1 Measurement Method

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide (NO_2).

13.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak NO_2
- API M200
- Environnement AC 31M
- Horiba APNA 360
- Monitor Labs 9841
- Rotork 447
- Thermo Electron 42

*Defra does not give approval or endorsement for any products or equipment

13.3 Data Quality Requirements of EC Directive 1999/30/EC

Uncertainty 15%
Minimum data capture 90%

13.4 Objectives and Bandings

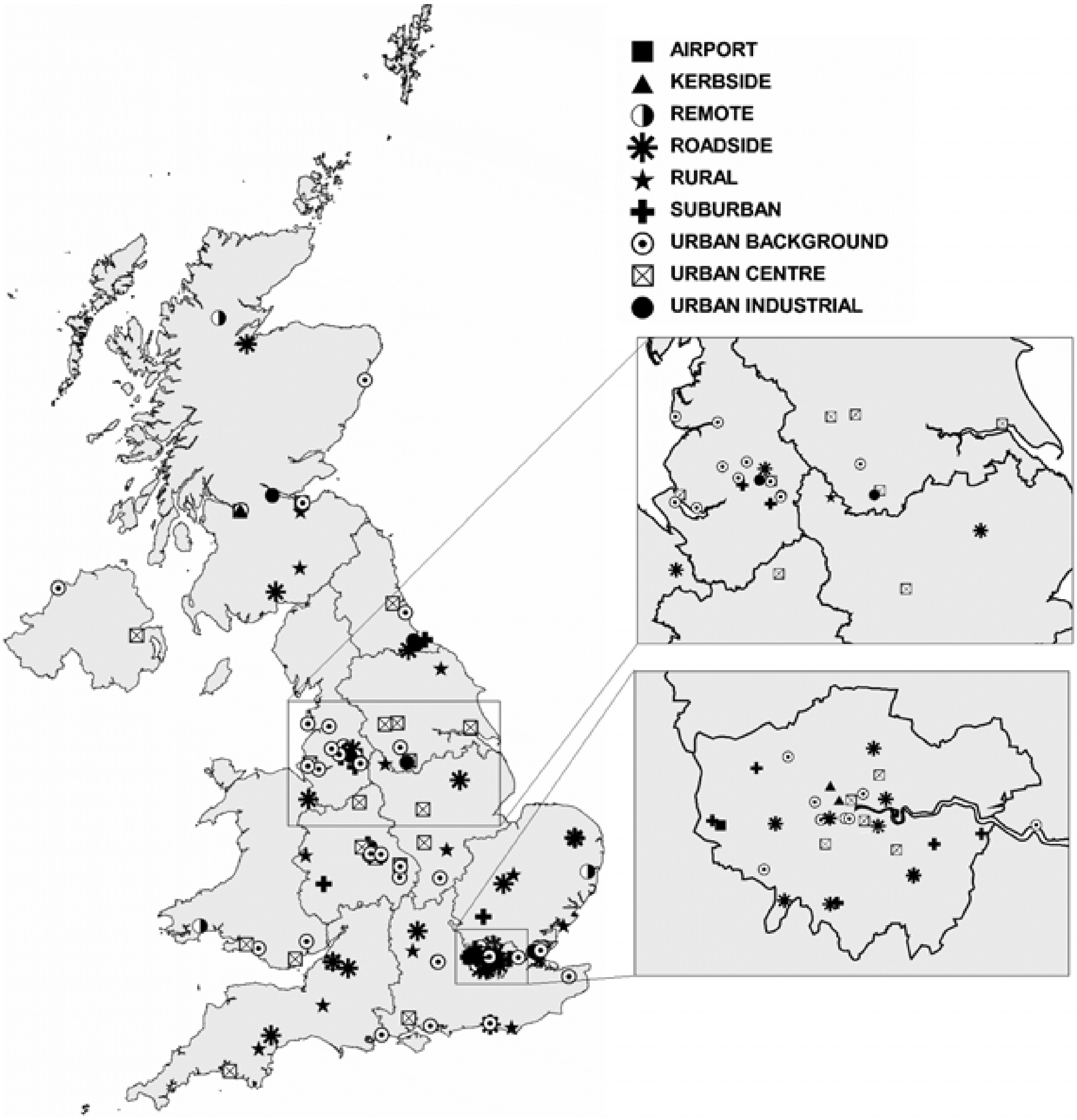
Summary of objectives of the National Air Quality Strategy			
	Objective*	**Measured as**	**To be achieved by**
	30 µg m^{-3}	Annual Mean	31 December 2000

*Assuming NO_x is taken as NO_2. Also note this objective is for the protection of vegetation and ecosystems

No bandings are set for oxides of nitrogen, as there are no known short-term effects of this pollutant.

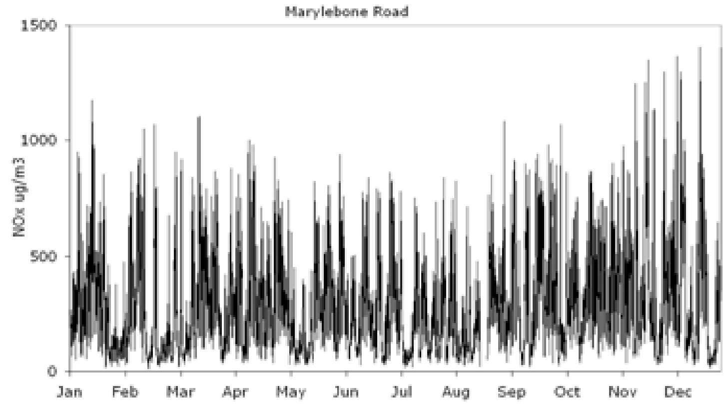
13.5 Site Locations

UK AUTOMATIC NITROGEN OXIDES MONITORING SITES 2005

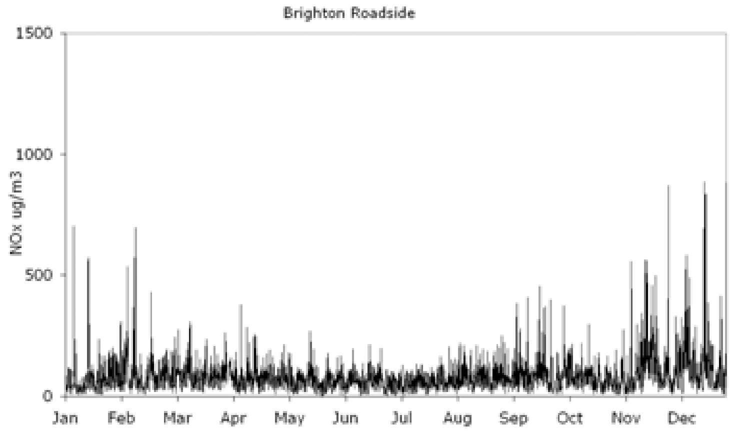


13.6 Hourly Average Concentrations

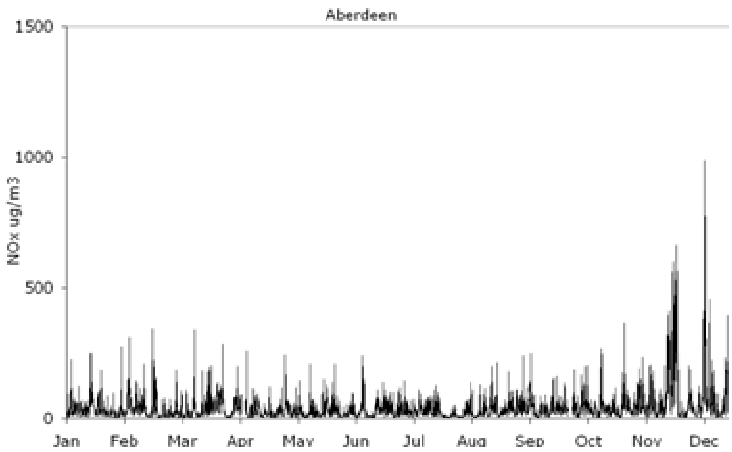
These figures show time series graphs of hourly average nitrogen oxides concentrations at four *typical* site types for 2005.



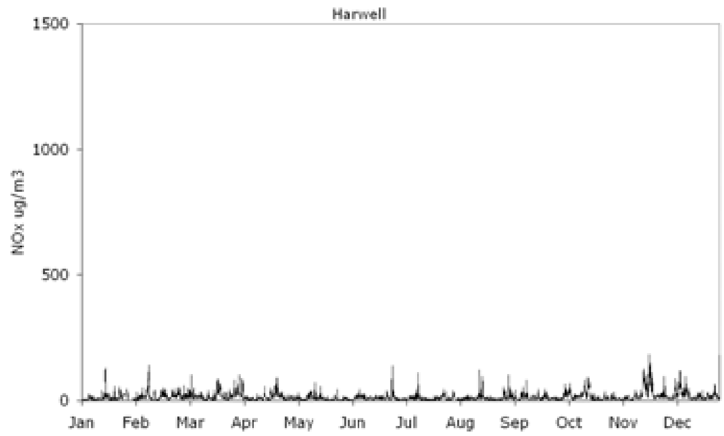
Kerbside Site
(*Marylebone Road)*



Roadside Site
(Brighton)



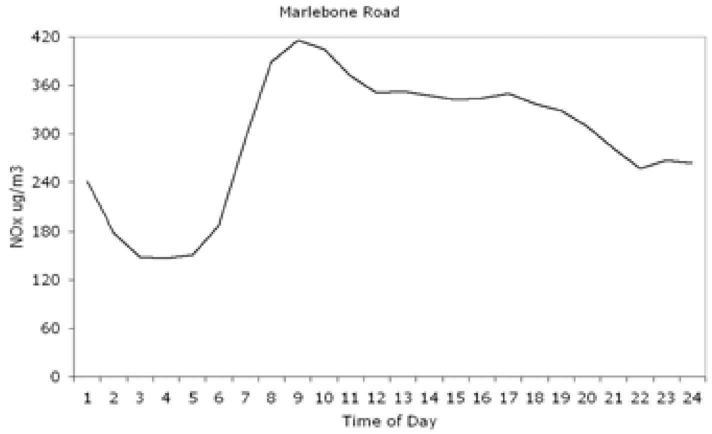
Urban Background Site
(*Aberdeen)*



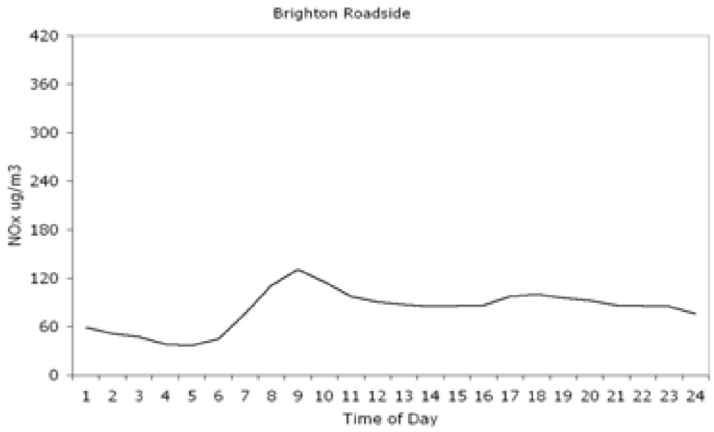
Rural Site
(Harwell)

13.7 Diurnal Variations

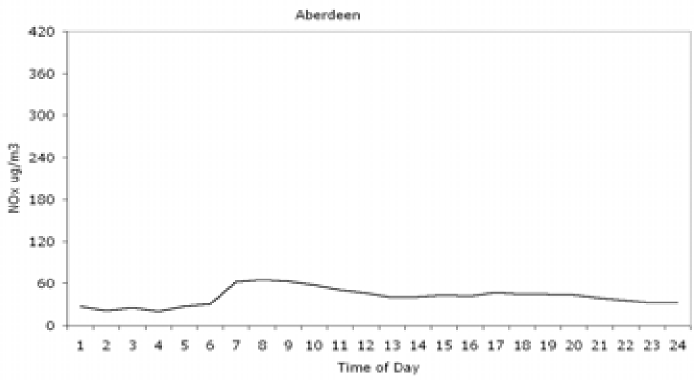
These figures show how nitrogen oxides concentrations vary on average for each hour of day during the year, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



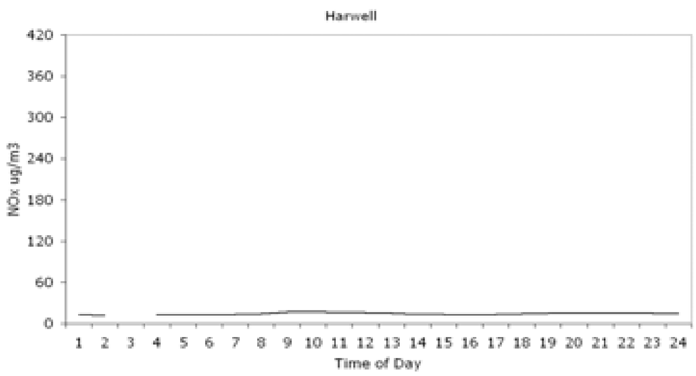
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Brighton)*



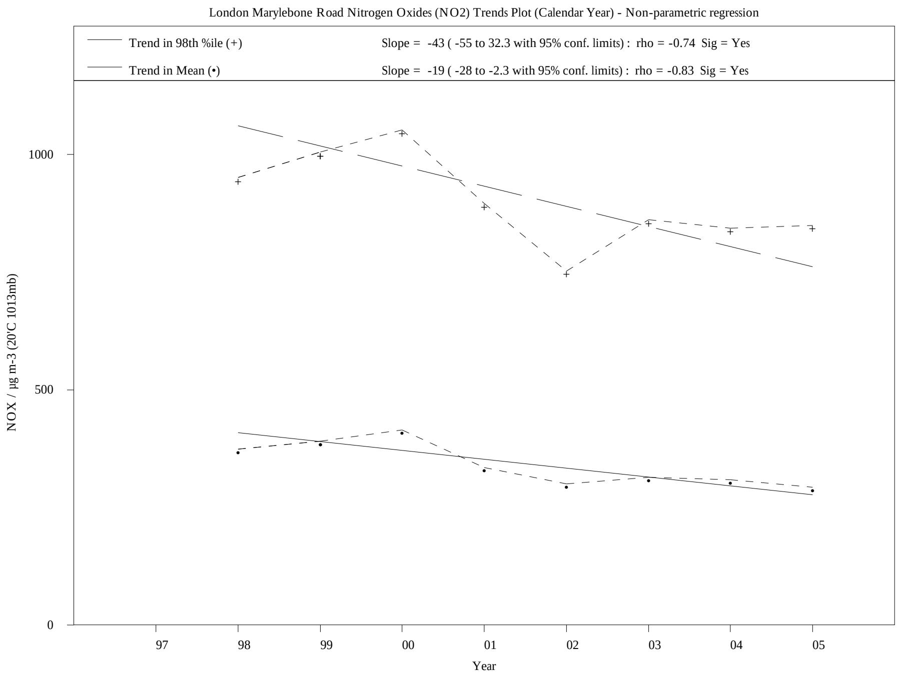
Urban Background Site
(*Aberdeen)*



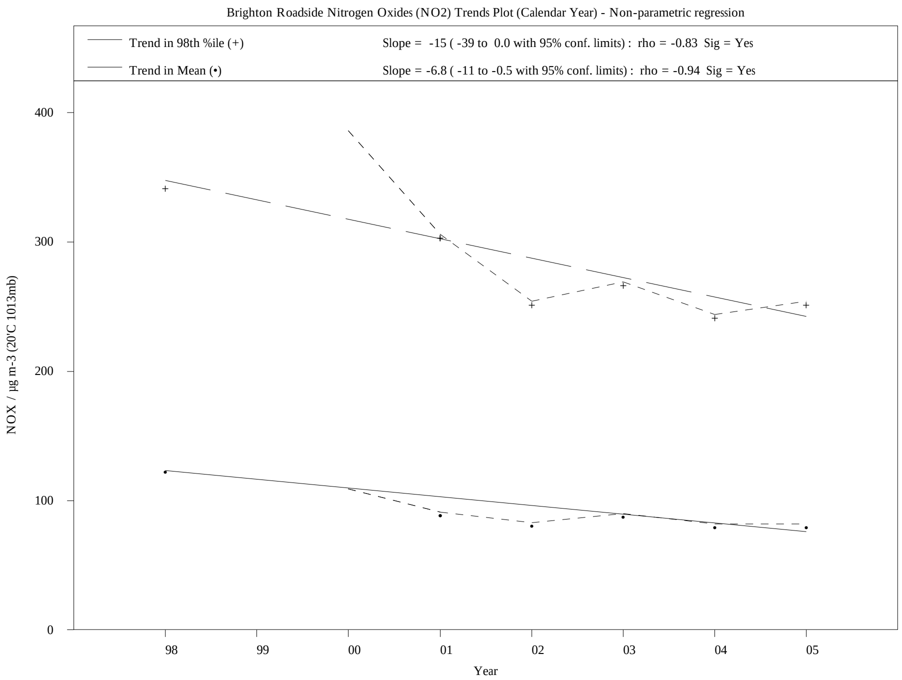
Rural Site
(Harwell)

13.8 Trends in annual concentrations

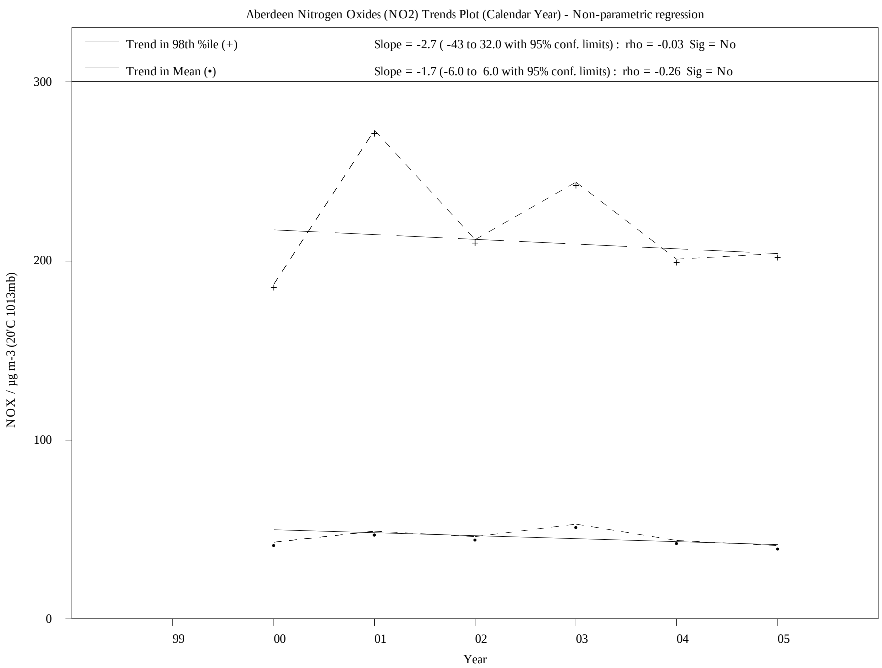
Statistically significant trends in concentration are shown for sites with at least ≥5 years of measurement.



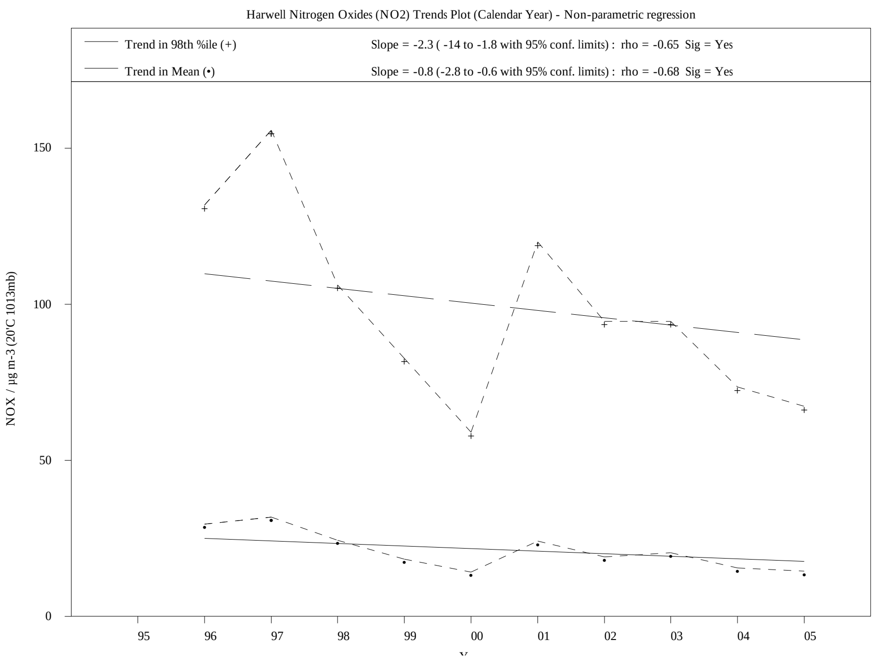
Kerbside Site
(*Marylebone Road*)



Roadside site
(*Brighton*)



Urban Background
(*Aberdeen)*



Rural Site
(Harwell)

13.9 Nitrogen Oxides Statistical Summary 2005

i) ANNUAL STATISTICS- I

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England				
Barnsley Gawber	UB	37	81.0	926
Bath Roadside	RD	179	93.8	984
Billingham	I	50	97.5	989
Birmingham Centre	UC	53	81.1	558
Birmingham Tyburn	UB	66	99.0	1371
Blackpool Marton	UB	36	52.1	581
Bolton	UB	35	58.9	636
Bournemouth	UB	26	94.4	523
Bradford Centre	UC	58	88.4	1112
Brentford Roadside	RD	147	99.4	1526
Brighton Preston Park	UB	34	96.3	800
Brighton Roadside	RD	82	99.0	884
Bristol Centre	UC	68	68.7	1060
Bristol Old Market	RD	171	98.9	1253
Bury Roadside	RD	188	90.4	1186
Cambridge Roadside	RD	113	96.4	701
Camden Kerbside	KB	193	84.8	1629
Canterbury	UB	29	95.5	481
Coventry Memorial Park	UB	34	98.9	739
Exeter Roadside	RD	99	83.4	888
Glazebury	SU	31.7	91.6	764.6
Haringey Roadside	RD	91	97.0	1203
Harwell	RU	14.6	91.4	184.3
High Muffles	RU	9.7	88.7	121.9
Hove Roadside	RD	65	95.7	697
Hull Freetown	UC	33	66.2	288
Ladybower	RU	10.5	91.8	124.0
Leamington Spa	UB	40	69.8	583
Leeds Centre	UC	63	91.9	892
Leicester Centre	UC	59	97.0	1010
Leominster		---	42.4	420
Liverpool Speke	UB	39	98.2	846
London A3 Roadside	RD	158	98.0	1713
London Bexley	SU	63	95.3	1215
London Bloomsbury	UC	103	93.8	1115
London Brent	UB	56	89.0	1198
London Bromley	RD	87	94.9	796
London Cromwell Road 2	RD	187	93.7	1242
London Eltham	SU	46	84.5	741
London Hackney	UC	92	97.2	1390
London Harlington	A	72	99.0	1310
London Hillingdon	SU	106	93.6	1268
London Lewisham	UC	104	99.2	987
London Marylebone Road	KB	293	97.7	1406
London N. Kensington	UB	67	95.8	1083
London Southwark	UC	88	98.7	913
London Teddington	UB	42.7	94.6	763.6
London Wandsworth	UC	115	96.4	1268
London Westminster	UB	84	82.6	921
Lullington Heath	RU	12.3	86.1	126.4
Manchester Piccadilly	UC	---	48.6	1190
Manchester South	SU	---	6.5	344
Manchester Town Hall	UB	71	94.9	942
Market Harborough	RU	14.8	93.2	216.2
Middlesbrough	I	36	92.6	1028
Newcastle Centre	UC	49	95.2	1083
Northampton	UB	36	52.0	489
Norwich Centre	UC	35	83.1	510
Norwich Forum Roadside	RD	64	70.1	623

ii) EXCEEDENCE STATISTICS- I

Site	Daughter Directive Ecosystem and Air Quality Standard (Annual Mean) > 30 µg m^{-3}
England	
Barnsley Gawber	**1**
Bath Roadside	**1**
Billingham	**1**
Birmingham Centre	**1**
Birmingham Tyburn	**1**
Blackpool Marton	**1**
Bolton	**1**
Bournemouth	0
Bradford Centre	**1**
Brentford Roadside	**1**
Brighton Preston Park	**1**
Brighton Roadside	**1**
Bristol Centre	**1**
Bristol Old Market	**1**
Bury Roadside	**1**
Cambridge Roadside	**1**
Camden Kerbside	**1**
Canterbury	0
Coventry Memorial Park	**1**
Exeter Roadside	**1**
Glazebury	**1**
Haringey Roadside	**1**
Harwell	0
High Muffles	0
Hove Roadside	**1**
Hull Freetown	**1**
Ladybower	0
Leamington Spa	**1**
Leeds Centre	**1**
Leicester Centre	**1**
Leominster	---
Liverpool Speke	**1**
London A3 Roadside	**1**
London Bexley	**1**
London Bloomsbury	**1**
London Brent	**1**
London Bromley	**1**
London Cromwell Road 2	**1**
London Eltham	**1**
London Hackney	**1**
London Harlington	**1**
London Hillingdon	**1**
London Lewisham	**1**
London Marylebone Road	**1**
London N. Kensington	**1**
London Southwark	**1**
London Teddington	**1**
London Wandsworth	**1**
London Westminster	**1**
Lullington Heath	0
Manchester Piccadilly	---
Manchester South	---
Manchester Town Hall	**1**
Market Harborough	0
Middlesbrough	**1**
Newcastle Centre	**1**
Northampton	**1**
Norwich Centre	**1**
Norwich Forum Roadside	**1**

iii) ANNUAL STATISTICS- II

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
Norwich Roadside	RD	---	11.8	405
Nottingham Centre	UC	62	91.9	1148
Oxford Centre Roadside	RD	182	97.7	1291
Plymouth Centre	UC	42	98.0	844
Portsmouth	UB	38	98.0	919
Preston	UB	42	73.9	800
Reading New Town	UB	40	95.3	928
Redcar	SU	36	50.7	464
Rochester	RU	28.0	95.3	417.3
Rotherham Centre	UC	65	92.5	1129
Salford Eccles	I	69	83.2	1133
Sandwell West	UB	41	96.2	850
Sheffield Centre	UC	55	66.0	411
Sheffield Tinsley	I	74	97.4	1643
Somerton	RU	10.5	87.1	115.4
Southampton Centre	UC	67	87.2	1171
Southend-on-Sea	UB	37	91.9	579
Southwark Roadside	RD	137	98.8	1060
St Osyth	RU	20.1	93.0	225.0
Stockport Shaw Heath	UB	52	91.0	712
Stockton-on-Tees Yarm	RD	110	99.1	1259
Stoke-on-Trent Centre	UC	68	95.6	1631
Sunderland Silksworth	UB	24	92.7	701
Thurrock	UB	65	84.7	1039
Tower Hamlets Roadside	RD	147	99.0	1175
Walsall Alumwell	UB	79	99.0	1988
Walsall Willenhall	SU	40	69.6	447
West London	UB	85	94.6	976
Wicken Fen	RU	15.3	98.7	212.4
Wigan Centre	UB	46	97.6	837
Wirral Tranmere	UB	27	63.9	447
Wolverhampton Centre	UC	53	91.6	930
Yarner Wood	RU	10.4	81.5	57.3
N Ireland				
Belfast Centre	UC	67	54.5	1364
Derry	UB	18	92.0	800
Scotland				
Aberdeen	UB	41	96.6	987
Bush Estate	RU	---	45.7	237.8
Dumfries	RD	90	96.8	844
Edinburgh St Leonards	UC	36	96.0	611
Eskdalemuir	RU	4.7	92.8	48.5
Glasgow Centre	UC	66	95.6	1303
Glasgow City Chambers	UB	98	94.6	1043
Glasgow Kerbside	KB	251	98.3	2122
Grangemouth	I	30	99.2	724
Inverness	RD	44	95.1	642
Wales				
Aston Hill	RU	6.1	97.8	102.9
Cardiff Centre	UC	59	56.3	626
Cwmbran	UB	25	99.3	520
Narberth	RU	6.6	92.2	81.6
Port Talbot	UB	30	97.1	607
Swansea	UC	77	94.7	626
Wrexham	RD	38	94.6	749

iv) EXCEEDENCE STATISTICS- II

Site	Daughter Directive Ecosystem and Air Quality Standard (Annual Mean) > 30 µg m^{-3}
Norwich Roadside	---
Nottingham Centre	**1**
Oxford Centre Roadside	**1**
Plymouth Centre	**1**
Portsmouth	**1**
Preston	**1**
Reading New Town	**1**
Redcar	**1**
Rochester	0
Rotherham Centre	**1**
Salford Eccles	**1**
Sandwell West Bromwich	**1**
Sheffield Centre	**1**
Sheffield Tinsley	**1**
Somerton	0
Southampton Centre	**1**
Southend-on-Sea	**1**
Southwark Roadside	**1**
St Osyth	0
Stockport Shaw Heath	**1**
Stockton-on-Tees Yarm	**1**
Stoke-on-Trent Centre	**1**
Sunderland Silksworth	0
Thurrock	**1**
Tower Hamlets Roadside	**1**
Walsall Alumwell	**1**
Walsall Willenhall	**1**
West London	**1**
Wicken Fen	0
Wigan Centre	**1**
Wirral Tranmere	0
Wolverhampton Centre	**1**
Yarner Wood	0
N Ireland	
Belfast Centre	**1**
Derry	0
Scotland	
Aberdeen	**1**
Bush Estate	---
Dumfries	**1**
Edinburgh St Leonards	**1**
Eskdalemuir	0
Glasgow Centre	**1**
Glasgow City Chambers	**1**
Glasgow Kerbside	**1**
Grangemouth	0
Inverness	**1**
Wales	
Aston Hill	0
Cardiff Centre	**1**
Cwmbran	0
Narberth	0
Port Talbot	0
Swansea	**1**
Wrexham	**1**

14. PM_{10} - Measurement Sites, Instrumentation and Statistics

14.1 Measurement Methods

The tapered element oscillating microbalance (**TEOM**) system determines particulate concentration by continuously weighing particles deposited on a filter.
The **beta-gauge** (BAM) monitor consists of a paper band filter located between a source of beta rays and a radiation detector. A pump draws ambient air through the filter and the reduction in intensity of beta-radiation measured at the detector is proportional to the mass of particulate deposited on the filter.
The **Partisol** is a gravimetric sampler that collects daily samples onto a filter for subsequent weighing to determine the PM_{10} concentration.

14.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- R&P TEOM 1400
- R&P Partisol
- Met One BAM 1020

*Defra does not give approval or endorsement for any products or equipment

Please also see detailed information on particle measurements and conversion factors used in this report (Appendix 6).

14.3 Data Quality Requirements of EC Directive 1999/30/EC

Uncertainty 25%
Minimum data capture 90%

14.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Particles (PM_{10}) (gravimetric) All authorities	50 µg m^{-3} Not to be exceeded more than 35 times per year	Daily Mean	31 December 2005
	40 µg m^{-3}	Annual Mean	31 December 2005
Particles (PM_{10}) Authorities in Scotland only	50 µg m^{-3} Not to be exceeded more than 7 times per year	Daily Mean	31 December 2010
	18 µg m^{-3}	Annual Mean	31 December 2010

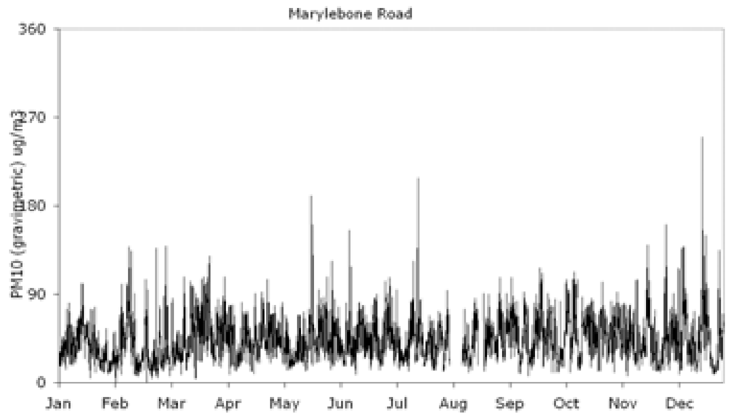
Air Quality Bands and Index Values		
Band	**Index**	**PM_{10} µg m^{-3} (Gravimetric)**
Low	1	0-21
	2	22-42
	3	43-64
Moderate	4	65-74
	5	75-86
	6	87-96
High	7	97-107
	8	108-118
	9	119-129
Very High	10	130 or more

14.5 Site Locations

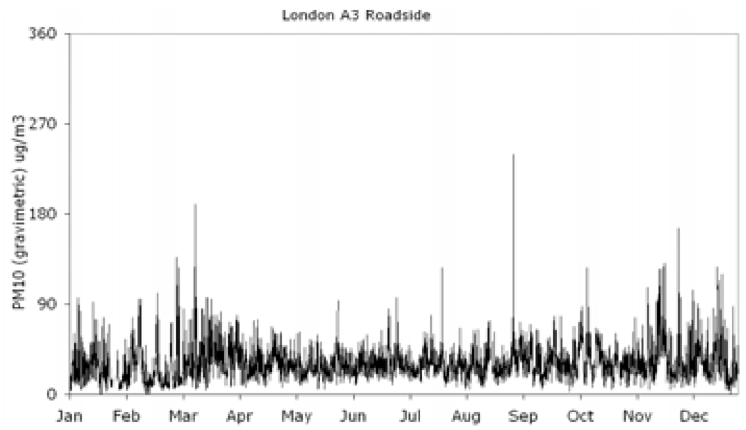
UK PM_{10} Monitoring Sites 2005

14.6 Hourly Average Concentrations

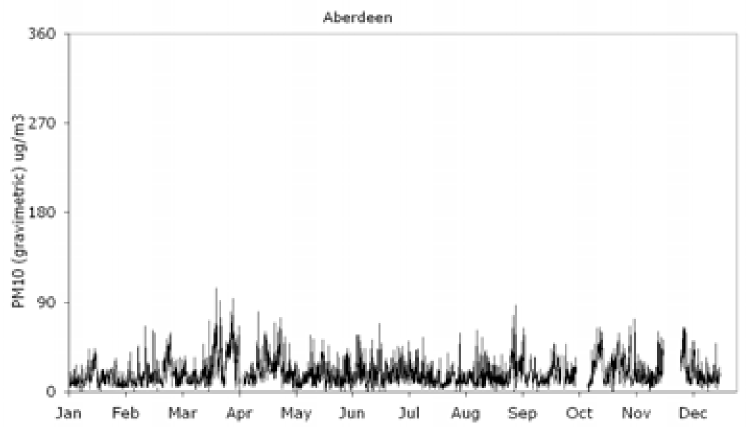
These figures show time series graphs of hourly average PM_{10} concentrations at four *typical* site types for 2005. Units are gravimetric equivalent (TEOM*1.3).



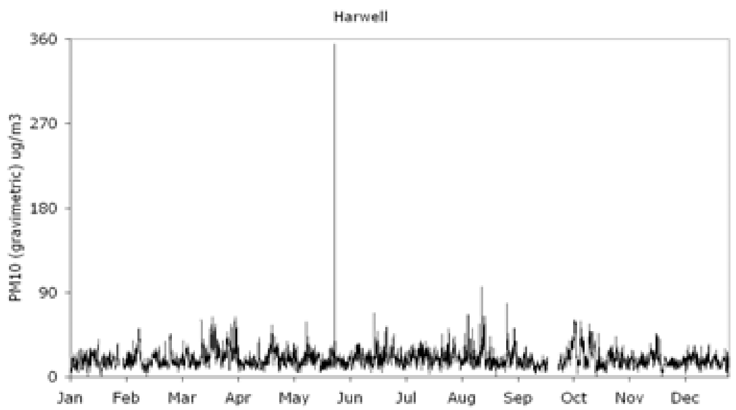
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*London A3)*



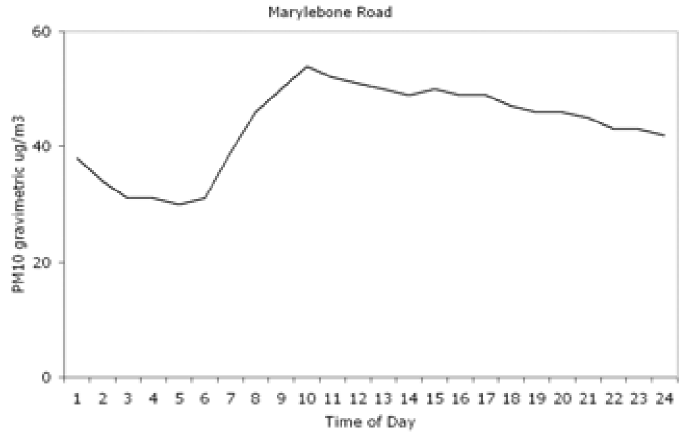
Urban Background Site
(*Aberdeen)*



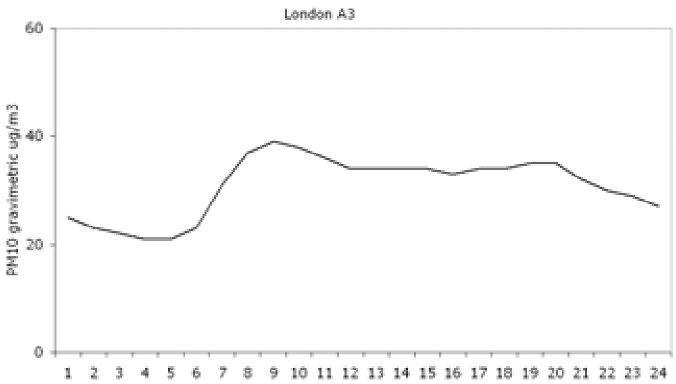
Rural Site
(Harwell)

14.7 Diurnal Variations

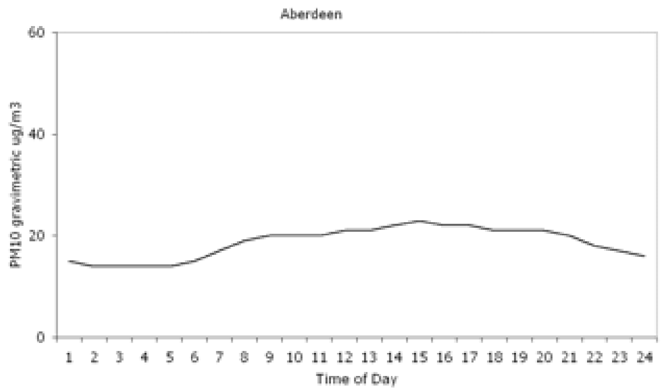
These figures show how PM_{10} concentrations vary on average for each hour of day during the year, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



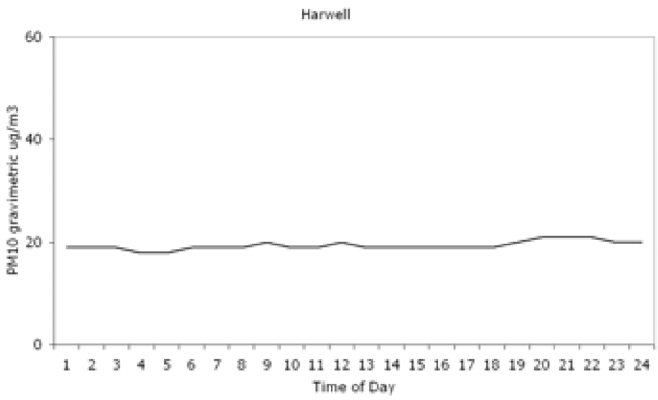
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*London A3)*

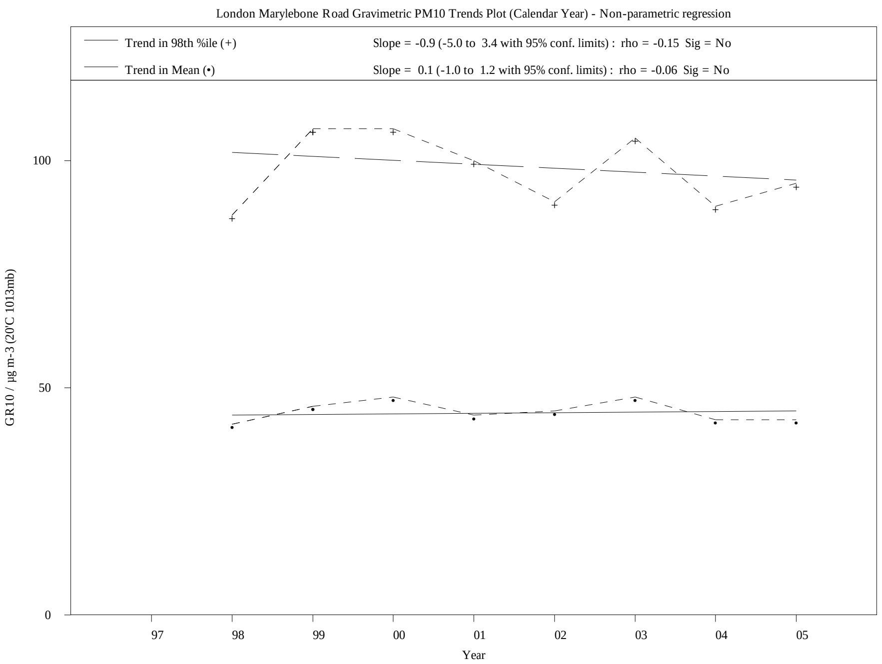


Urban Background Site
(*Aberdeen)*

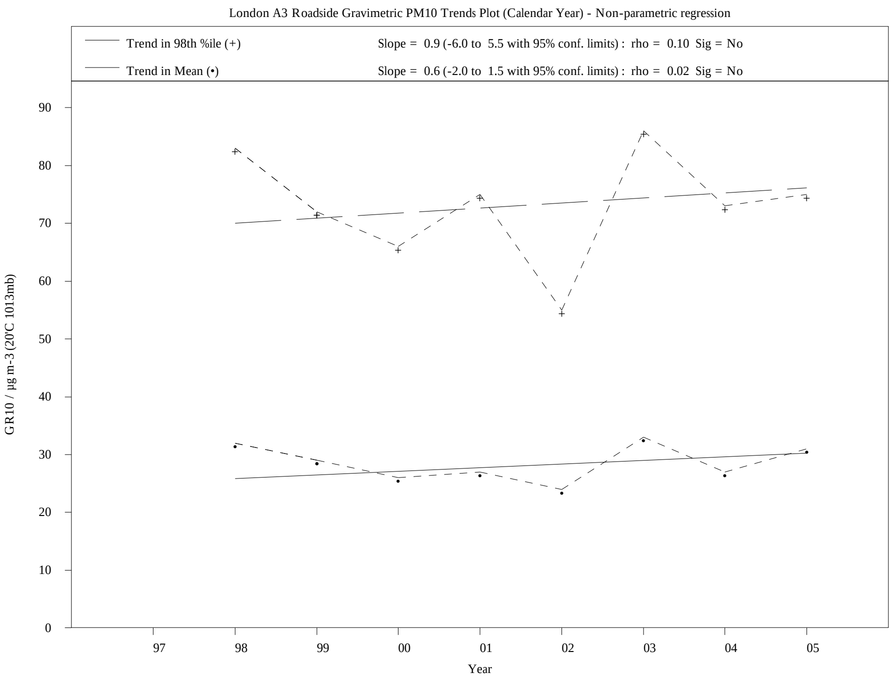


Rural Site
(Harwell)

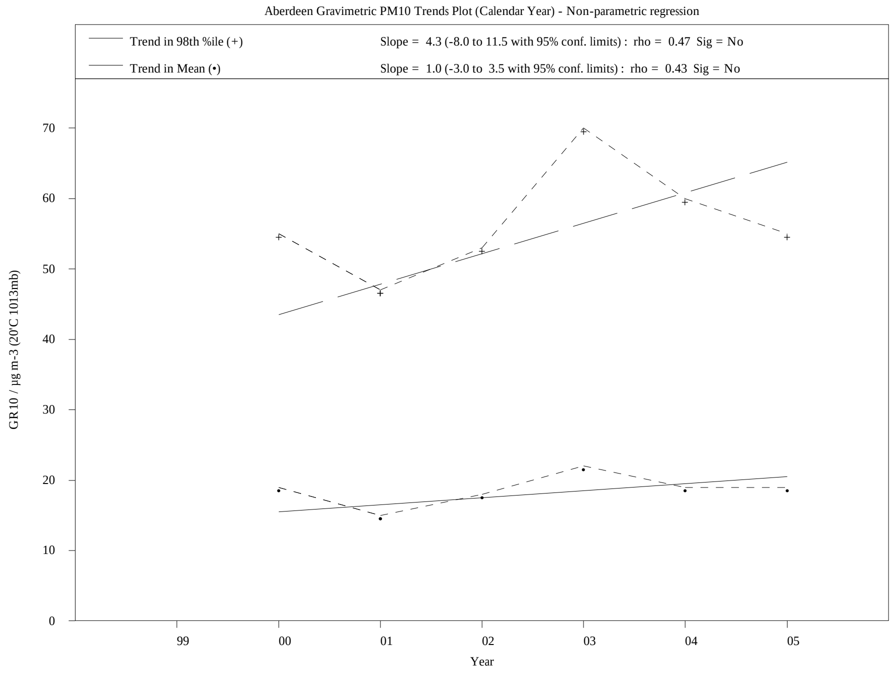
14.8 Trends in annual concentrations



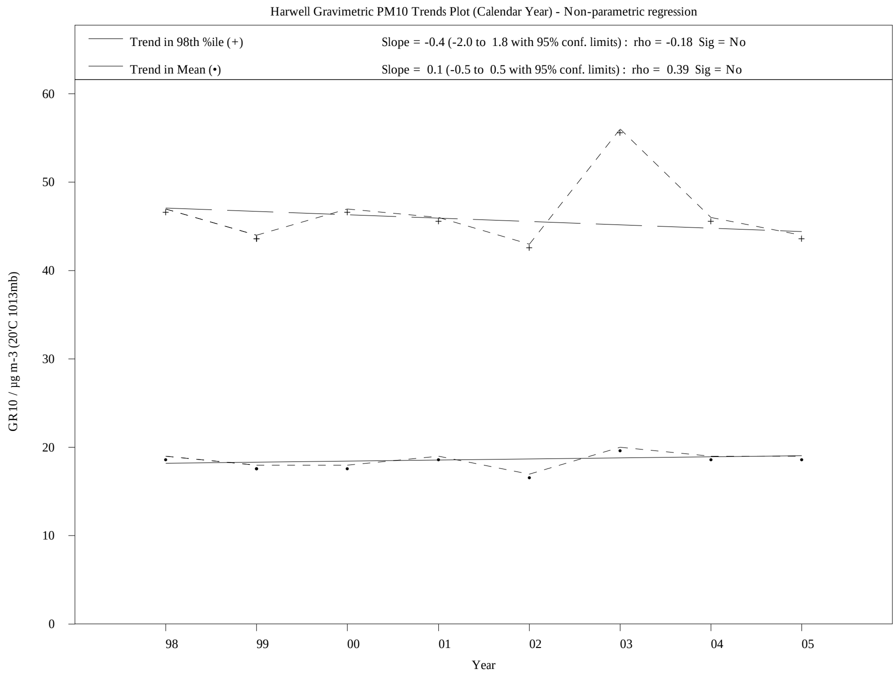
Kerbside Site
(*Marylebone Road*)



Roadside Site
(*London A3)*



Urban Background Site (*Aberdeen)*



Rural Site (*Harwell)*

14.9 PM_{10} Statistical Summary 2005

i) ANNUAL STATISTICS- I

Site	Site Type	Annual average µg m^{-3}	Annual data capture of hourly means % (for Partisol, capture of daily means)	Maximum hourly mean µg m^{-3}	Maximum running 24-hour mean µg m^{-3}	Date of maximum running 24-hour mean	90%ile of daily means µg m^{-3}	98%ile of daily means µg m^{-3}
England								
Birmingham Centre	UC	25	87.4	259	63	06/10/2005	38	48
Birmingham Tyburn	UB	22	98.6	131	74	20/11/2005	32	44
Blackpool Marton	UB	24	53.1	593	65	04/08/2005	33	44
Bolton	UB	20	96.5	213	64	21/11/2005	31	46
Bournemouth	UB	25 *	94.2	---	---	---	40	58
Bradford Centre	UC	32	92.8	774	168	15/12/2005	52	81
Brighton Roadside PM10	RD	35 *	93.7	---	---	---	51	72
Bristol Centre	UC	24	68.4	283	56	08/02/2005	39	44
Bury Roadside	RD	28	96.2	163	68	30/11/2005	42	53
Camden Kerbside	KB	37	96.8	254	88	20/11/2005	54	67
Canterbury	UB	23	99.1	264	63	06/10/2005	33	47
Coventry Memorial Park	UB	19	98.9	459	61	25/01/2005	30	42
Haringey Roadside	RD	26	95.6	198	68	10/12/2005	40	48
Harwell	RU	19	96.8	355	55	08/10/2005	28	37
Hull Freetown	UC	23	97.7	105	61	22/11/2005	35	43
Leamington Spa	UB	21	72.9	78	52	19/11/2005	31	42
Leeds Centre	UC	27	75.3	399	92	22/11/2005	43	59
Leicester Centre	UC	22	97.1	113	68	19/11/2005	31	43
Liverpool Speke	UB	20	96.9	118	65	21/11/2005	31	42
London A3 Roadside	RD	31	98.2	239	82	22/11/2005	44	61
London Bexley	SU	23	70.3	130	58	02/04/2005	35	49
London Bloomsbury	UC	27	94.6	107	65	08/10/2005	39	49
London Brent	UB	22	82.8	138	62	08/02/2005	34	42
London Eltham	SU	23	78.7	363	57	02/04/2005	36	46
London Harlington	A	25	84.9	230	62	08/02/2005	38	48
London Hillingdon	SU	27	96.1	150	70	08/02/2005	42	55
London Marylebone Road	KB	43	96.2	250	112	21/12/2005	63	74
London N. Kensington	UB	25	99.0	153	75	20/11/2005	38	48
London Westminster	UB	30 *	95.1	---	---	---	49	68
Manchester Piccadilly	UC	25	97.8	621	74	21/11/2005	38	52
Middlesbrough	I	27	95.7	906	116	06/09/2005	43	64
Newcastle Centre	UC	17	97.4	285	68	06/11/2005	27	40
Northampton	UB	19	98.3	113	49	31/03/2005	28	36
Northampton PM10	UB	25 *	94.2	---	---	---	41	59
Norwich Centre	UC	17	96.5	90	46	24/06/2005	25	34
Nottingham Centre	UC	23	96.9	155	95	22/11/2005	35	45
Plymouth Centre	UC	17	97.4	165	50	22/03/2005	28	38
Portsmouth	UB	22	98.7	90	53	21/12/2005	30	41
Preston	UB	17	94.9	150	45	31/03/2005	27	36
Reading New Town	UB	21	97.0	142	58	22/11/2005	31	40
Redcar	UB	24	94.7	261	86	02/02/2005	38	50
Rochester	SU	21	98.2	995	145	04/08/2005	33	44
Salford Eccles	RU	22	88.0	117	75	21/11/2005	35	49
Scunthorpe Town	I	25	98.1	205	92	22/03/2005	40	70
Sheffield Centre	UC	22	96.6	117	81	31/03/2005	35	49
Southampton Centre	UC	25	91.0	122	65	08/10/2005	37	47
Southend-on-Sea	UB	22	93.6	100	59	08/10/2005	34	45
Stockport Shaw Heath	UB	---	43.2	100	51	13/01/2005	---	---
Stockton-on-Tees Yarm	RD	26	99.0	156	81	31/03/2005	39	50
Stoke-on-Trent Centre	UC	25	97.8	151	73	20/11/2005	35	45
Thurrock	UB	24	94.6	191	75	14/07/2005	38	49
Wigan Centre	UB	22	95.7	429	109	13/05/2005	34	52

* Measurements made using the Partisol gravimetric sampler– the se provide daily averages only

ii) EXCEEDENCE STATISTICS- I

Site	Moderate band	Days	High band	Days	Very High band	Days	Daughter Directive Limit Value Daily Mean & Air Quality Standard	Days	Daughter Directive Limit Value Annual Mean and Air Quality Standard	Annual Mean Standard (Scotland)
England										
Birmingham Centre	0	0	0	0	0	0	**2**	**2**	0	--
Birmingham Tyburn	14	2	0	0	0	0	**3**	**3**	0	--
Blackpool Marton	7	1	0	0	0	0	**3**	**3**	0	--
Bolton	0	0	0	0	0	0	**3**	**3**	0	--
Bournemouth	-	-	-	-	-	-	**14**	**14**	0	--
Bradford Centre	348	32	**73**	**9**	**34**	**4**	**37**	**37**	0	--
Brighton Roadside PM10	-	-	-	-	-	-	**37**	**37**	0	--
Bristol Centre	0	0	0	0	0	0	**4**	**4**	0	--
Bury Roadside	10	3	0	0	0	0	**12**	**12**	0	--
Camden Kerbside	227	26	0	0	0	0	**52**	**52**	0	--
Canterbury	0	0	0	0	0	0	**4**	**4**	0	--
Coventry Memorial Park	0	0	0	0	0	0	**1**	**1**	0	--
Haringey Roadside	16	3	0	0	0	0	**5**	**5**	0	--
Harwell	0	0	0	0	0	0	**1**	**1**	0	--
Hull Freetown	0	0	0	0	0	0	**1**	**1**	0	--
Leamington Spa	0	0	0	0	0	0	0	0	0	--
Leeds Centre	83	11	0	0	0	0	**14**	**14**	0	--
Leicester Centre	16	3	0	0	0	0	**4**	**4**	0	--
Liverpool Speke	1	1	0	0	0	0	**5**	**5**	0	--
London A3 Roadside	137	12	0	0	0	0	**19**	**19**	0	--
London Bexley	0	0	0	0	0	0	**2**	**2**	0	--
London Bloomsbury	2	1	0	0	0	0	**5**	**5**	0	--
London Brent	0	0	0	0	0	0	**3**	**3**	0	--
London Eltham	0	0	0	0	0	0	**3**	**3**	0	--
London Harlington	0	0	0	0	0	0	**3**	**3**	0	--
London Hillingdon	32	2	0	0	0	0	**10**	**10**	0	--
London Marylebone	685	59	**19**	**2**	0	0	**118**	**118**	**1**	--
London N. Kensington	26	2	0	0	0	0	**6**	**6**	0	--
London Westminster	-	-	-	-	-	-	**32**	**32**	0	--
Manchester Piccadilly	32	4	0	0	0	0	**9**	**9**	0	--
Middlesbrough	137	19	**40**	**4**	0	0	**24**	**24**	0	--
Newcastle Centre	9	1	0	0	0	0	**2**	**2**	0	--
Northampton	0	0	0	0	0	0	0	0	0	--
Northampton PM10	-	-	-	-	-	-	**22**	**22**	0	--
Norwich Centre	0	0	0	0	0	0	0	0	0	--
Nottingham Centre	47	4	0	0	0	0	**6**	**6**	0	--
Plymouth Centre	0	0	0	0	0	0	0	0	0	--
Portsmouth	0	0	0	0	0	0	**1**	**1**	0	--
Preston	0	0	0	0	0	0	0	0	0	--
Reading New Town	0	0	0	0	0	0	**1**	**1**	0	--
Redcar	35	4	0	0	0	0	**7**	**7**	0	--
Rochester	1	1	**17**	**2**	**4**	**1**	**3**	**3**	0	--
Salford Eccles	19	1	0	0	0	0	**6**	**6**	0	--
Scunthorpe Town	253	24	0	0	0	0	**25**	**25**	0	--
Sheffield Centre	24	2	0	0	0	0	**6**	**6**	0	--
Southampton Centre	2	1	0	0	0	0	**3**	**3**	0	--
Southend-on-Sea	0	0	0	0	0	0	**2**	**2**	0	--
Stockport Shaw Heath	0	0	0	0	0	0	**1**	**1**	---	--
Stockton-on-Tees Yarm	34	3	0	0	0	0	**5**	**5**	0	--
Stoke-on-Trent Centre	30	4	0	0	0	0	**4**	**4**	0	--
Thurrock	18	2	0	0	0	0	**5**	**5**	0	--
Wigan Centre	23	4	**21**	**2**	0	0	**8**	**8**	0	--

* Measurements made using the Partisol gravimetric sampler– the se provide daily averages only

iii) ANNUAL STATISTICS- II

Site	Site Type	Annual average µg m^{-3}	Annual data capture of hourly means % (for Partisol, capture of daily means)	Maximum hourly mean µg m^{-3}	Maximum running 24-hour mean µg m^{-3}	Date of maximum running 24-hour mean	90%ile of daily means µg m^{-3}	98%ile of daily means µg m^{-3}
Wirral Tranmere	UB	19	60.2	78	55	20/03/2005	27	43
Wolverhampton Centre	UC	23	95.1	1017	138	23/08/2005	36	56
N Ireland								
Belfast Centre	UC	19	95.1	252	90	22/11/2005	30	48
Belfast Clara St	SU	13	94.7	228	85	16/10/2005	28	50
Derry	UB	21	97.1	259	100	22/11/2005	33	46
Lough Navar	RE	11	99.3	111	33	16/10/2005	15	23
Scotland								
Aberdeen	UB	19	91.8	105	66	31/03/2005	31	45
Dumfries	RD	20 *	97.5	---	---	---	33	47
Edinburgh St Leonards	UC	18	97.6	1375	155	21/05/2005	26	37
Glasgow Centre	UC	20	97.9	421	79	06/10/2005	31	49
Glasgow Kerbside	KB	29	90.8	239	93	26/02/2005	49	68
Grangemouth	I	15	98.9	170	49	31/03/2005	23	34
Inverness	RD	17*	94.0	---	---	---	28	41
Wales								
Cardiff Centre	UC	26	53.8	452	82	05/10/2005	37	47
Cwmbran	UB	18	99.2	2695	200	07/12/2005	25	35
Narberth	RU	16	82.9	191	44	29/03/2005	23	31
Port Talbot	UB	30	86.6	447	103	29/05/2005	49	76
Swansea	UC	25	97.6	103	56	04/09/2005	36	47
Wrexham	RD	22 *	91.8	---	---	---	40	71

* Measurements made using the Partisol gravimetric sampler– the se provide daily averages only

iv) EXCEEDENCE STATISTICS- II

Site	Moderate band	Days	High band	Days	Very High band	Days	Daughter Directive Limit Value Daily Mean and Air Quality Standard (Daily Mean)	Days	Daughter Directive Limit Value Annual Mean and Air Quality Standard (Annual Mean)	Annual Mean Standard (Scotland)
Wirral Tranmere	0	0	0	0	0	0	0	0	0	--
Wolverhampton Centre	97	12	**3**	**2**	**20**	**2**	**10**	**10**	0	--
N Ireland										
Belfast Centre	44	3	0	0	0	0	**6**	**6**	0	--
Belfast Clara St	230	17	**15**	**2**	0	0	**7**	**7**	0	--
Derry	31	4	**11**	**1**	0	0	**3**	**3**	0	--
Lough Navar	0	0	0	0	0	0	0	0	0	--
Scotland										
Aberdeen	4	1	0	0	0	0	**4**	**4**	0	**1**
Dumfries	-	-	-	-	-	-	**6**	**6**	0	**1**
Edinburgh St Leonards	2	2	0	0	**23**	**2**	**3**	**3**	0	0
Glasgow Centre	65	6	0	0	0	0	**6**	**6**	0	**1**
Glasgow Kerbside	196	14	0	0	0	0	**27**	**27**	0	**1**
Grangemouth	0	0	0	0	0	0	0	0	0	0
Inverness	-	-	-	-	-	-	**2**	**2**	0	0
Wales										
Cardiff Centre	24	2	0	0	0	0	**3**	**3**	0	--
Cwmbran	47	4	0	0	**24**	**2**	**3**	**3**	0	--
Narberth	0	0	0	0	0	0	0	0	0	--
Port Talbot	293	28	**24**	**6**	0	0	**29**	**29**	0	--
Swansea	0	0	0	0	0	0	**1**	**1**	0	--
Wrexham	-	-	-	-	-	-	**22**	**22**	0	--

* Measurements made using the Partisol gravimetric sampler– the se provide daily averages only

15. $PM_{2.5}$ - Measurement Sites, Instrumentation and Statistics

15.1 Measurement Method

The tapered element oscillating microbalance (TEOM) system determines particulate concentration by continuously weighing particles deposited on a filter.

15.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- R&P TEOM 1400

*Defra does not give approval or endorsement for any products or equipment

Please also see detailed information on particle measurements and conversion factors used in this report (Appendix 6).

15.3 Data Quality Requirements of EC Directive 1999/30/EC

Uncertainty 25%
Minimum data capture 90%

15.4 Objectives and Bandings

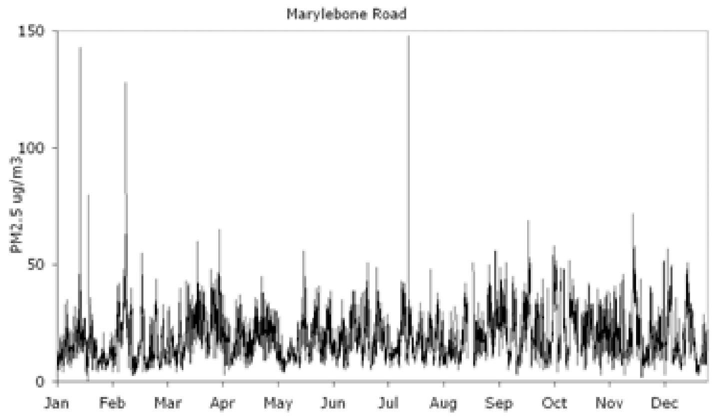
No Objectives or Bandings have yet been set for $PM_{2.5}$

15.5 Site Locations

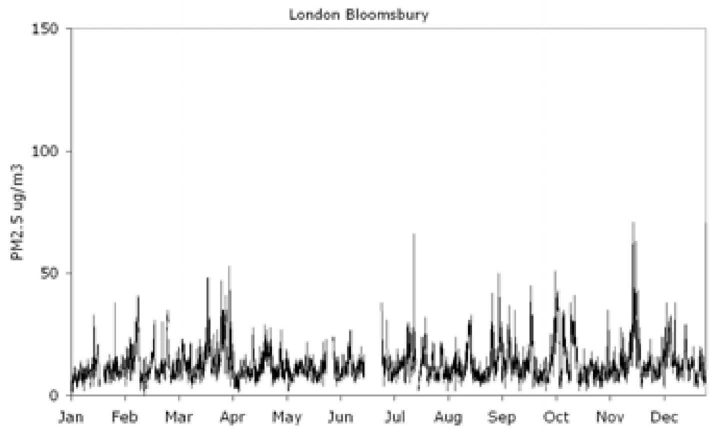
UK Automatic $PM_{2.5}$ Monitoring Sites 2005

15.6 Hourly Average Concentrations

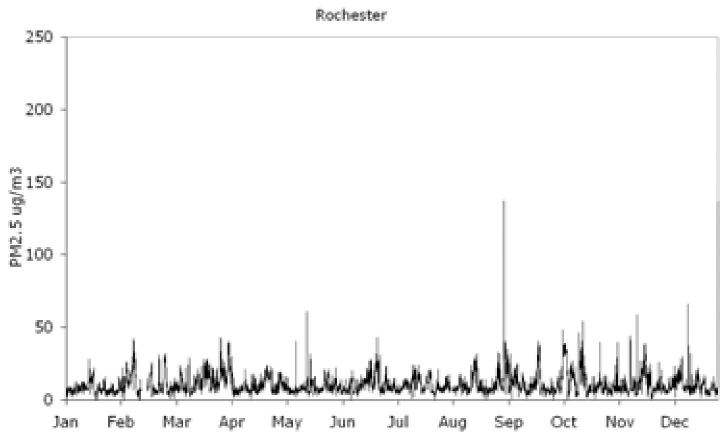
These figures show time series graphs of hourly average $PM_{2.5}$ concentrations at four *typical* site types for 2005.



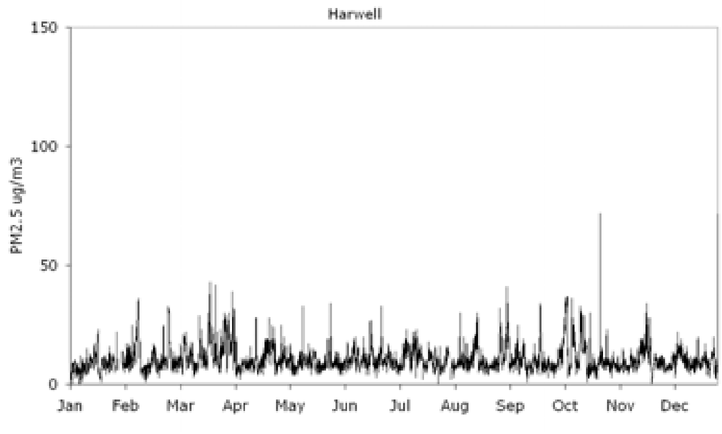
Kerbside Site
(*Marylebone Road)*



Urban Centre Site
(*Bloomsbury)*



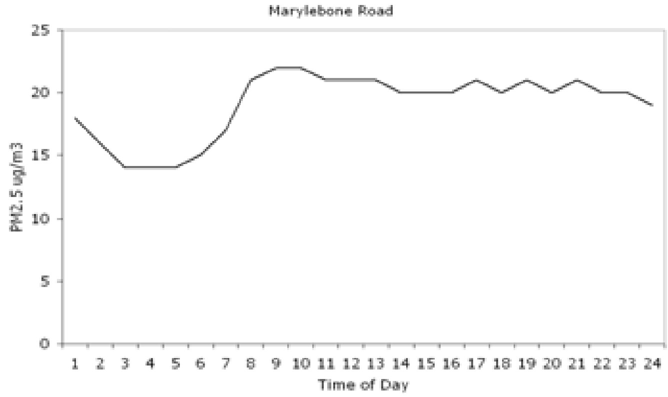
Rural Site
(*Rochester)*



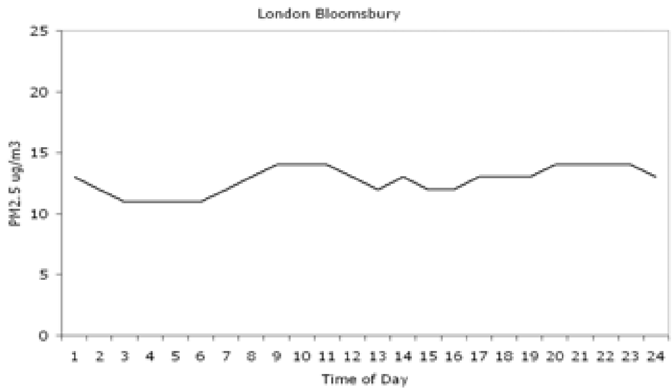
Rural Site
(Harwell)

15.7 Diurnal Variations

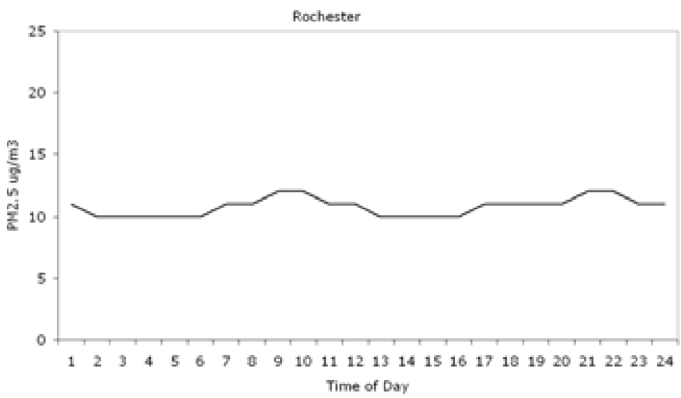
These figures show how $PM_{2.5}$ concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



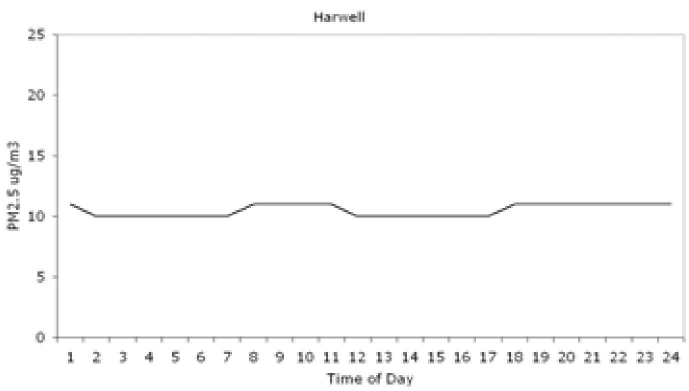
Kerbside Site
(*Marylebone Road)*



Urban Centre Site
(*Bloomsbury)*

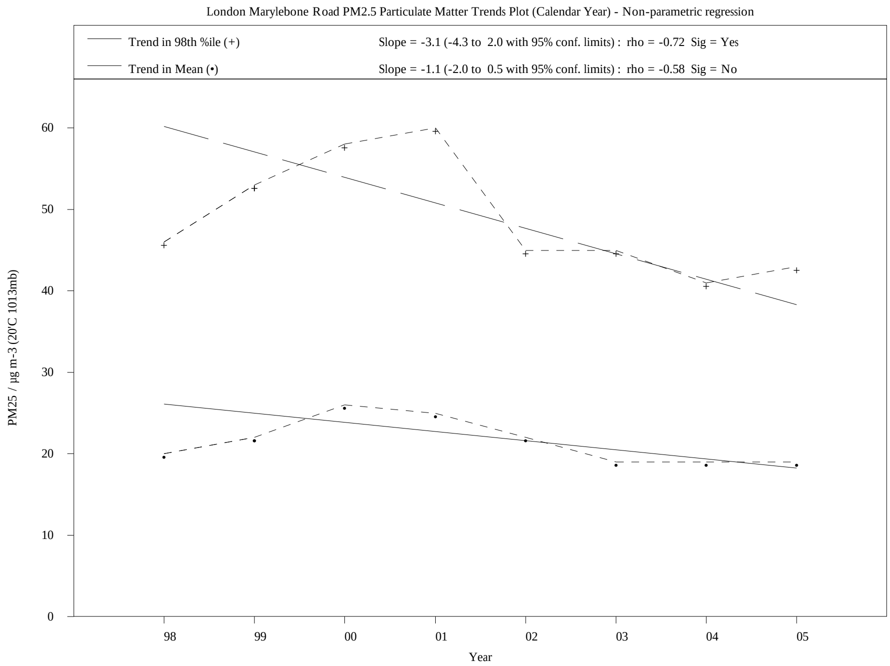


Rural Site
(*Rochester)*

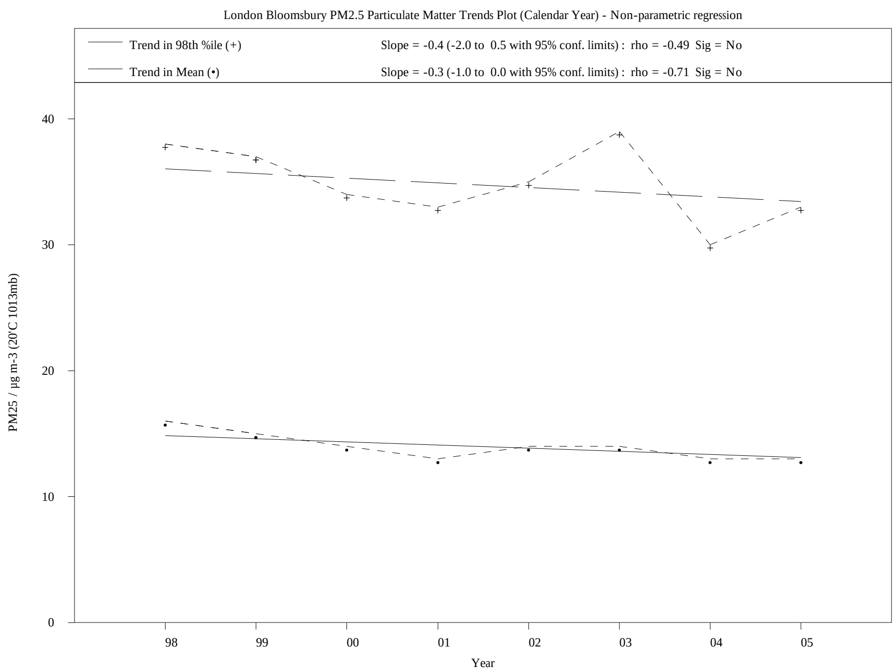


Rural Site
(Harwell)

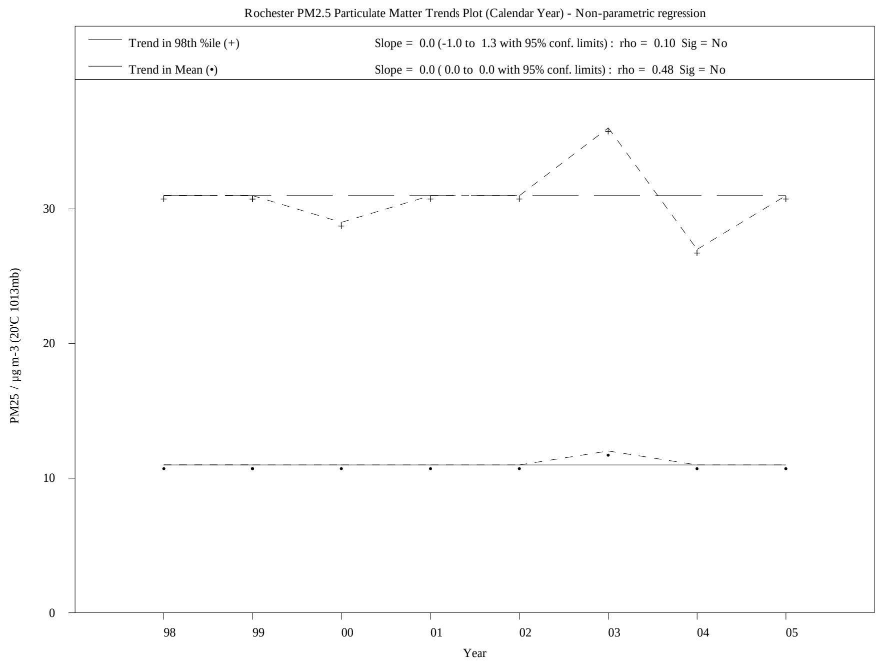
15.8 Trends in annual concentrations



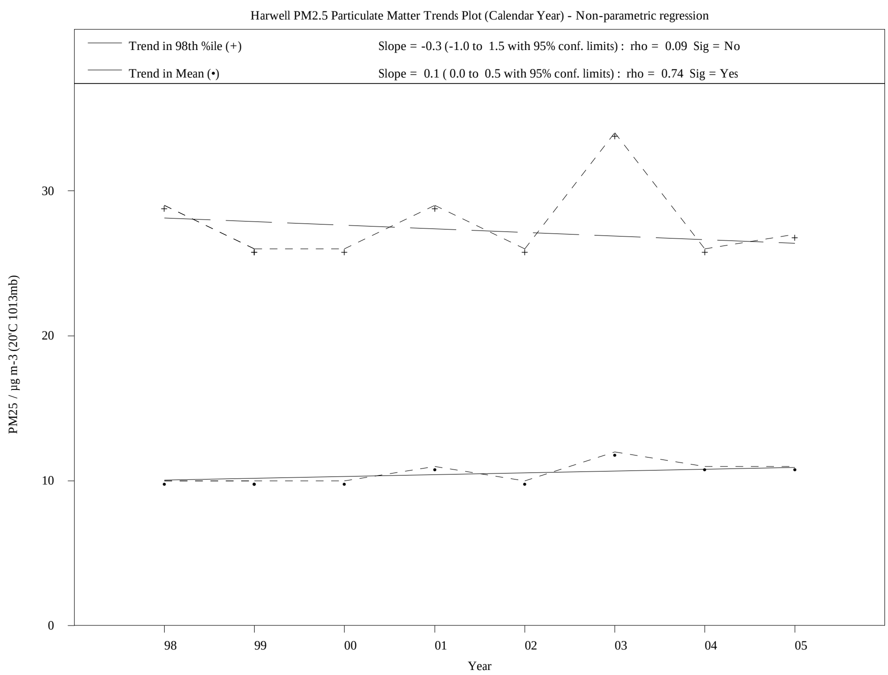
Kerbside Site
(Marylebone Road)



Urban Centre Site
(*London Bloomsbury)*



Rural Site
(Rochester)



Rural Site
(Harwell)

15.9 $PM_{2.5}$ Statistical Summary 2005

i) ANNUAL STATISTICS- I

Site	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}
England			
Harwell	11	98.3	72
London Bloomsbury	13	94.4	71
London Marylebone Road	19	97.5	148
Rochester	11	98.3	137

ii) Exceedence Statistics-

There are no exceedences statistics for $PM_{2.5}$ Particulate Matter

16. SO_2 - Measurement Sites, Instrumentation and Statistics

16.1 Measurement Method

The sulphur dioxide analyser works on the principle of ultra violet (UV) fluorescence. SO_2 molecules are excited to energy states by UV radiation. These energy states decay causing an emission of secondary fluorescent radiation with intensity proportional to the concentration of SO_2 in the sample.

16.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak SO_2
- API M100
- Environnement AF 21M
- Horiba APSA 360
- Monitor Labs 9850
- Rotork 477
- Thermo Electron 43

*Defra does not give approval or endorsement for any products or equipment

16.3 Data Quality Requirements of EC Directive 1999/30/EC

Uncertainty 15%
Minimum data capture 90%

16.4 Objectives and Bandings

Summary of objectives of the Air Quality Strategy			
	Objective	**Measured as**	**To be achieved by**
Sulphur Dioxide	266 µg m^{-3} Not to be exceeded more than 35 times per year	15 Minute Mean	31 December 2005
	350 µg m^{-3} Not to be exceeded more than 24 times per year	1 Hour Mean	31 December 2005
	125 µg m^{-3} Not to be exceeded more than 3 times per year	24 Hour Mean	31 December 2005
	(V) 20 µg m^{-3}	Annual Mean	31 December 2000
	(V) 20 µg m^{-3}	Winter Mean (01 October - 31 March)	31 December 2000

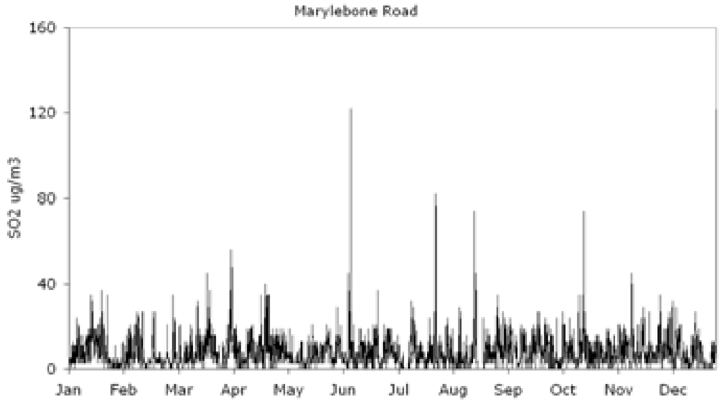
Air Quality Bands and Index Values		
Band	Index	Sulphur Dioxide µg m^{-3}
Low	1	0-88
	2	89-176
	3	177-265
Moderate	4	266-354
	5	355-442
	6	443-531
High	7	532-708
	8	709-886
	9	887-1063
Very High	10	1064 or more

16.5 Site Locations

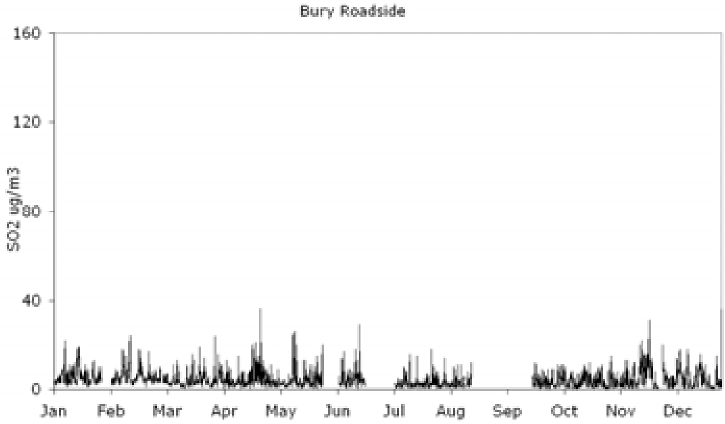
UK Automatic Sulphur Dioxide Monitoring Sites 2005

16.6 Hourly Average Concentrations

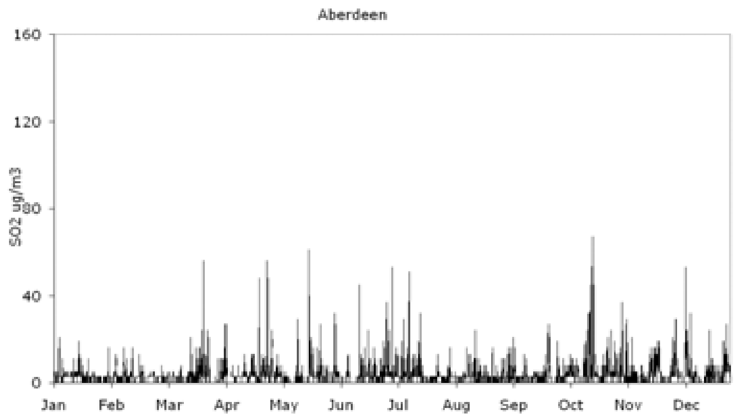
These figures show time series graphs of hourly average sulphur dioxide concentrations at four *typical* site types for 2005.



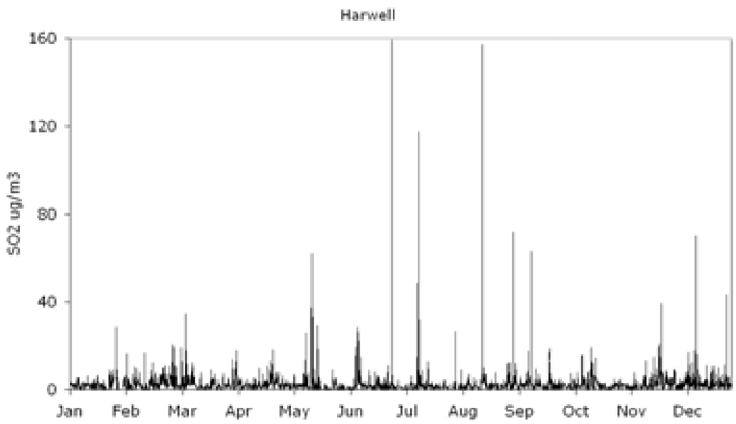
Kerbside Site
(London Marylebone Road)



Roadside Site
(*Bury)*



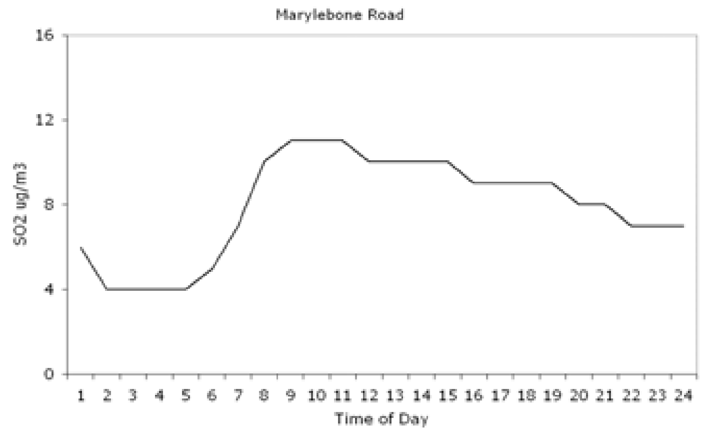
Urban Background Site
(*Aberdeen)*



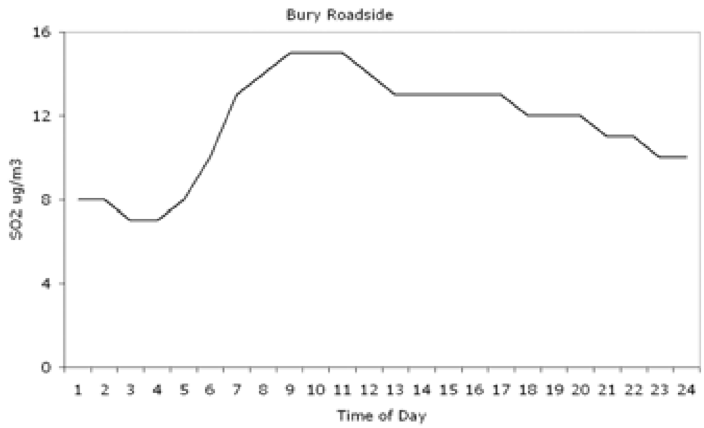
Rural Site
(*Harwell)*

16.7 Diurnal Variations

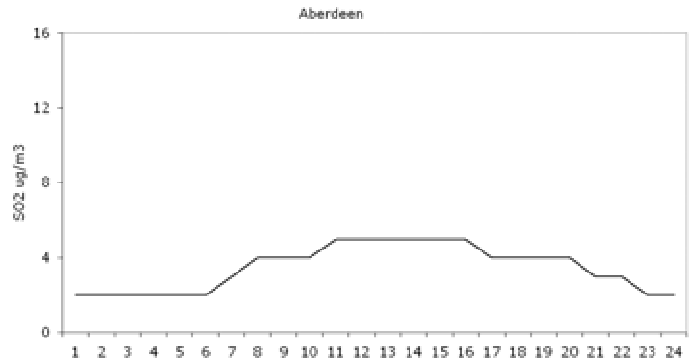
These figures show how sulphur dioxide concentrations vary on average for each hour of day during 2005, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



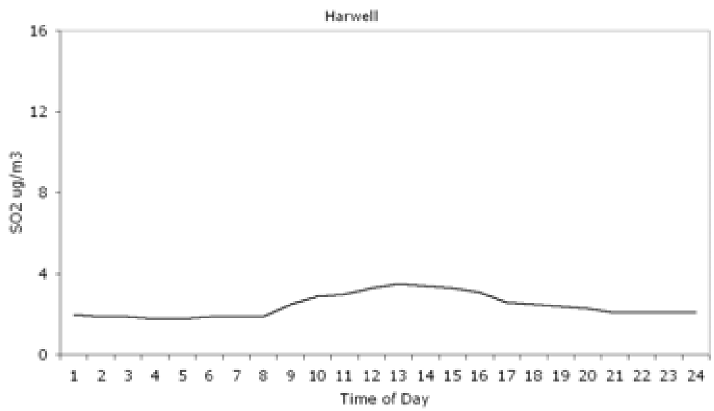
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Bury)*

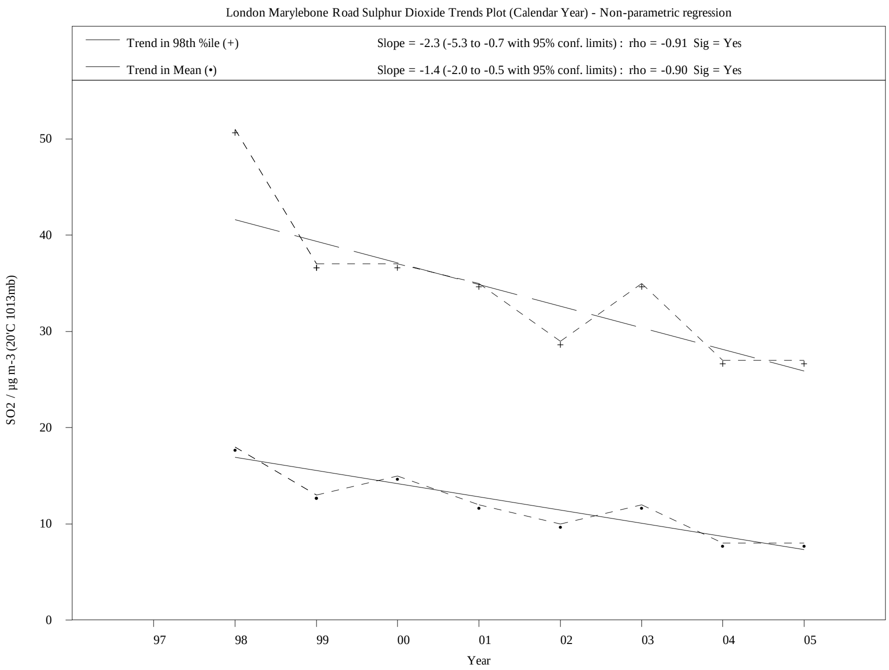


Urban Background Site
(*Aberdeen)*

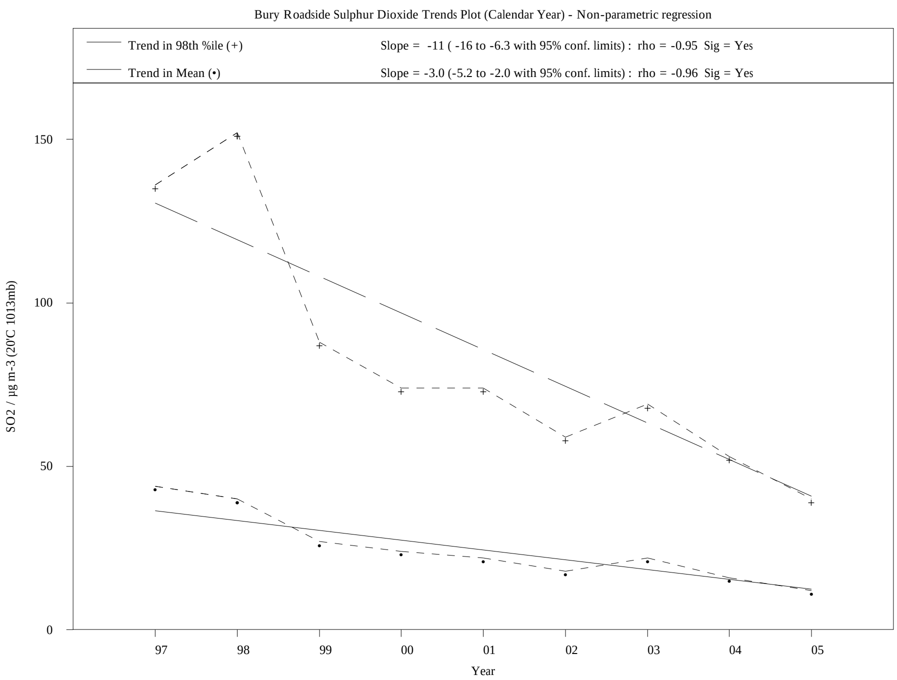


Rural Site
(Harwell)

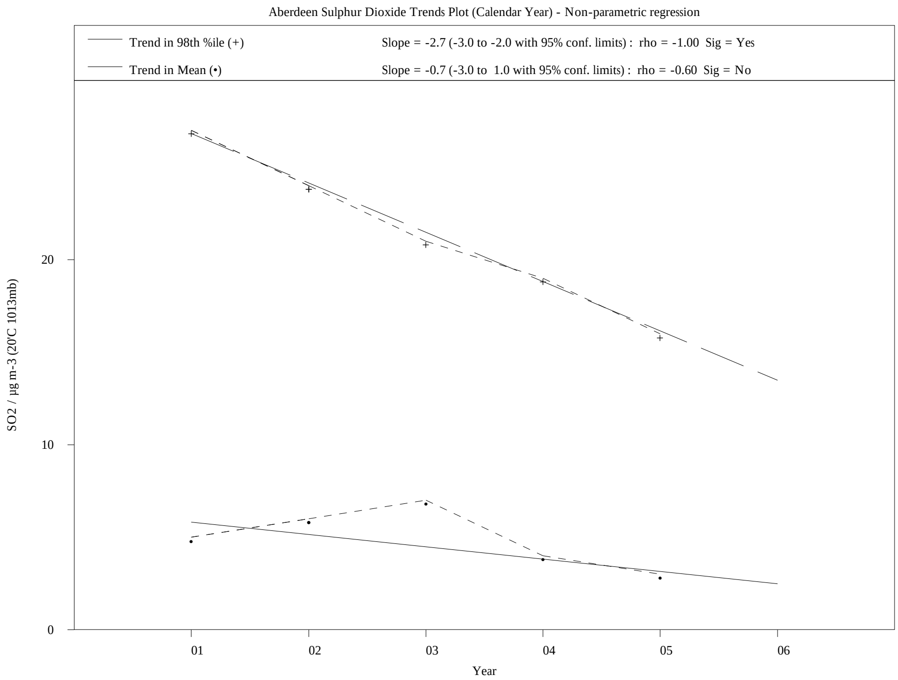
16.8 Trends in annual concentrations



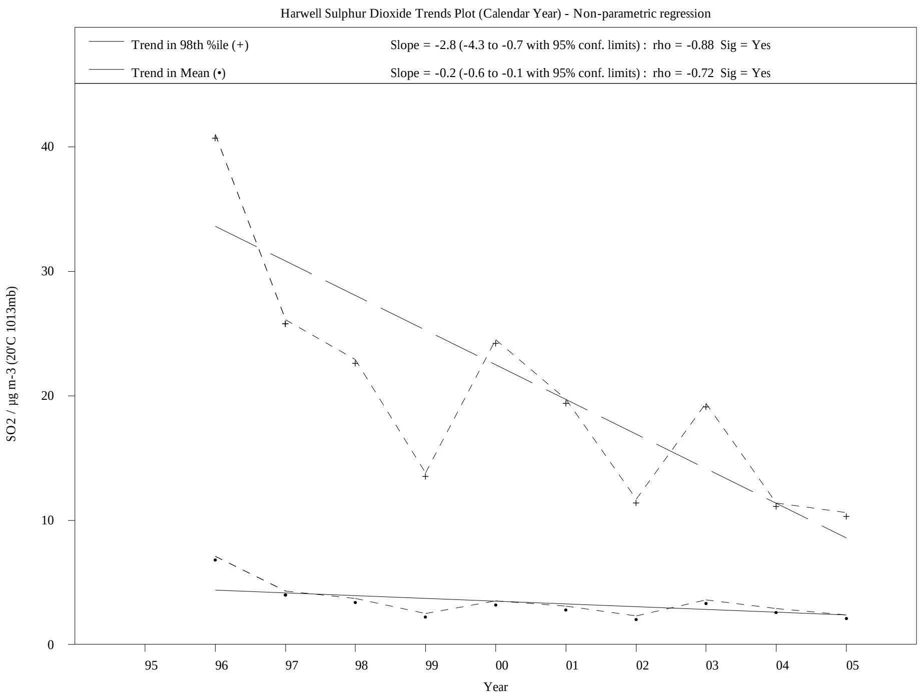
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Bury Roadside)*



Urban Background
(*Aberdeen*)



Rural Site
(Harwell)

16.9 Sulphur Dioxide Statistical Summary 2005

i) ANNUAL STATISTICS- I

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	Maximum 15-minute mean µg m^{-3}	Date of maximum 15-minute mean	99.9 %ile of 15-min means µg m^{-3}	99.7 %ile of hourly means µg m^{-3}	99 %ile of daily means µg m^{-3}
England									
Barnsley 12	UB	6	97.2	80	202	07/01/200	56	40	20
Barnsley Gawber	UB	15	89.3	98	109	11/05/200	67	56	28
Birmingham Centre	UC	4	85.5	146	160	20/06/200 5	48	32	14
Birmingham Tyburn	UB	2	98.9	43	56	06/03/200 5	27	21	10
Blackpool Marton	UB	3	50.6	45	53	02/09/200 5	35	21	8
Bolton	UB	2	94.2	80	120	08/06/200	29	24	13
Bournemouth	UB	2	98.2	80	136	11/06/200	21	16	7
Bradford Centre	UC	11	90.0	128	144	28/06/200	61	51	25
Bristol Centre	UC	3	67.5	40	82	06/05/200	35	24	10
Bury Roadside	RD	12	80.8	96	101	23/04/200	77	56	31
Coventry Memorial Park	UB	2	98.8	37	45	23/11/200 5	27	19	9
Exeter Roadside	RD	2	81.1	13	16	13/01/200	11	11	5
Harwell	RU	2.4	97.9	159.3	247.4	27/06/200	90.4	41.5	11.1
Hove Roadside	RD	3	96.3	37	48	21/11/200	24	16	10
Hull Freetown	UC	5	82.3	88	125	19/08/200	51	35	14
Ladybower	RU	2.9	94.6	64.9	91.5	18/11/200	45.0	27.4	11.6
Leamington Spa	UB	3	74.6	37	59	16/05/200	24	16	7
Leeds Centre	UC	4	92.8	88	104	12/05/200	64	45	16
Leicester Centre	UC	3	94.1	85	104	30/05/200	32	21	9
Liverpool Speke	UB	7	98.3	117	136	12/09/200	74	51	17
London Bexley	SU	5	97.2	160	181	08/06/200	101	69	27
London Bloomsbury	UC	5	93.9	128	146	08/06/200 5	61	35	19
London Brent	UB	4	94.9	96	117	08/06/200	35	27	12
London Cromwell Road 2	RD	5	95.0	69	85	02/04/200 5	37	27	15
London Eltham	SU	4	94.6	125	162	27/06/200	72	51	20
London Hillingdon	SU	3	96.1	45	138	27/05/200 5	32	21	10
London Lewisham	UC	4	97.0	96	109	27/06/200 5	59	43	16
London Marylebone Road	KB	8	97.8	122	141	08/06/200 5	64	40	21
London N. Kensington	UB	3	99.3	93	104	08/06/200 5	56	32	14
London Southwark	UC	7	98.3	93	125	26/07/200 5	51	37	17
London Teddington	UB	3.0	98.9	59.9	79.0	19/03/200 5	39.9	28.2	13.0
London Westminster	UB	4	95.6	80	109	26/07/200 5	51	32	17
Lullington Heath	RU	2.7	97.5	33.5	59.1	30/04/200	23.7	17.6	9.0
Manchester Piccadilly	UC	---	21.4	29	32	18/11/200 5	---	---	---
Manchester South	SU	---	20.0	27	29	18/11/200 5	---	---	---
Middlesbrough	I	4	97.0	160	186	09/07/200	96	67	20
Newcastle Centre	UC	3	95.8	90	152	13/10/200 5	56	35	11
Northampton	UB	3	95.0	43	85	12/06/200	27	21	8
Norwich Centre	UC	9	96.9	51	74	14/03/200	45	32	25

ii) EXCEEDENCE STATISTICS- I

Site	Mod. band	Days	High band	Days	Very High band	Days	Air Quality Standard (15-Minute Mean)	Days	Daughter Directive Hourly Mean and Air Quality Standard (Hourly Mean)	Days	Daughter Directive Daily Mean and Air Quality Standard (Daily Mean)	Days
England												
Barnsley 12	0	0	0	0	0	0	0	0	0	0	0	0
Barnsley Gawber	0	0	0	0	0	0	0	0	0	0	0	0
Birmingham Centre	0	0	0	0	0	0	0	0	0	0	0	0
Birmingham Tyburn	0	0	0	0	0	0	0	0	0	0	0	0
Blackpool Marton	0	0	0	0	0	0	0	0	0	0	0	0
Bolton	0	0	0	0	0	0	0	0	0	0	0	0
Bournemouth	0	0	0	0	0	0	0	0	0	0	0	0
Bradford Centre	0	0	0	0	0	0	0	0	0	0	0	0
Bristol Centre	0	0	0	0	0	0	0	0	0	0	0	0
Bury Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Coventry Memorial Park	0	0	0	0	0	0	0	0	0	0	0	0
Exeter Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Harwell	0	0	0	0	0	0	0	0	0	0	0	0
Hove Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Hull Freetown	0	0	0	0	0	0	0	0	0	0	0	0
Ladybower	0	0	0	0	0	0	0	0	0	0	0	0
Leamington Spa	0	0	0	0	0	0	0	0	0	0	0	0
Leeds Centre	0	0	0	0	0	0	0	0	0	0	0	0
Leicester Centre	0	0	0	0	0	0	0	0	0	0	0	0
Liverpool Speke	0	0	0	0	0	0	0	0	0	0	0	0
London Bexley	0	0	0	0	0	0	0	0	0	0	0	0
London Bloomsbury	0	0	0	0	0	0	0	0	0	0	0	0
London Brent	0	0	0	0	0	0	0	0	0	0	0	0
London Cromwell Road 2	0	0	0	0	0	0	0	0	0	0	0	0
London Eltham	0	0	0	0	0	0	0	0	0	0	0	0
London Hillingdon	0	0	0	0	0	0	0	0	0	0	0	0
London Lewisham	0	0	0	0	0	0	0	0	0	0	0	0
London Marylebone Road	0	0	0	0	0	0	0	0	0	0	0	0
London N. Kensington	0	0	0	0	0	0	0	0	0	0	0	0
London Southwark	0	0	0	0	0	0	0	0	0	0	0	0
London Teddington	0	0	0	0	0	0	0	0	0	0	0	0
London Westminster	0	0	0	0	0	0	0	0	0	0	0	0
Lullington Heath	0	0	0	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	0	0	0	0	0	0	0	0	0	0	0	0
Manchester South	0	0	0	0	0	0	0	0	0	0	0	0
Middlesbrough	0	0	0	0	0	0	0	0	0	0	0	0
Newcastle Centre	0	0	0	0	0	0	0	0	0	0	0	0
Northampton	0	0	0	0	0	0	0	0	0	0	0	0
Norwich Centre	0	0	0	0	0	0	0	0	0	0	0	0

iii) ANNUAL STATISTICS- II

Site	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	Maximum 15-minute mean µg m^{-3}	Date of maximum 15-minute mean	99.9 %ile of 15-min means µg m^{-3}	99.7 %ile of hourly means µg m^{-3}	99 %ile of daily means µg m^{-3}
Nottingham Centre	UC	10	92.6	51	69	17/01/2005	51	37	23
Oxford Centre Roadside	RD	3	98.1	29	32	17/11/2005	21	16	10
Plymouth Centre	UC	3	94.8	19	21	14/03/2005	13	13	9
Portsmouth	UB	4	98.9	59	80	31/05/2005	43	24	9
Preston	UB	3	96.5	59	64	11/09/2005	37	24	11
Reading New Town	UB	5	69.8	56	106	23/11/2005	35	27	17
Redcar	SU	9	93.2	125	202	16/06/2005	112	74	29
Rochester	RU	6.1	95.8	136.5	211.7	16/08/2005	83.0	50.0	17.0
Rotherham Centre	UC	---	0.0	---	---	---	---	---	---
Salford Eccles	I	10	95.7	285	442	21/11/2005	104	61	32
Sandwell West Bromwich	UB	2	92.2	109	133	20/06/2005	35	19	9
Scunthorpe Town	I	8	73.6	165	205	30/08/2005	101	69	33
Sheffield Centre	UC	9	98.1	37	45	12/05/2005	29	21	15
Southampton Centre	UC	4	89.9	239	247	06/04/2005	72	40	17
Southend -on-Sea	UB	6	93.6	104	205	16/08/2005	56	37	17
Southwark Roadside	RD	4	98.7	82	85	08/06/2005	40	27	11
Stockport Shaw Heath	UB	4	99.0	67	96	02/08/2005	35	27	12
Stoke-on-Trent Centre	UC	5	50.7	59	67	13/07/2005	32	24	11
Sunderland	UB	2	98.5	37	67	13/07/2005	21	13	6
Thurrock	UB	5	94.0	154	192	13/07/2005	90	61	20
Wicken Fen	RU	3.9	93.5	33.8	47.9	17/11/2005	25.3	18.6	10.2
Wigan Centre		3	96.7	93	125	12/09/2005	35	27	14
Wirral Tranmere	UB	6	51.9	80	141	11/07/2005	61	40	21
Wolverhampton Centre	UC	3	90.9	106	112	20/01/2005	51	27	11
N Ireland									
Belfast Centre	UC	6	95.2	109	122	29/05/2005	72	56	28
Belfast East	UB	5	99.3	109	149	29/05/2005	74	53	25
Derry	UB	5	91.8	85	120	02/12/2005	56	37	19
Scotland									
Aberdeen	UB	3	98.7	67	184	02/07/2005	61	35	13
Edinburgh St Leonards	UB	3	98.6	90	213	08/03/2005	51	32	12
Glasgow Centre	UC	1	97.5	35	59	14/04/2005	19	16	7
Grangemouth	I	7	98.9	202	503	28/01/2005	141	96	41
Wales									
Cardiff Centre	UC	3	55.4	59	85	20/10/2005	45	21	8
Cwmbran	UB	3	94.0	24	48	19/09/2005	19	13	8
Narberth	RU	2.2	94.5	44.2	52.9	18/11/2005	26.6	15.7	7.2
Port Talbot	UB	7	93.3	223	287	04/04/2005	130	82	24
Swansea	UC	4	91.8	69	80	22/04/2005	43	29	14
Wrexham	RD	3	98.7	43	53	03/03/2005	27	21	10

iv) EXCEEDENCE STATISTICS- II

Site	Mod. band	Days	High band	Days	Very High band	Days	Air Quality Standard (15-Minute Mean)	Days	Daughter Directive Hourly Mean and Air Quality Standard (Hourly Mean)	Days	Daughter Directive Daily Mean and Air Quality Standard (Daily Mean)	Days
Nottingham Centre	0	0	0	0	0	0	0	0	0	0	0	0
Oxford Centre Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Plymouth Centre	0	0	0	0	0	0	0	0	0	0	0	0
Portsmouth	0	0	0	0	0	0	0	0	0	0	0	0
Preston	0	0	0	0	0	0	0	0	0	0	0	0
Reading New Town	0	0	0	0	0	0	0	0	0	0	0	0
Redcar	0	0	0	0	0	0	0	0	0	0	0	0
Rochester	0	0	0	0	0	0	0	0	0	0	0	0
Rotherham Centre	---	---	---	---	---	---	---	---	---	---	---	---
Salford Eccles	6	3	0	0	0	0	**6**	**3**	0	0	0	0
Sandwell West Bromwich	0	0	0	0	0	0	0	0	0	0	0	0
Scunthorpe Town	0	0	0	0	0	0	0	0	0	0	0	0
Sheffield	0	0	0	0	0	0	0	0	0	0	0	0
Southampton Centre	0	0	0	0	0	0	0	0	0	0	0	0
Southend-on-Sea	0	0	0	0	0	0	0	0	0	0	0	0
Southwark Roadside	0	0	0	0	0	0	0	0	0	0	0	0
Stockport Shaw Heath	0	0	0	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	0	0	0	0	0	0	0	0	0	0	0	0
Sunderland	0	0	0	0	0	0	0	0	0	0	0	0
Thurrock	0	0	0	0	0	0	0	0	0	0	0	0
Wicken Fen	0	0	0	0	0	0	0	0	0	0	0	0
Wigan Centre	0	0	0	0	0	0	0	0	0	0	0	0
Wirral	0	0	0	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	0	0	0	0	0	0	0	0	0	0	0	0
N Ireland												
Belfast Centre	0	0	0	0	0	0	0	0	0	0	0	0
Belfast East	0	0	0	0	0	0	0	0	0	0	0	0
Derry	0	0	0	0	0	0	0	0	0	0	0	0
Scotland												
Aberdeen	0	0	0	0	0	0	0	0	0	0	0	0
Edinburgh St Leonards	0	0	0	0	0	0	0	0	0	0	0	0
Glasgow Centre	0	0	0	0	0	0	0	0	0	0	0	0
Grangemouth	4	2	0	0	0	0	**4**	**2**	0	0	0	0
Wales												
Cardiff Centre	0	0	0	0	0	0	0	0	0	0	0	0
Cwmbran	0	0	0	0	0	0	0	0	0	0	0	0
Narberth	0	0	0	0	0	0	0	0	0	0	0	0
Port Talbot	2	2	0	0	0	0	**1**	**1**	0	0	0	0
Swansea	0	0	0	0	0	0	0	0	0	0	0	0
Wrexham	0	0	0	0	0	0	0	0	0	0	0	0

17. Ozone - Measurement Sites, Instrumentation and Statistics

17.1 Measurement Method

The measurement of ozone is based on the absorption of ultra violet light by ozone. The absorption by an air path with no ozone present is measured to give a reference intensity. The absorption of the ozone-containing sample is then measured. The ozone concentration is calculated using the Beer-Lamberts absorption equation.

17.2 Instrumentation

The following instrument types* are currently deployed in the AURN:

- Ambirak O_3
- API M400
- Environnement O341M
- Horiba APOA 360
- Monitor Labs 9850
- Rotork 427
- Thermo Electron 49

*Defra does not give approval or endorsement for any products or equipment

17.3 Data Quality Requirements of EC Directive 2002/3/EC

Uncertainty 15%
Minimum data capture 90%

17.4 Objectives and Bandings

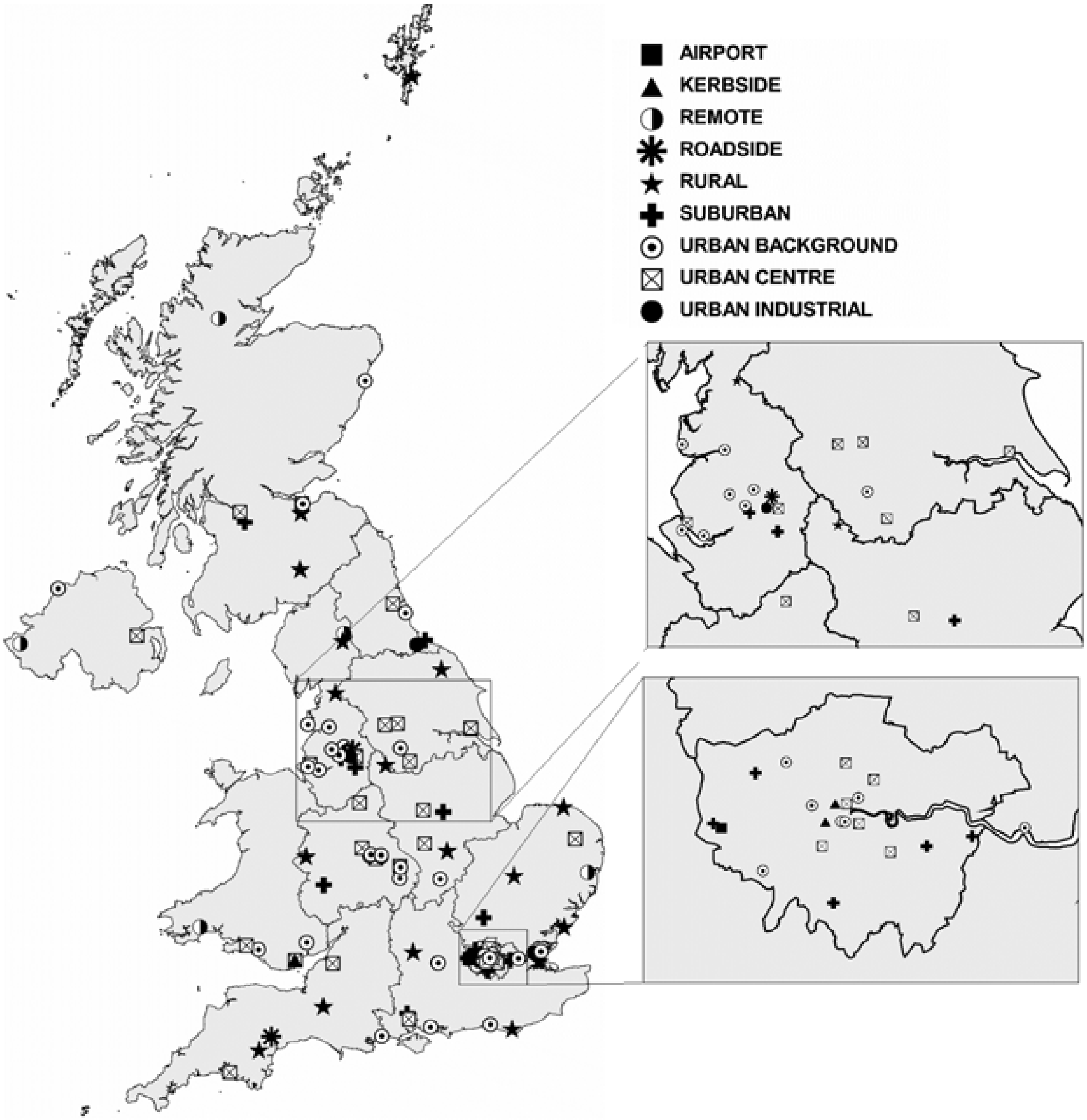
Summary of objectives of the Air Quality Strategy			
	Objective*	**Measured as**	**To be achieved by**
Ozone	100 µg m^{-3} Not to be exceeded more than 10 times per year	Daily maximum of running 8-hour mean	31 December 2005

*Not included in the Regulations for the purpose of Air Quality Management

Air Quality Bands and Index Values		
Band	**Index**	**Ozone µgm^{-3}**
Low	1	0-33
	2	34-65
	3	66-99
Moderate	4	100-125
	5	126-153
	6	154-179
High	7	180-239
	8	240-299
	9	300-359
Very High	10	360 or more

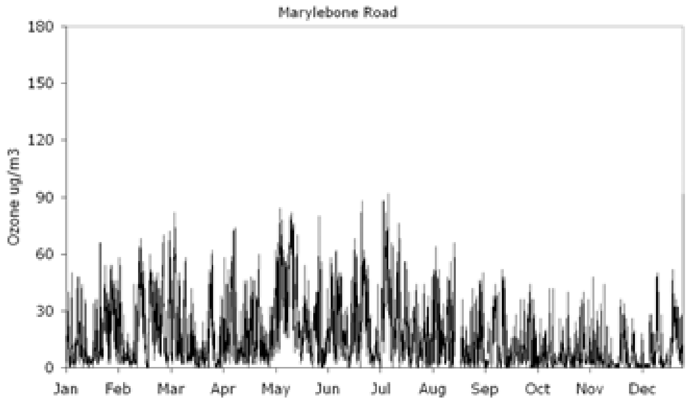
17.5 Site Locations

UK AUTOMATIC OZONE MONITORING SITES 2005

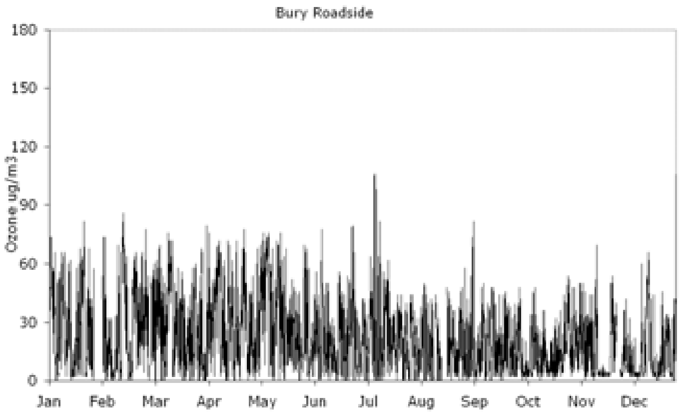


17.6 Hourly Average Concentrations

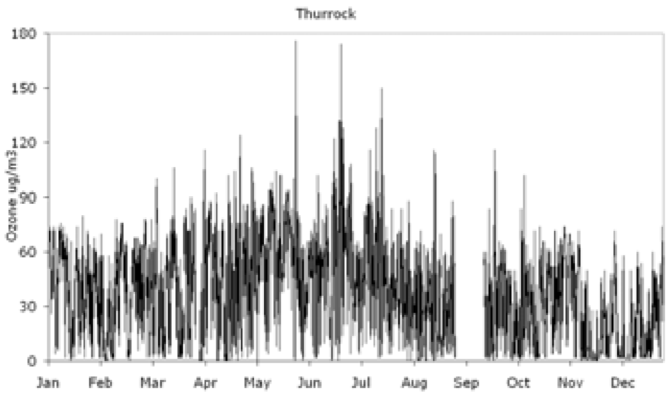
These figures show time series graphs of hourly average ozone concentrations at four *typical* site types for 2005.



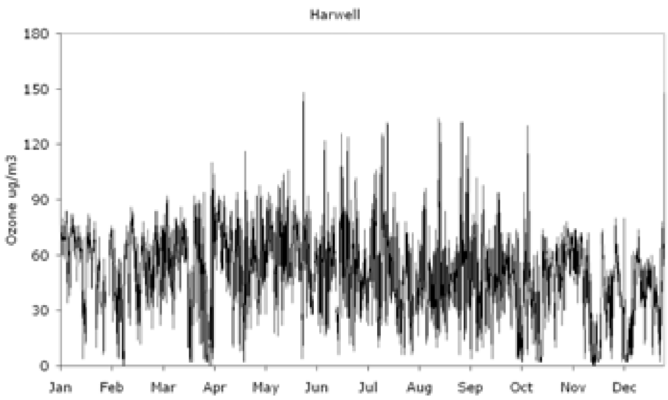
Kerbside Site
(*Marylebone Road)*



Roadside Site
(*Bury)*



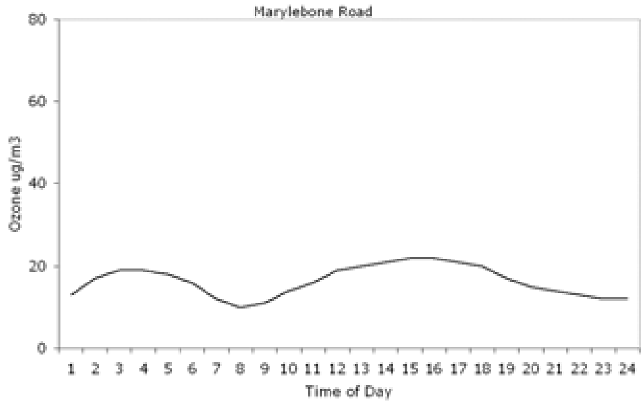
Urban Background Site
(*Thurrock)*



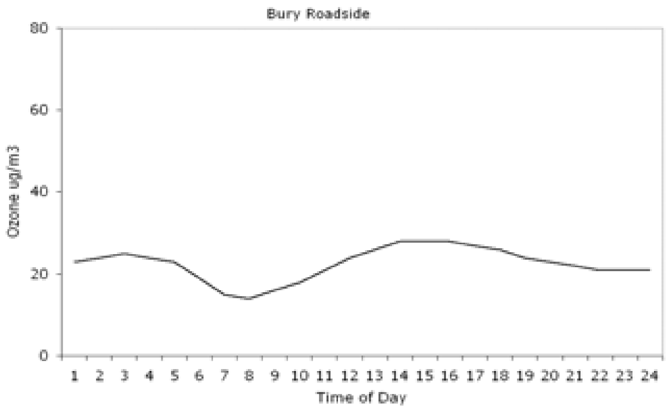
Rural Site
(Harwell)

17.7 Diurnal Variations

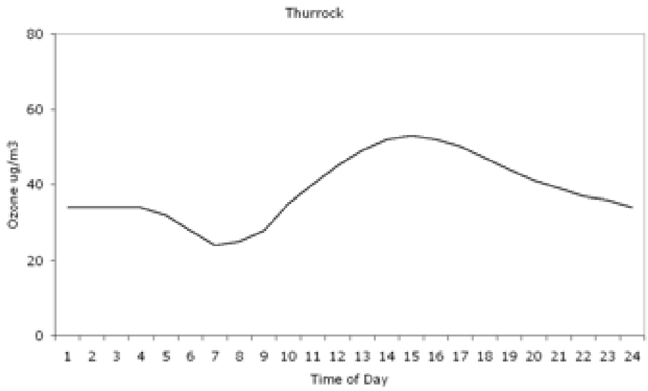
These figures show how ozone concentrations vary on average for each hour of day during the year, at a number of selected *typical* monitoring site types. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of man-made emissions.



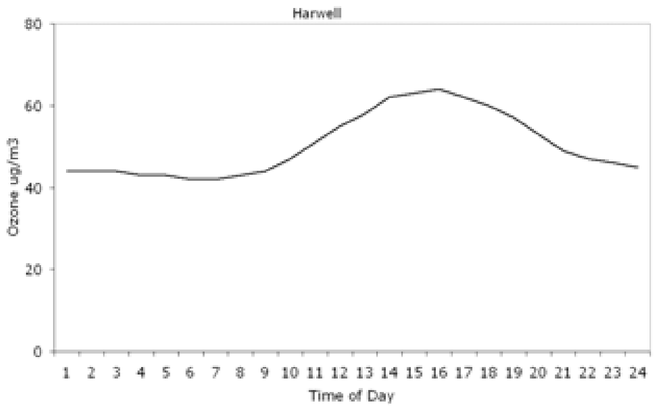
Kerbside Site
(Marylebone Road)



Roadside Site
(Bury)

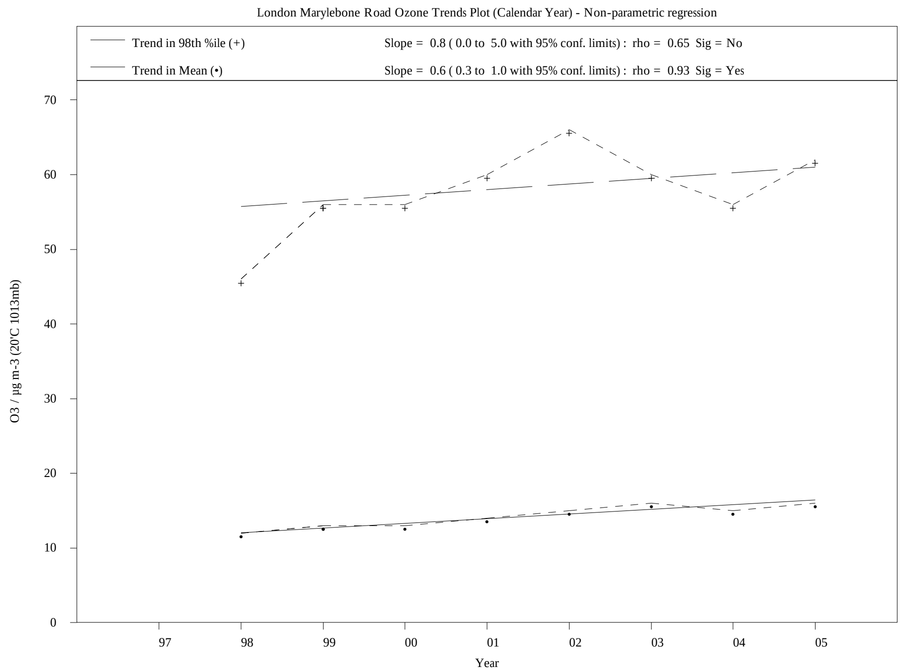


Urban Background Site
(Thurrock)

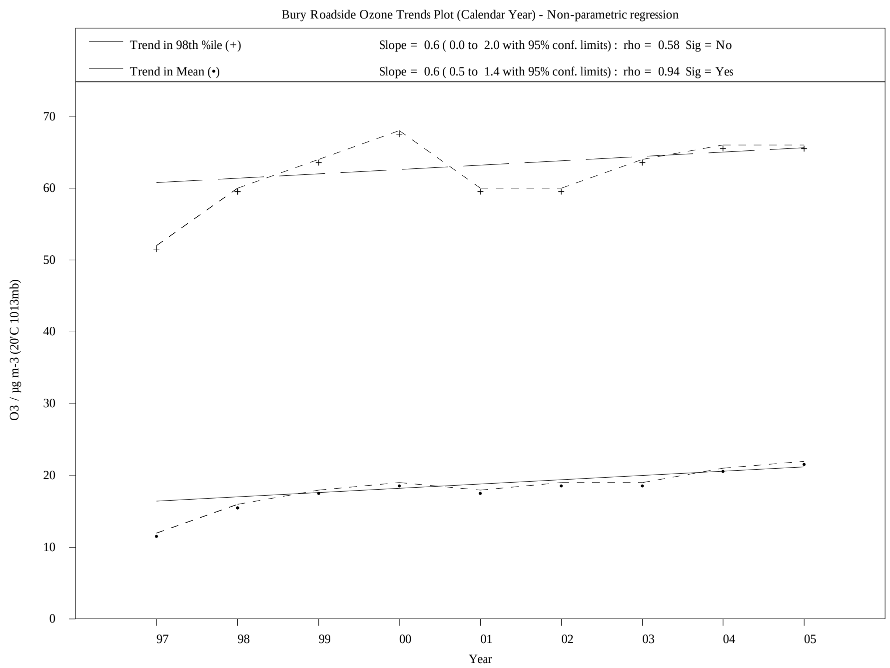


Rural Site
(Harwell)

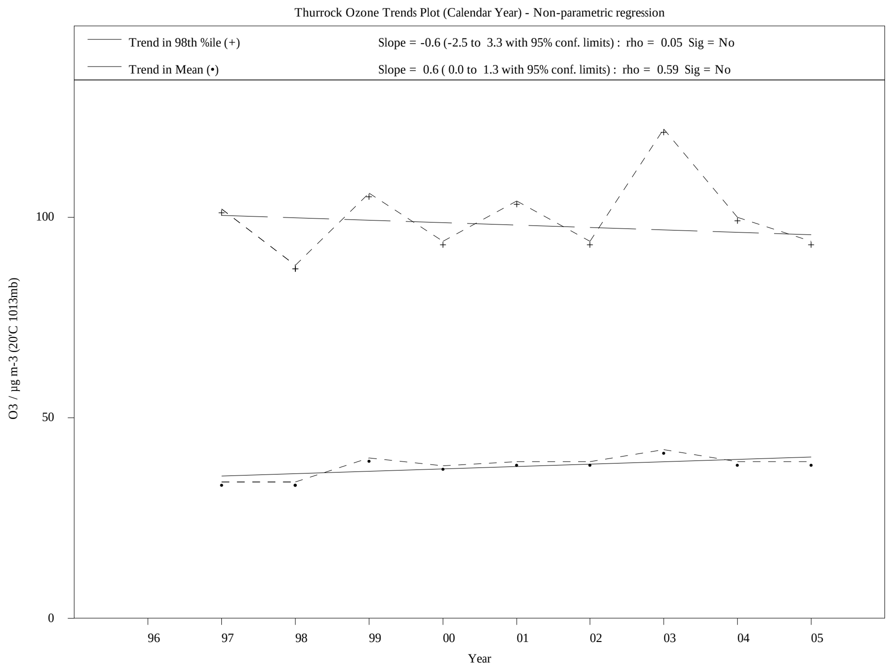
17.8 Trends in annual concentrations



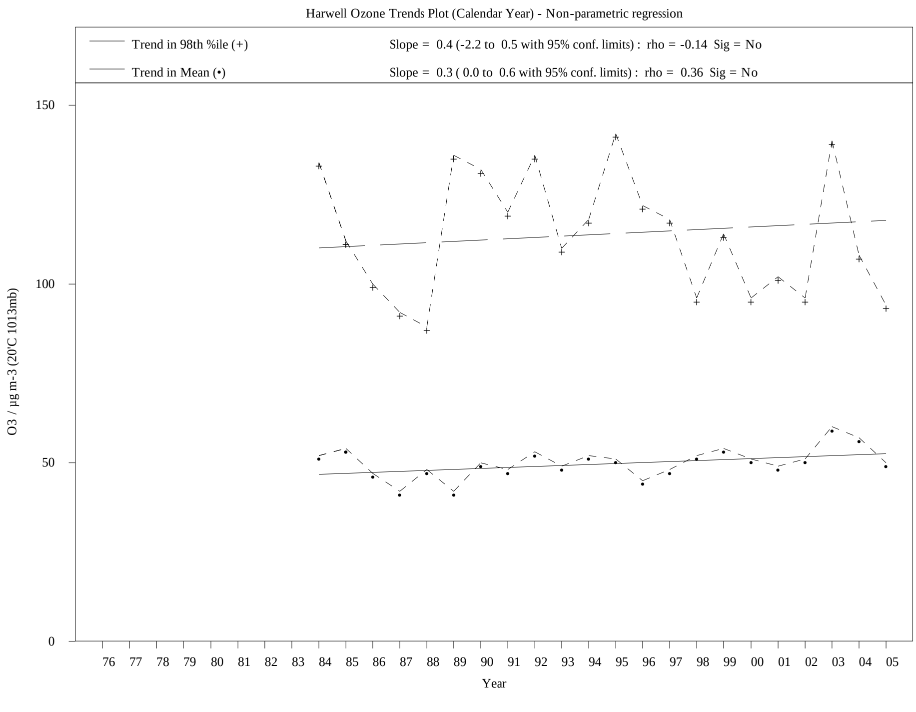
Kerbside Site
(*Marylebone Road)*



Roadside Site
(Bury)



Urban Background
(Thurrock)



Rural Site
(*Harwell)*

17.9 Ozone Statistical Summary 2005

i) ANNUAL STATISTICS- I

	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	Maximum running 8-hour mean µg m^{-3}	Date of maximum running 8-hour mean	97%ile of daily max run 8hr µg m^{-3}
England							
Barnsley Gawber	UB	43	96.2	142	129	10/07/2005	95
Birmingham Centre	UC	40	87.0	146	123	27/05/2005	93
Birmingham Tyburn	UB	41	99.2	142	127	10/07/2005	100
Blackpool Marton	UB	45	52.8	132	104	04/09/2005	86
Bolton	UB	41	97.6	116	104	02/04/2005	87
Bottesford	SU	47	99.3	170	137	18/08/2005	106
Bournemouth	UB	51	98.5	180	144	19/06/2005	112
Bradford Centre	UC	35	93.1	102	89	08/06/2005	78
Brighton Preston Park	RD	51	98.6	178	162	27/05/2005	115
Bristol Centre	UC	45	68.8	136	124	10/07/2005	97
Bury Roadside	RD	22	95.7	106	88	09/07/2005	68
Coventry Memorial Park	UB	45	98.7	170	155	27/05/2005	110
Exeter Roadside	RD	34	98.8	110	99	17/08/2005	80
Glazebury	SU	46	98.3	134	119	02/04/2005	99
Great Dun Fell	RU	60	99.4	136	127	25/04/2005	97
Harwell	RU	50	97.9	148	140	27/05/2005	104
High Muffles	RU	60	93.3	150	126	25/04/2005	113
Hull Freetown	UC	43	97.7	150	132	24/06/2005	100
Ladybower	RU	50	96.5	128	115	10/07/2005	88
Leamington Spa	UB	41	72.8	152	139	27/05/2005	107
Leeds Centre	UC	36	92.7	122	113	09/07/2005	85
Leicester Centre	UC	37	97.3	152	133	14/07/2005	105
Leominster		---	45.4	140	123	18/08/2005	---
Liverpool Speke	UB	47	98.3	124	102	02/04/2005	97
London Bexley	SU	38	97.5	192	159	23/06/2005	101
London Bloomsbury	UC	23	91.2	138	130	17/07/2005	81
London Brent	UB	40	96.4	188	167	27/05/2005	111
London Eltham	SU	39	98.0	182	167	23/06/2005	105
London Hackney	UC	37	77.9	168	143	04/09/2005	113
London Haringey	UC	39	99.6	192	171	23/06/2005	118
London Harlington	A	32	99.1	154	141	23/06/2005	101
London Hillingdon	SU	26	92.4	126	108	10/07/2005	90
London Lewisham	UC	32	99.2	172	140	27/05/2005	104
London Marylebone	KD	16	98.0	92	84	10/07/2005	66
London N. Kensington	UB	35	97.7	176	155	27/05/2005	101
London Southwark	UC	32	96.3	136	123	27/05/2005	88
London Teddington	UB	48	99.0	186	169	27/05/2005	120
London Wandsworth	UC	27	97.5	138	119	27/05/2005	85
London Westminster	UB	33	95.9	168	146	27/05/2005	95
Lullington Heath	RU	59	98.2	202	179	27/05/2005	134
Manchester Piccadilly	UC	28	97.9	144	118	10/07/2005	84
Manchester South	SU	30	95.0	130	101	09/07/2005	75

ii) EXCEEDENCE STATISTICS- I

Site	Moderate band	Days	High band	Days	Very High band	Days	Air Quality Standard (Running 8-hour Mean)	Days
England								
Barnsley Gawber	89	18	0	0	0	0	**27**	**6**
Birmingham Centre	64	13	0	0	0	0	**19**	**5**
Birmingham Tyburn	152	28	0	0	0	0	**50**	**11**
Blackpool Marton	17	6	0	0	0	0	**4**	**1**
Bolton	46	11	0	0	0	0	**6**	**3**
Bottesford	191	31	0	0	0	0	**85**	**16**
Bournemouth	298	52	**1**	**1**	0	0	**127**	**22**
Bradford Centre	2	2	0	0	0	0	0	0
Brighton Preston Park	345	53	0	0	0	0	**157**	**26**
Bristol Centre	67	16	0	0	0	0	**22**	**7**
Bury Roadside	2	1	0	0	0	0	0	0
Coventry Memorial Park	232	40	0	0	0	0	**106**	**22**
Exeter Roadside	10	4	0	0	0	0	0	0
Glazebury	150	33	0	0	0	0	**48**	**11**
Great Dun Fell	154	19	0	0	0	0	**92**	**10**
Harwell	163	27	0	0	0	0	**68**	**14**
High Muffles	406	51	0	0	0	0	**235**	**31**
Hull Freetown	154	27	0	0	0	0	**56**	**11**
Ladybower	60	10	0	0	0	0	**25**	**4**
Leamington Spa	120	22	0	0	0	0	**51**	**10**
Leeds Centre	36	7	0	0	0	0	**16**	**3**
Leicester Centre	158	24	0	0	0	0	**79**	**15**
Leominster	54	8	0	0	0	0	**22**	**4**
Liverpool Speke	85	24	0	0	0	0	**10**	**6**
London Bexley	165	29	**3**	**2**	0	0	**75**	**12**
London Bloomsbury	23	5	0	0	0	0	**10**	**2**
London Brent	273	42	**1**	**1**	0	0	**128**	**24**
London Eltham	181	32	**2**	**2**	0	0	**90**	**15**
London Hackney	155	28	0	0	0	0	**79**	**15**
London Haringey	284	49	**2**	**2**	0	0	**124**	**21**
London Harlington	132	19	0	0	0	0	**60**	**12**
London Hillingdon	34	8	0	0	0	0	**7**	**3**
London Lewisham	187	33	0	0	0	0	**78**	**14**
London Marylebone	0	0	0	0	0	0	0	0
London N. Kensington	159	30	0	0	0	0	**73**	**12**
London Southwark	56	11	0	0	0	0	**26**	**5**
London Teddington	409	67	**2**	**1**	0	0	**186**	**32**
London Wandsworth	57	9	0	0	0	0	**20**	**6**
London Westminster	110	19	0	0	0	0	**57**	**10**
Lullington Heath	487	69	**7**	**3**	0	0	**271**	**39**
Manchester Piccadilly	25	8	0	0	0	0	**7**	**2**
Manchester South	19	6	0	0	0	0	**1**	**1**

v) ANNUAL STATISTICS- II

	Site Type	Annual average of hourly means µg m^{-3}	Annual data capture of hourly means %	Maximum hourly mean µg m^{-3}	Maximum running 8-hour mean µg m^{-3}	Date of maximum running 8-hour mean	97%ile of daily max run 8hr µg m^{-3}
Market Harborough	RU	47	98.9	150	129	27/05/2005	102
Middlesbrough	I	44	95.8	114	101	22/04/2005	89
Newcastle Centre	UC	44	97.4	120	111	25/04/2005	88
Northampton	UB	44	96.5	166	144	27/05/2005	104
Norwich Centre	UC	41	93.6	166	147	23/06/2005	106
Nottingham Centre	UC	34	97.7	134	112	10/07/2005	84
Plymouth Centre	UC	42	88.2	118	112	10/07/2005	85
Portsmouth	UB	46	99.2	204	162	27/05/2005	112
Preston	UB	48	95.6	130	122	24/04/2005	95
Reading New Town	UB	46	96.6	188	168	27/05/2005	111
Redcar	SU	47	80.3	124	113	22/04/2005	96
Rochester	RU	45	98.7	172	151	27/05/2005	101
Rotherham Centre	UC	31	91.6	130	118	10/07/2005	83
Salford Eccles	I	35	95.9	138	108	17/08/2005	86
Sandwell West Bromwich	UB	40	95.8	134	124	10/07/2005	98
Sheffield Centre	UC	31	98.3	128	115	10/07/2005	80
Sibton	RU	59	91.3	190	177	23/06/2005	137
Somerton	RU	55	95.4	152	126	27/05/2005	110
Southampton Centre	UC	33	91.3	112	90	14/07/2005	76
Southend-on-Sea	UB	42	93.2	162	149	23/06/2005	113
St Osyth	RU	53	94.4	186	164	19/06/2005	112
Stoke-on-Trent Centre	UC	42	96.1	126	111	17/08/2005	89
Sunderland Silksworth	UB	50	88.6	118	108	25/04/2005	94
Thurrock	UB	39	94.2	176	150	23/06/2005	106
Weybourne	RU	68	86.1	202	188	24/06/2005	126
Wicken Fen	RU	53	89.7	178	165	31/08/2005	127
Wigan Centre	UB	44	98.2	146	119	24/04/2005	96
Wirral Tranmere	UB	49	66.3	122	102	24/04/2005	89
Wolverhampton Centre	UC	42	96.6	140	121	27/05/2005	96
Yarner Wood	RU	60	96.4	154	133	11/07/2005	113
N Ireland							
Belfast Centre	UC	40	95.4	112	100	23/04/2005	86
Derry	UB	52	86.7	130	119	25/04/2005	95
Lough Navar	RU	50	98.3	140	127	25/04/2005	91
Scotland							
Aberdeen	UB	50	98.9	120	105	24/04/2005	94
Bush Estate	RU	55	98.1	128	113	12/07/2005	88
Edinburgh St Leonards	UB	53	93.3	120	110	13/05/2005	102
Eskdalemuir	RU	51	96.0	128	102	31/08/2005	87
Glasgow Centre	UC	33	97.0	98	87	20/01/2005	79
Lerwick		56	57.8	104	93	03/07/2005	84
Strath Vaich	RE	67	92.7	126	122	26/04/2005	106
Wales							
Aston Hill	RU	70	98.8	158	139	27/05/2005	116
Cardiff Centre	UC	38	58.3	114	104	02/04/2005	80
Cwmbran	UB	52	99.5	156	124	10/07/2005	105
Narberth	RU	63	60.5	110	103	08/11/2005	95
Port Talbot	UB	53	94.8	144	123	31/08/2005	100
Swansea	UC	43	97.5	130	116	10/07/2005	97

vi) EXCEEDENCE STATISTICS- II

Site	Moderate band	Days	High band	Days	Very High band	Days	Air Quality Standard (Running 8-hour Mean)	Days
Market Harborough	156	24	0	0	0	0	**71**	**13**
Middlesbrough	28	10	0	0	0	0	**1**	**1**
Newcastle Centre	38	7	0	0	0	0	**19**	**2**
Northampton	180	30	0	0	0	0	**76**	**14**
Norwich Centre	162	24	0	0	0	0	**96**	**14**
Nottingham Centre	58	12	0	0	0	0	**13**	**4**
Plymouth Centre	42	10	0	0	0	0	**10**	**3**
Portsmouth	232	37	**2**	**1**	0	0	**120**	**22**
Preston	91	21	0	0	0	0	**34**	**6**
Reading New Town	249	39	**1**	**1**	0	0	**115**	**22**
Redcar	101	14	0	0	0	0	**43**	**6**
Rochester	190	35	0	0	0	0	**75**	**13**
Rotherham Centre	30	10	0	0	0	0	**7**	**1**
Salford Eccles	41	9	0	0	0	0	**11**	**4**
Sandwell West Bromwich	104	19	0	0	0	0	**38**	**10**
Sheffield Centre	19	6	0	0	0	0	**5**	**1**
Sibton	816	97	**9**	**2**	0	0	**482**	**63**
Somerton	238	34	0	0	0	0	**113**	**20**
Southampton Centre	6	3	0	0	0	0	0	0
Southend-on-Sea	196	25	0	0	0	0	**115**	**15**
St Osyth	321	54	**3**	**1**	0	0	**152**	**29**
Stoke-on-Trent Centre	40	14	0	0	0	0	**8**	**2**
Sunderland Silksworth	66	10	0	0	0	0	**30**	**6**
Thurrock	162	30	0	0	0	0	**71**	**13**
Weybourne	626	74	**11**	**4**	0	0	**391**	**43**
Wicken Fen	345	55	0	0	0	0	**160**	**29**
Wigan Centre	88	20	0	0	0	0	**32**	**7**
Wirral Tranmere	32	9	0	0	0	0	**2**	**1**
Wolverhampton Centre	84	22	0	0	0	0	**21**	**8**
Yarner Wood	223	35	0	0	0	0	**112**	**19**
N Ireland								
Belfast Centre	20	7	0	0	0	0	0	0
Derry	61	14	0	0	0	0	**22**	**4**
Lough Navar	45	11	0	0	0	0	**14**	**3**
Scotland								
Aberdeen	87	14	0	0	0	0	**26**	**6**
Bush Estate	19	6	0	0	0	0	**6**	**1**
Edinburgh St Leonards	192	28	0	0	0	0	**80**	**13**
Eskdalemuir	22	5	0	0	0	0	**1**	**1**
Glasgow Centre	0	0	0	0	0	0	0	0
Lerwick	2	2	0	0	0	0	0	0
Strath Vaich	293	38	0	0	0	0	**140**	**18**
Wales								
Aston Hill	447	64	0	0	0	0	**228**	**36**
Cardiff Centre	13	3	0	0	0	0	**3**	**1**
Cwmbran	210	33	0	0	0	0	**85**	**17**
Narberth	37	11	0	0	0	0	**5**	**2**
Port Talbot	142	32	0	0	0	0	**56**	**11**
Swansea	107	27	0	0	0	0	**31**	**8**

Air Pollution in the UK: 2005

Part 3 - Appendices

1- The Major Air Pollutants measured in the UK

2- Regional Maps of UK Automatic Air Monitoring Sites

3- The UK's Automatic and Sampler-based Air Monitoring Networks

4- Analysis of statistically significant trends in UK air pollution levels

5- Listing of current UK, European and WHO Air Quality Criteria

6- Calculation methods, statistical methods and measurement uncertainty

Appendix 1- The Major Air Pollutants measured in the UK

We describe major sources and effects of these pollutants, together with typical UK-wide patterns of exposure.

Measured Pollutants

The principal air pollutants measured in UK National Air Monitoring networks are:

- Nitrogen oxides, and primarily nitrogen dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Ozone (O_3)
- Particles- primarily measured as PM_{10} at the present time
- Benzene (C_6H_6)
- 1,3-butadiene (C_4H_6)
- Lead and heavy metals

The first five of these are measured in the AURN, whilst the two volatile organic compounds- benzene and 1,3-butadiene- are measured in the automatic hydrocarbon network. The various pollutants have different sources and behave very differently once emitted into the atmosphere. As a result, spatial and temporal patterns can differ markedly between the pollutants.

In this appendix, we briefly examine the sources, effects and distributions of these major pollutants. For more detail, please refer to the authoritative series of pollutant-specific analyses and guidelines produced by EPAQS (the UK Expert Panel on Air Quality Standards)[18-25] and World Health Organisation[26].

Nitrogen Oxides

Nitrogen oxides (NO_x) are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides - nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x - is road traffic. For the UK as a whole, approximately 45% of all oxide of nitrogen emission originates from this source, with most of the remainder arising from power stations and other industrial sources. Since power station and industrial emissions are usually from elevated sources (i.e. high chimneys), motor vehicles represent by far the largest source of low-level NOx emission and therefore make the largest contribution (75% or greater) to long-term ground level concentrations in urban areas.

Nitric oxide is not generally considered to be harmful to health at the concentrations found in the ambient atmosphere. However, once released to the atmosphere, it rapidly oxidises to nitrogen dioxide, which has a variety of environmental and health impacts. Its direct health impact as a respiratory irritant may be significant. Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.

In the presence of sunlight, nitrogen oxides can react with Volatile Organic Compounds (VOCs) to produce photochemical pollutants including ozone. Nitrogen dioxide can also be further oxidised in air to acid gases such as nitric acid, which contribute to the production of acid rain over regional scales.

The highest NOx levels in UK cities are generally observed at kerbside locations. However, since much of the NO_2 is formed from primary emissions of NO by time-dependent oxidation processes in the atmosphere, the relative decline in NO_2 concentration away from the kerbside is slower than for NO.

Modelling and monitoring studies- for example with diffusion tube samplers- have shown that NO_2 concentrations tend to be greatest in central urban areas. However, this cannot always be assumed to be the case, especially where major road systems, industrial areas or other large sources are located away from city centre areas.

Sulphur Dioxide

Sulphur dioxide (SO_2) is an acid gas which acts as an irritant to the respiratory system and may exacerbate or initiate symptoms in asthmatics. Even moderate concentrations of SO2 may result in a decline in lung function in asthmatics. Tightness in the chest and coughing occur at high levels, and lung function of asthmatics may be impaired to the extent that medical help is required. Sulphur dioxide pollution is considered more harmful when particle and other pollution concentrations are high. This is a good example of combined or *synergistic* effects of air pollutants.

Primary emissions of sulphur dioxide are a major contributor to the formation of acid rain; this can be transported over long distances, with important consequences for terrestrial and aquatic ecosystems, as well as the man-made built environment.

This pollutant is formed by the oxidation of sulphur impurities in fuels during combustion processes. A very high proportion (approximately 85%) of UK SO_2 emissions originate from power stations and industrial sources. As the use of coal for domestic heating has decreased, its emissions and atmospheric concentrations in urban areas have decreased considerably over the last 20-30 years.

Geographically, SO_2 concentrations in the UK are highest in urban areas such as mining regions in the north of England and in Northern Ireland, where there is still significant use of coal for domestic heating. Modelling studies have indicated that the highest SO_2 concentrations in cities usually occur in the central areas.

Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless but toxic gas produced by incomplete combustion of fossil fuels. At worst-case ambient levels (in congested streets, car-parks or tunnels), exposure may reduce the oxygen-carrying capacity of the blood and impair oxygen delivery to the brain and other organs, particularly affecting adults with angina and diseases of the coronary arteries.

Carbon monoxide in urban areas results almost entirely from vehicle emissions. The emission rate for individual vehicles depends critically on vehicle speed, being higher at low speeds.

Since CO is a primary pollutant, its ambient concentrations closely follow emissions. In urban areas, concentrations are therefore highest at the kerbside and decrease rapidly with increasing distance from the road. Since traffic is by far the most important source of CO, its spatial distribution will follow that of traffic: this will generally result in the highest levels being observed in the city centre, where most congested areas tend to be found.

Ozone

Ozone (O_3) is a highly reactive oxidising agent, with a wide range of material, vegetation and human health impacts. Acute health effects of ozone may include eye/nose irritation, respiratory problems and airway inflammation.

In addition to its serious impacts on human health, ozone is also *phytotoxic* – damaging to many plants and commercial crops. It can also damage or age some man-made materials such as rubbers and elastomers, as well as bleaching paints and fabrics.

A natural background ozone concentration exists in the atmosphere due to mixing of ozone from the stratosphere and its generation in the troposphere. The background concentration depends on latitude and time of year: in the UK, measurements show the resulting annual average background concentration to be about 70 $\mu g/m^3$.

Ozone is not emitted directly into the atmosphere in any significant quantity and its presence in the lower atmosphere at concentrations exceeding background results primarily from a complex series of reactions in the atmosphere; these may be summarised as the sunlight-initiated oxidation of volatile organic compounds (VOCs) in the presence of nitrogen oxides (NO_x). The sources of VOCs are similar to those described for NO_x above, but also include other activities such as solvent use, and petrol distribution and handling.

The reactions producing ozone occur in air containing these NO_x and VOC precursors as it moves downwind; ozone formation can occur over a timescale of a few hours to several days. As a result, ozone concentrations are decoupled temporally and spatially from precursor sources and ambient concentrations are strongly dependent on meteorological conditions, together with scavenging and deposition rates. The net result is that ozone concentrations measured at a particular location may have arisen from VOC and NOx emissions many hundreds or even thousands of miles away. Maximum concentrations, therefore, generally occur some distance downwind of the original sources of precursor emissions.

In urban areas, chemical scavenging by NO_x emissions results in ozone concentrations that are generally lower than in rural areas. Moreover, urban ozone concentrations tend to be highly variable over small spatial scales, with concentrations lowest where corresponding levels of other pollutants such as NO are highest. In cities, therefore, ozone concentrations will tend to be lower in central areas and increase in the suburbs, although the spatial variation will be complex and, in open spaces in urban areas, levels of ozone may approach those found in nearby rural areas.

Particulate Matter

Particulate Matter (PM) is a generic descriptor covering a wide range of particle size fractions, morphologies and chemical compositions. Although coarse (large) particle size ranges may cause significant local nuisance or soiling impacts, it is the finer (small) fractions that are capable of deep lung/airway penetration. This is why these fractions such as PM_{10} and $PM_{2.5}$ are measured in UK national monitoring networks.

Particles also have a range of important non-biological impacts including:

- Soiling of man-made materials and buildings, resultant loss of amenity
- Reducing visibility (fine particles- aerosol)
- Effects on heterogeneous atmospheric chemistry

Particles are produced from a variety of natural and man-made sources. Natural sources include sea salt, soil blowoff, Saharan dust, forest fires and volcanic activity. Man-made sources include incomplete combustion processes (e.g. coal and diesel smoke), industry and construction activity. Industrial accidents such as the Buncefield 2005 event can also produce large quantities of particles.

Particles may be either directly emitted into the atmosphere (primary particles) or formed there by chemical reactions (secondary particles). Sulphate and nitrate aerosol is a good example of the latter; this can often transported over national or continental distances. Both particle size, usually expressed in terms of its aerodynamic diameter, and chemical composition are greatly influenced by its origin.

The principal source of PM_{10} (the mass fraction of particles collected by a sampler with a 50% inlet cut-off at aerodynamic diameter 10µm) in many cities is road traffic emissions, particularly from diesel vehicles. As well as creating dirt, odour and visibility problems, PM_{10} particles are associated with health effects including increased risk of heart and lung disease. In addition, they may carry surface- absorbed carcinogenic compounds into the lungs. Concern about the potential health impacts of fine particulate matter has increased over recent years. In particular, increasing policy and measurement action – both Europe-wide and within the UK – is now focussing on $PM_{2.5}$.

Existing PM_{10} data show that daily average concentrations are usually highest in the winter months and lowest in the summer. During winter episode periods, PM_{10} levels increase together with other traffic-related pollutants such as oxides of nitrogen. During the spring and summer, the photochemical oxidation of sulphur dioxide and oxides of nitrogen to particulate sulphate and nitrate is another important source.

Benzene

Benzene (C_6H_6) is a fat-soluble volatile organic compound (VOC) with a range of potential health effects. Acute exposure to benzene at occupational levels can cause narcotic, anaesthetic or fatal consequences. Benzene is a proven genotoxic carcinogen, and ambient long-term exposure is implicated in the formation of a range of types of leukaemia in the general population. Potential chronic health effects of this pollutant also include central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects.

Benzene has no significant natural sources, so that ambient exposure results primarily from petrol combustion in road transport emissions or evaporation of petrol (which contains benzene) from filling stations. Benzene is naturally broken down by chemical reactions in the atmosphere, although these reactions can take several days. As a result, outdoor benzene concentrations tend to closely follow road networks and traffic density patterns.

1,3-Butadiene

Evidence from occupational human exposure and laboratory studies on animals shows 1,3-butadiene (C_4H_6) to be a carcinogen, exposure to which can cause a range of cancers of the lymphoid system, blood-forming tissues, lymphomas and leukaemias. Potential chronic health effects of this pollutant also include central nervous system disorders, liver and kidney damage, reproductive disorders and birth defects.

This substance is used in some industrial sectors, primarily in the production of synthetic rubber. However, ambient exposure of the general population results primarily from fuel combustion- mainly from petrol-fuelled motor vehicles, but also from other fossil fuels, accidental fires and industrial releases.

Unlike benzene, this is not a constituent of petrol, so evaporative or fugitive emissions are not a significant source. Although 1,3-butadiene is removed by catalytic converters and not produced from diesel engines, spatial and temporal exposure patterns in the UK are dominated by road transport.

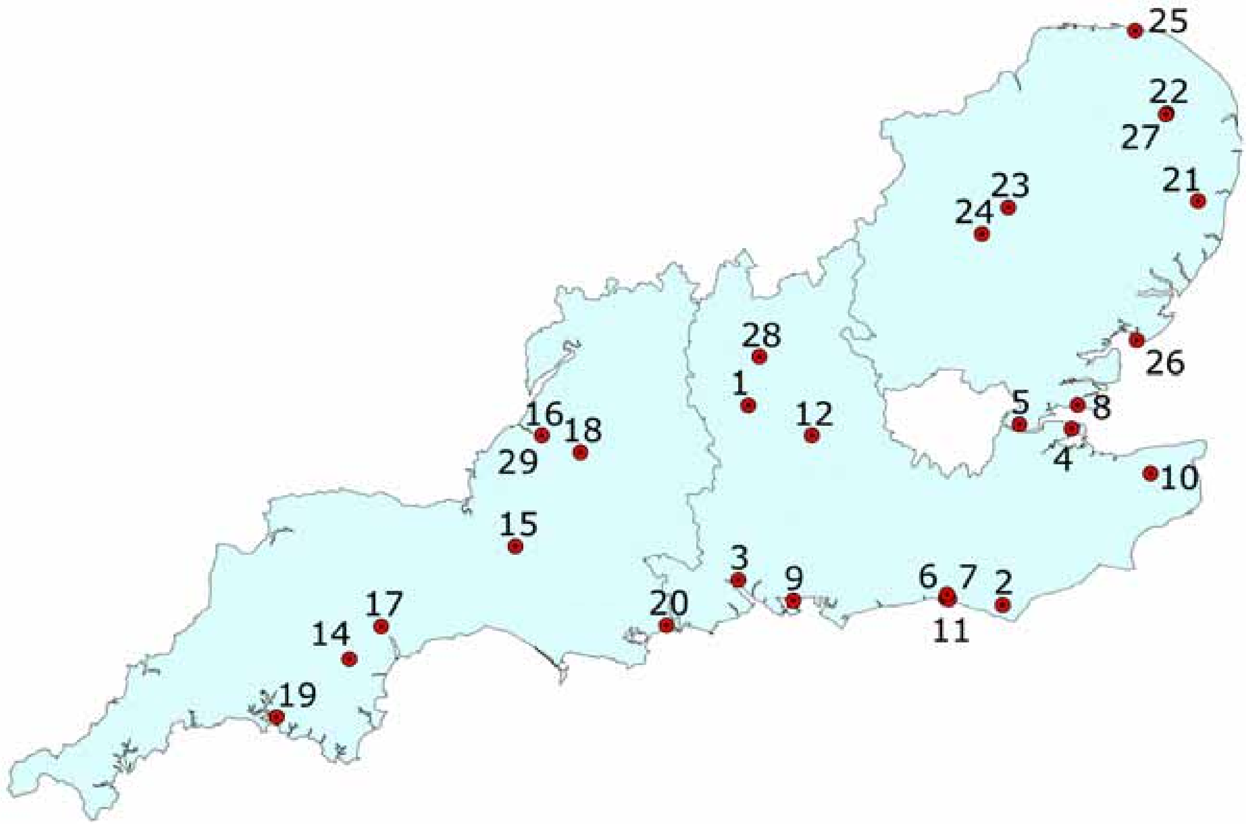
Lead

The majority of Lead (Pb) emissions arise from older vehicles fuelled with leaded petrol. Industry, in particular secondary non-ferrous metal smelters, may also contribute to emissions of lead in localised industrial areas. This source is becoming increasingly significant due to the progressive reduction in the lead content of leaded petrol and the increasing use of unleaded petrol; this has led to significant reductions in urban lead levels over recent years.

Even small amounts of lead can be harmful, especially to infants and young children. In addition, lead taken in by the mother can interfere with the health of the unborn child. Exposure has also been linked to impaired mental function, visual-motor performance and neurological damage in children, and memory and attention span.

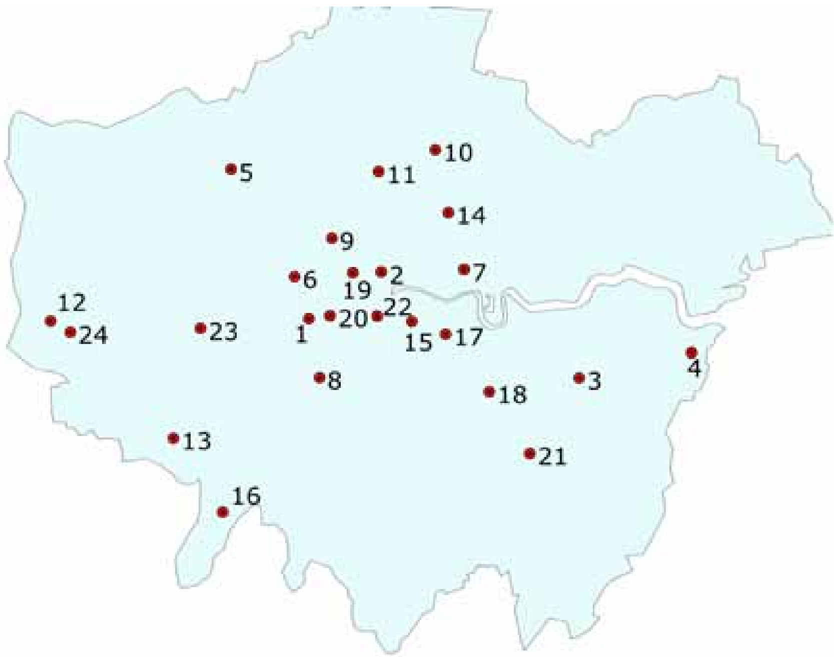
Appendix 2- Regional Maps of UK Automatic Air Monitoring Stations

These maps show Automatic Urban and Rural Network (AURN) and Hydrocarbon air monitoring sites in different parts of the UK.



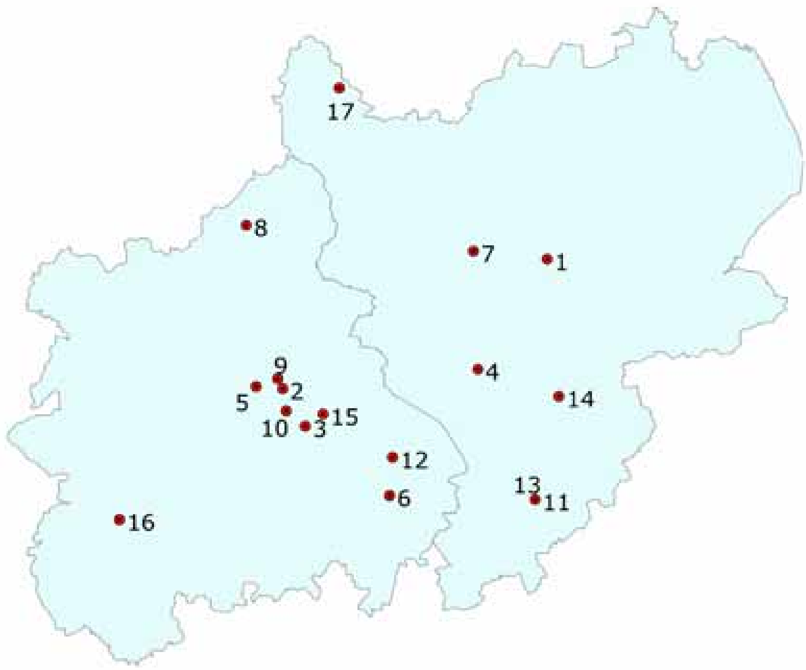
No	Site Name
1	Harwell
2	Lullington Heath
3	Southampton Centre
4	Rochester
5	Thurrock
6	Hove Roadside
7	Brighton Roadside
8	Southend-on-Sea
9	Portsmouth
10	Canterbury
11	Brighton Roadside PM10
12	Reading New Town
13	Brighton Preston Park
14	Yarner Wood
15	Somerton
16	Bristol Old Market
17	Exeter Roadside
18	Bath Roadside
19	Plymouth Centre
20	Bournemouth
21	Sibton
22	Norwich Centre
23	Wicken Fen
24	Cambridge Roadside
25	Weybourne
26	St Osyth
27	Norwich Forum Roadside
28	Oxford Centre Roadside
29	Bristol St Paul's

Figure 2.1 Automatic Sites, Southern England



No	Site Name
1	West London
2	London Bloomsbury
3	London Eltham
4	London Bexley
5	London Brent
6	London N. Kensington
7	Tower Hamlets Roadside
8	London Wandsworth
9	Camden Kerbside
10	Haringey Roadside
11	London Haringey
12	London Hillingdon
13	London Teddington
14	London Hackney
15	London Southwark
16	London A3 Roadside
17	Southwark Roadside
18	London Lewisham
19	London Marylebone Road
20	London Cromwell Road 2
21	London Bromley
22	London Westminster
23	Brentford Roadside
24	London Harlington

Figure 2.2 Automatic Sites, London



No	Site Name
1	Bottesford
2	Walsall Alumwell
3	Birmingham Centre
4	Leicester Centre
5	Wolverhampton Centre
6	Leamington Spa
7	Nottingham Centre
8	Stoke-on-Trent Centre
9	Walsall Willenhall
10	Sandwell West Bromwich
11	Northampton
12	Coventry Memorial Park
13	Northampton PM10
14	Market Harborough
15	Birmingham Tyburn
16	Leominster
17	Ladybower

Figure 2.3 Automatic Sites, Midlands

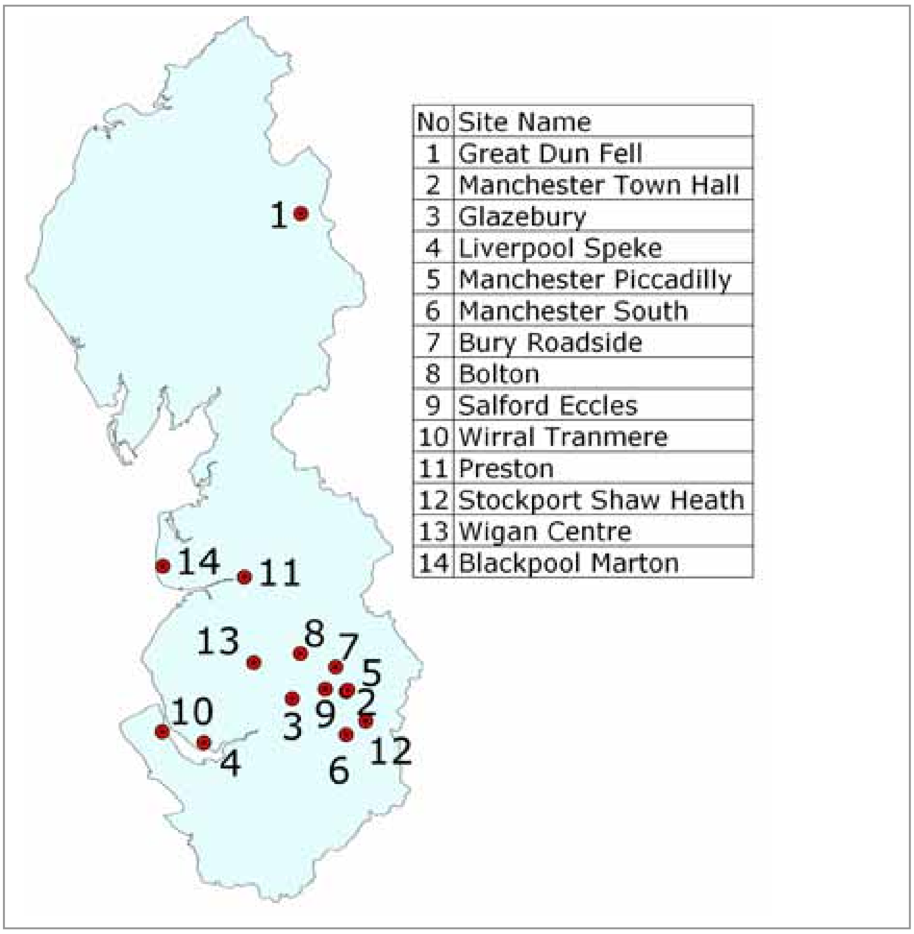


Figure 2.4 Automatic Sites, NW England

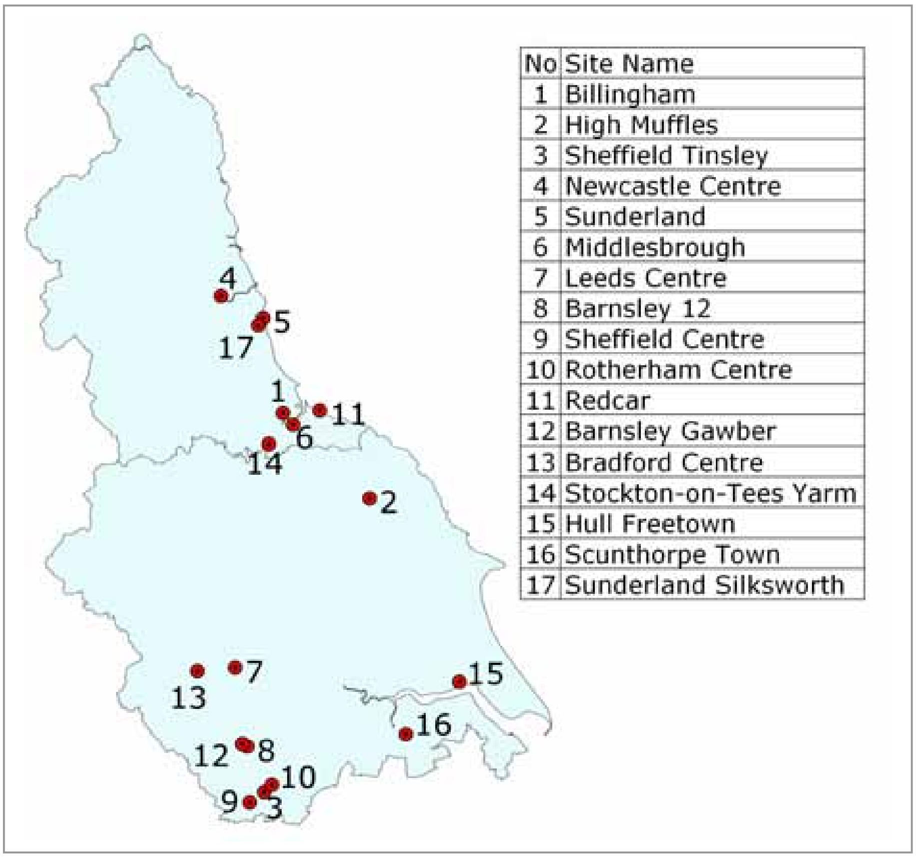


Figure 2.5 Automatic Sites, NE England

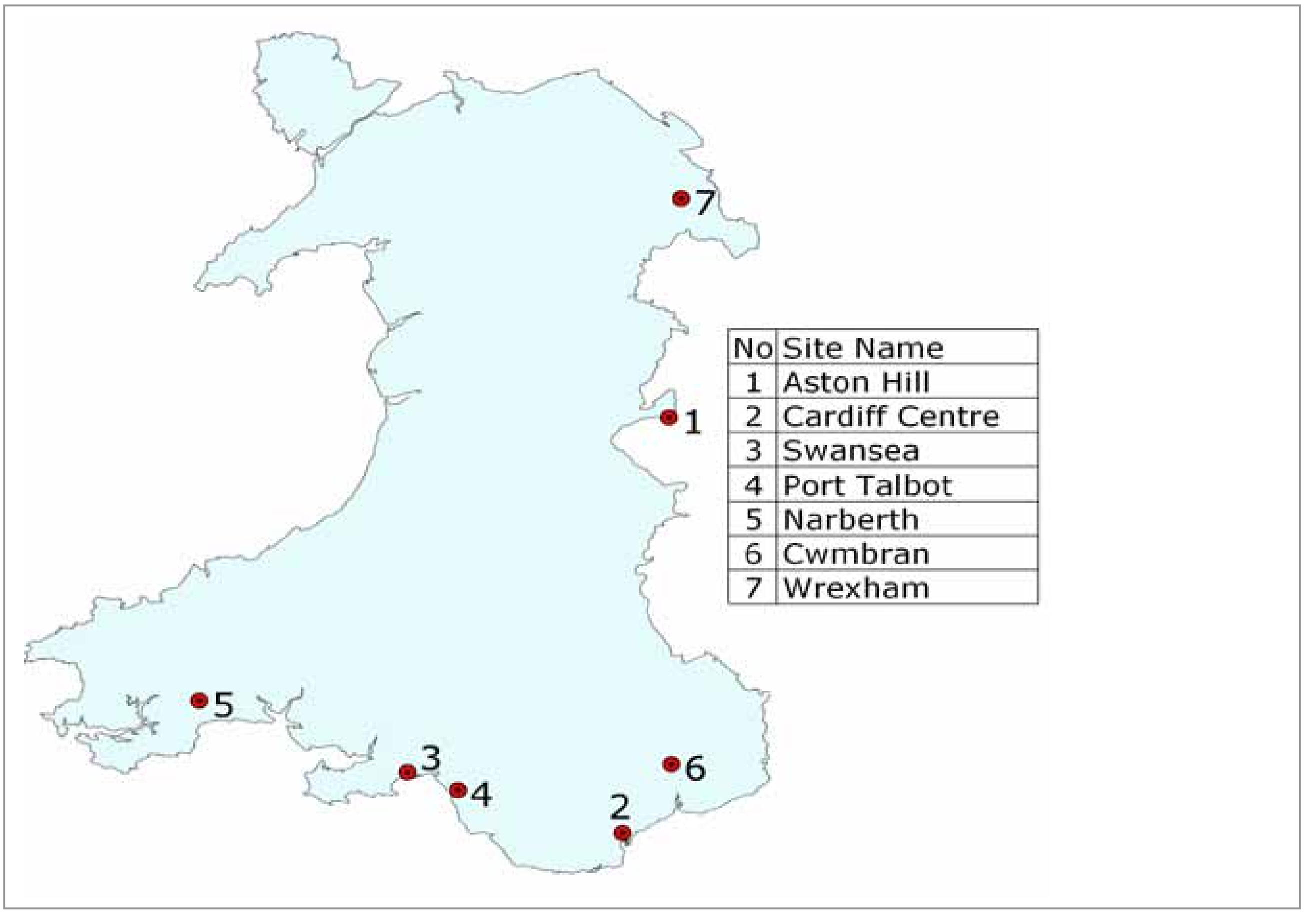


Figure 2.6 Automatic Sites, Wales

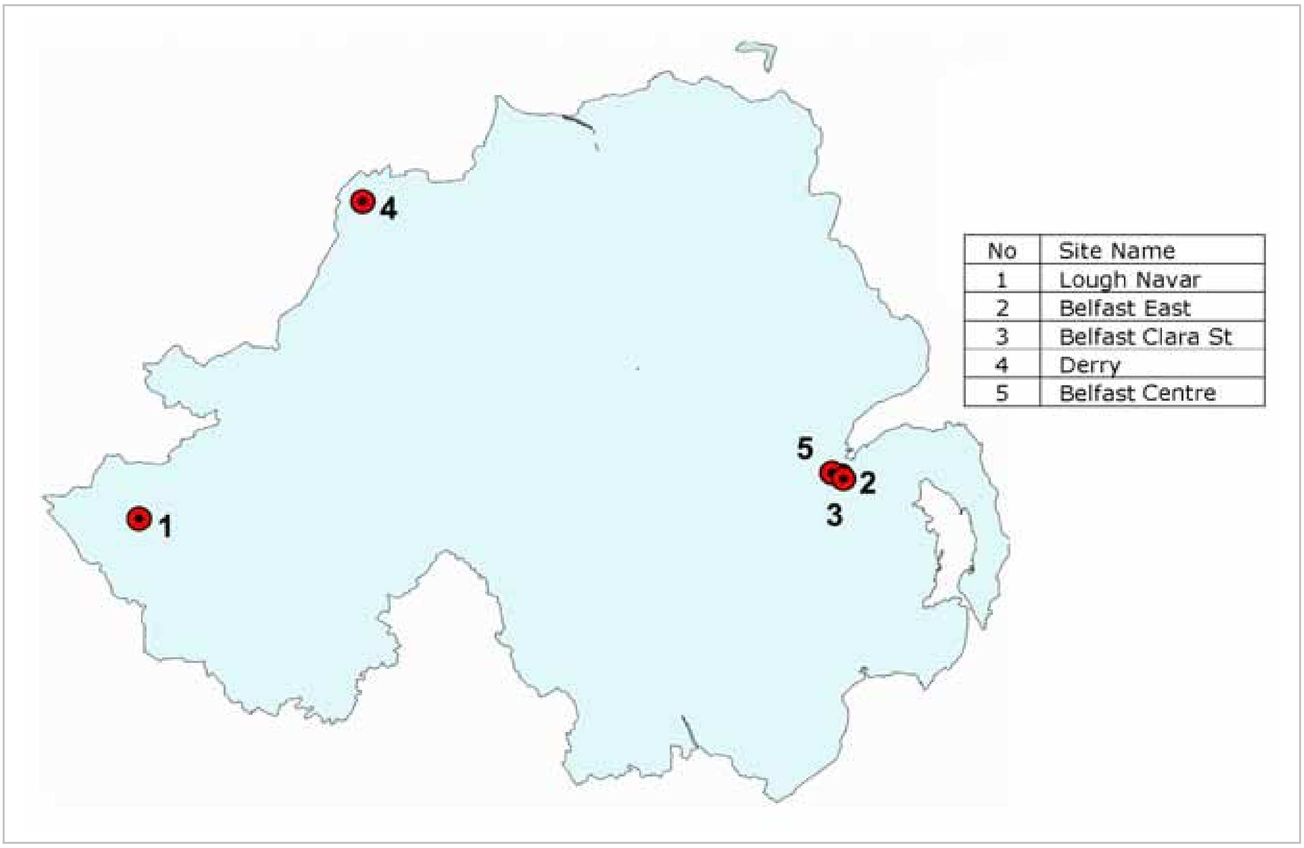
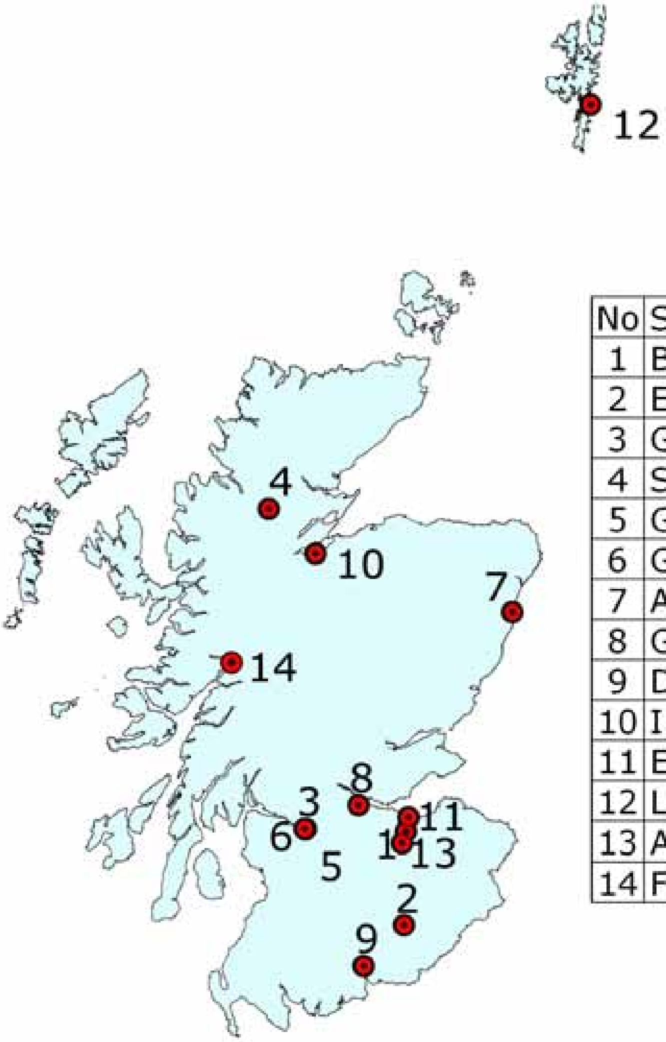


Figure 2.7 Automatic Sites, Northern Ireland



No	Site Name
1	Bush Estate
2	Eskdalemuir
3	Glasgow City Chambers
4	Strath Vaich
5	Glasgow Centre
6	Glasgow Kerbside
7	Aberdeen
8	Grangemouth
9	Dumfries
10	Inverness
11	Edinburgh St Leonards
12	Lerwick
13	Auchencorth Moss
14	Fort William

Figure 2.8 Automatic Sites, Scotland

Appendix 3- The UK's Automatic and Sampler-based Air Monitoring Networks

Here we provide a concise guide to the different UK air monitoring networks, their objectives and methodologies.

A 3.1	**The Automatic Urban and Rural Network**
A 3.2	**The Acid Deposition and Rural SO_2 networks**
A 3.3	**The Hydrocarbon Monitoring Networks**
A 3.4	**The PAH and TOMPS Networks**
A 3.5	**The Heavy Metals Networks**
A 3.6	**The National Ammonia Monitoring Network (NAMN)**

A 3.1 The Automatic Urban and Rural Network (AURN)

(Network managed for Defra and the DAs by Bureau Veritas & quality assured by Netcen)

The AURN is the largest UK automatic monitoring programme. It consists of automatic air quality monitoring stations measuring oxides of nitrogen (NOx), sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO) and particles (PM_{10}). These are monitored on an hourly basis at measurement sites throughout the UK.

As of August 2005, the AURN consists of 127 monitoring sites. Of these, 64 are directly funded by Defra and the devolved administrations, and a further 63 affiliated sites are owned and operated by local authorities; 14 of these sites are also in the London Air Quality Network (LAQN). The network has grown dramatically since it was first established in 1992 (see Figure 1)

The major objectives of the network are as follows:

- Checking if statutory air quality standards and targets are met (e.g. EU Directives)
- Informing the public about air quality
- Providing information for local air quality review and assessments within the UK Air Quality Strategy
- Identifying long-term trends in air pollution concentrations
- Assessing the effectiveness of policies to control pollution

A number of organisations are involved in the day-to-day running of the network. Currently, the role of Central Management and Co-ordination Unit (CMCU) for the AURN is contracted to Bureau Veritas, whilst the Environmental Research Group (ERG) of King's College London has been appointed as Management Unit for the London Air Quality Network (LAQN). AEA Technology's Netcen undertakes the role of Quality Assurance and Control Unit (QA/QC Unit) for the AURN. The responsibility for operating individual monitoring sites is assigned to local organisations, such as local authority Environmental Health Officers with relevant experience in the field. Calibration gases for the network are supplied by Air Liquide Ltd and are provided with a UKAS certificate of calibration by Netcen.

The techniques used for monitoring within the AURN are summarised below. These techniques represent the current state-of-the-art for automated monitoring networks and, with the exception of the automatic PM_{10} analysers, are the reference methods of measurement defined in the relevant EU Directives. See Section 4.4 for information on recent evaluations of PM10 measurement techniques.

Additional monitors for NO_2, SO_2 and PM_{10} particulate matter were added to the AURN in 2001 and further monitors for CO were introduced in 2002. Additional monitors for O_3 and rural NOx have recently been installed to comply with the third Daughter Directive on Ozone. As $PM_{2.5}$ measurements are also required under the first Daughter Directive, 4 automatic analysers for $PM_{2.5}$ monitoring were incorporated into the AURN during 2003.

AURN Measurement Techniques (considered in greater detail in Part 2)

O_3	UV absorption
NO / NOx	Chemiluminescence
SO_2	UV fluorescence
CO	IR Absorption
PM_{10}	Tapered Element Oscillating Microbalance Beta Attenuation monitor Gravimetric monitor

There have been considerable changes in European air quality legislation in the last few years and the AURN has successfully expanded and evolved to conform to these new requirements.

A 3.2 The Acid Deposition and Rural SO_2 Monitoring Networks

(Managed and operated for Defra and the DAs by a consortium of CEH and Netcen)

The Acid Deposition Monitoring network (ADMN) was established in 1986 to monitor the composition of precipitation and hence to provide information on deposition of acidifying compounds in the United Kingdom. Its main emphasis has always been the assessment of potential impacts on UK ecosystems. Other measurements are also made within the programme - sulphur dioxide, nitrogen dioxide, particulate sulphate - to provide a more complete understanding of precipitation chemistry in the United Kingdom.

This network has evolved substantially over time. It was originally based on two sub-programmes- a 'primary' network providing high quality and high frequency data, which could be used to identify trends over time- and a 'secondary' network providing information on the spatial distribution of acid deposition in the UK. Originally, there were 9 primary and 59 secondary sampling sites. Subsequent changes made to the programme, including the incorporation of new measurement techniques for trace rural gases and altered sampling frequencies, have made this distinction less clearcut.

In 1999, 7 new sites were established to monitor rainwater composition in ecologically-sensitive areas and a new denuder-based sampler network of 12 sites was established to monitor nitric acid, other acid gases and aerosol components.

The SO_2 measurements in the ADMN and rural SO_2 programme were terminated at the end of 2005. These will be replaced in 2006 by SO_2 measurements made as part of an expanded nitric acid denuder measurement programme.

In 2005, the network covers the following measurements and sites:

The Acid Deposition Monitoring Network- site numbers and measured parameters

Precipitation Composition	– Rainwater sampling using a bulk collector on a ***fortnightly*** basis at 38 sites – Rainwater sampling using a bulk collector on a ***daily*** basis at one site
Sulphur Dioxide	– Sampled on a ***monthly*** basis at 8 sites
Particulate Sulphate	– Sampled on a ***daily*** basis at 5 sites
Nitrogen Dioxide	– Diffusion tube measurements on a ***monthly*** basis at 32 sites
Nitric Acid and Other Acid Gases	– Denuder measurements on a ***monthly*** basis at 12 sites

A 3.3 The Hydrocarbon monitoring networks

i) The Automatic Hydrocarbon Network

(Network managed and quality assured for Defra and the DAs by Netcen)

Automatic hourly measurements of speciated hydrocarbons, made using an advanced automatic gas chromatograph (VOCAIR), started in the UK in 1991. By 1995, monitoring had expanded considerably with the formation of a 13-site dedicated network measuring

26 species continuously at urban, industrial and rural locations. The focus in this measurement programme was two-fold: firstly to assess ambient concentrations of a range of Volatile Organic Compounds (VOCs) with significant photochemical oxidant formation potential, and secondly to measure two known genotoxic carcinogens (benzene and 1,3-butadiene) for comparison against emerging UK Air Quality Objectives. Data on these 'air toxics' was also regularly reported to the public.

The automatic hydrocarbon monitoring network, as originally constituted, used state-of-the-art measurement techniques, combined with advanced software techniques for signal processing and validation. It was the first network of its kind in the world. The Automatic Hydrocarbon Network operated successfully for 10 years before the programme was re-focussed, re-designed and simplified in 2002.

The UK Automatic Hydrocarbon Network currently consists of five sites, located at Cardiff, Glasgow, Harwell, London Eltham and London Marylebone Road. Three of these sites – Cardiff, Glasgow and Harwell- utilise an Environnment VOC71M analyser configured to measure and report the concentrations of 1,3-butadiene, benzene, toluene, ethylbenzene, (m+p)-xylene and o-xylene. Benzene data are used for comparison with the UK Air Quality Objectives and are also reported to the European Commission to fulfil requirements of the Benzene Daughter Directive; 1,3-butadiene data are used for comparison with UK Objectives.

The two London sites are fitted with automatic Perkin Elmer gas chromatographs measuring a wider range of VOCs, equivalent to that studied under the original measurement programme. Both instruments are capable of measuring and reporting at least 27 hydrocarbons. Measurements from all five sites will be reported to the European Commission, satisfying requirements under the Ozone Daughter Directive for monitoring photochemical ozone precursors. Corresponding benzene and the 1,3-butadiene data are used for comparison with the UK Air Quality Objectives, whilst benzene data are reported to the European Commission.

Auchencorth Moss, a new monitoring site measuring speciated VOCs, together with ozone, PM10 and PM2.5 (both via Partisol) for the AURN, commenced operation in June 2006.

Hourly benzene and 1,3-butadiene data from all sites continue to be reported to the public at large through a range of web, electronic, text and broadcast media.

ii) The Non-Automatic Hydrocarbon Network

(Managed and operated for Defra and the DAs by the National Physical Laboratory)

The UK Non-Automatic Hydrocarbon Network measures ambient benzene concentrations at 35 sites around the United Kingdom, as well as 1,3-butadiene at 10 of these locations. 1,3-Butadiene is measured at sites expected to have high concentrations of this carcinogenic pollutant, in order to assess compliance with the UK Air Quality Strategy Objective (2.25 $\mu g/m^3$ expressed as a running annual mean).

Benzene is also monitored to assess compliance with UK Objectives (between 3.25 and 16.25 $\mu g/m^3$ depending on area and compliance date, expressed as a running annual mean), as well as with the corresponding EC Air Quality Directive Limit Value (5 $\mu g/m^3$ annual average). Note that both species have Objectives and Limit Values expressed in the form of an annual average concentration, so that high time resolution is not required from the measurements.

Sampling is therefore undertaken for periods of a fortnight onto sorbent tubes containing Carbopack X. For benzene, the air is pumped through the sampling tubes using purpose-built pump units that switch between two tubes to produce two nominally identical samples covering each fortnight. For 1,3-butadiene, pairs of sorbent tubes sample the air passively (by diffusive processes) over the fortnight of sample exposure.

Every fortnight the tubes are changed, and the instruments checked by Local Site Operators, who send the exposed tubes to the network management unit for analysis.

Currently, all samplers are located at monitoring stations operated within the Automatic Urban and Rural Network (AURN)- discussed separately in Section A 3.3. Measurements began over the period December 2001 to August 2002, following the decommissioning of the first generation Automatic Hydrocarbon Network, which provided on-line measurements of hourly data for 26 hydrocarbon species at 13 sites (see A 3.5). The data obtained now provide a useful addition to automatic measurements undertaken in the current 5-site programme.

The fortnightly pumped measurement method for benzene was developed specifically for this network, following the requirement of the EU Directive that, in view of their inherently lower measurement uncertainty, measurements for reporting purposes be made by pumped sampling rather than by diffusive sampling. Previously, pumped sampling for benzene had been geared to short periods of a day or less. The combination of a suitable sorbent material and sound engineering in the pump control box has led to a very successful method.

The EU instructs CEN, the European Committee for Standardisation, to set out standard methods to be used to comply with Directives. The relevant CEN benzene standards (EN 14662, 5 parts) include the pumped method used in this network.

A 3.4 The PAH and TOMPs Networks

(Networks managed and operated for Defra and the DAs by Netcen and Lancaster University respectively since March 2004)

These two programmes are highly integrated, being based on a 24-site sampler network covering a broad range of representative urban, industrial, semi-rural and rural location types; 18 of these are operated wholly within the PAHs programme, whilst a further 6 sites are operated as the TOMPS monitoring network but with samples also analysed for PAHs.

i) PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a group of persistent bioaccumulative organic compounds, some of which are toxic and/or human carcinogens; they are produced through industrial, chemical and combustion processes.

There are three major policy drivers and data uses for this programme:

- The establishment of a UK Air Quality Objective for PAHs, based in turn on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) for an annual air quality standard of 0.25 ng benzo[a]pyrene /m^3.
- The European Community's fourth Air Quality Daughter Directive (2005/107/EC), which includes a target value for benzo[a]pyrene as a representative PAH as an annual average of 1 ng /m^3.
- The UK's decision to sign, and ratify, the UNECE protocol on Persistent Organic Pollutants (POPs), which includes PAHs. Under the protocol, there is a requirement for signatories to control and assess the long-range transport of specified PAHs.

All these policy imperatives require sound data on ambient concentrations, trends and distributions of PAHs in the environment.

Modified Anderson GPS-1 pesticide samplers, capturing both gas and particle-phase PAHs on glass fibre and polyurethane filters, are deployed at all 18 UK network locations. Careful extraction of the filter and foam media and subsequent analysis by Gas Chromatography/Mass Spectroscopy (GC/MS) provides data on 38 PAH species.

ii) TOMPs

Toxic Organic Micropollutants (TOMPs)- conventionally including Polychlorinated Dibenzo-*p*-Dioxins, Polychlorinated Dibenzofurans (PCDD/Fs), PAHs as above, and Polychlorinated Biphenyls (PCBs). PCDD/Fs and PAHs are formed as unwanted by-products during various chemical, industrial and combustion processes. The PCBs were previously manufactured for use in a wide range of electrical and other products until the mid-1980s. These highly toxic and persistent species are ubiquitous in the environment, but normally at extremely low concentrations.

The TOMPs network provides data to inform the public of air quality and information to support the development of policy to protect the environment. The specific aims of the TOMPs programme are:

- To identify sources of TOMPs in the UK's atmosphere
- To quantify sources that are regarded as potentially significant
- To measure concentrations of TOMPs in ambient air in UK cities, in order to assess both human exposure and the relationship between source emissions and levels in the ambient atmosphere.
- The UK's decision to sign, and ratify when possible, the UNECE protocol on Persistent Organic Pollutants (POPs), which includes PAHs. Under the protocol, there is a requirement for signatories to control and assess the long-range transport of specified PAHs
- The network is also used to investigate the behaviour of newly identified persistent organic pollutants such as brominated flame retardants and other industrial chemicals.

The TOMPS network measures concentrations of these trace organic species at six sites. Samples from these sites are then analysed for PAHs as part of the PAH network. The sampling method is again based around the use of a modified Andersen GPS-1 sampler, with subsequent chemical analysis requiring the use of a range of sophisticated chemical analysis techniques including gas chromatography coupled with high-resolution mass spectrometry.

A 3.5 UK Heavy Metals Monitoring Networks

(i) UK urban/industrial network (previously the Lead, Multi-element and Industrial Metals Networks)

(Network managed and operated for Defra and the DAs by the National Physical Laboratory)

The UK Government has in the past funded separate long-term monitoring programmes responding to specific needs of EC Directives in relation to toxic and industrial metals. These originally included:

- Five urban multi-element monitoring sites providing measurements of 9 important trace elements (Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn and V)
- Eight sites for the monitoring of lead-in-petrol (2 rural, 3 urban and 3 kerbside) and
- Eight sites operating in three industrial areas monitoring lead - Walsall (IMI and Brookside works) and Newcastle (Elswick works).

The EU Framework Directive (96/62/EC)[3] establishes a framework under which, by means of Daughter Directives, the EU can establish limit and target values for concentrations in ambient air of certain pollutants. The First Daughter Directive (99/30/EC)[28] sets a Limit Value for lead in air concentrations at 0.5 µg/m^3, expressed as an annual mean to be achieved by 1st January 2005.

The agreement reached between the European Parliament and the Environment Council on the Directive on the Quality of Petrol and Diesel Fuels led to the ban of sales of leaded petrol in the UK with effect from 1 January 2000. This has, in turn, led to a dramatic decline in ambient lead levels in many UK environments. As a consequence, some monitoring sites, which only measured lead concentrations, have since been closed.

In 2000, a year-long monitoring network was established at 30 industrial site locations across the UK in order to establish the UK's position with respect to the requirements of the 4th Daughter Directive which was then being drafted with the aim of setting limit values for arsenic, cadmium, nickel and mercury. Results of this programme showed that further monitoring at a number of sites was required in order to establish compliance with the proposed Target Values. Monitoring continues currently at five of these sites – Avonmouth, Hallen Village, Swansea, Sheffield and Runcorn.

The 4th Daughter Directive (2004/107/EC) was published in the Official Journal of the European Commission on 26th January 2005. The 4th Daughter Directive sets 'target values' for arsenic, cadmium, nickel (and polycyclic aromatic hydrocarbons) in the PM_{10} particulate fraction of ambient air.

Member States must transpose the 4th Daughter Directive into national law by 15th February 2007. The European Commission will report on its implementation by 31st December 2010. Governments must report to the Commission on zones and agglomerations where the target values are exceeded with the first such reports being required by 30th September 2008. The 4th Daughter Directive also requires monitoring of mercury although no limit or target values have been set.

The disparate nature of the historic monitoring networks for heavy metals in the UK, which have individually responded to specific Directive needs, resulted in differences in practice between networks and did not permit UK-wide reporting in a consistent manner. In 2003, all monitoring was rationalised into a single integrated network (with the exception of the Rural Trace Element sites), referred to as the UK Heavy Metals Monitoring Network. Sampling is now undertaken for weekly periods at sites on the PM_{10} fraction of particulates using R&P Partisol 2000 samplers. Analysis of samples occurs with UKAS-accredited ICP-MS analysis, with acid digest techniques consistent with the draft CEN WG14 reference method, which has now been sent out to Member States for final vote. Consistency in approach has been achieved with historical data collection and analyses through thorough equivalence exercises.

Since September 2004, the number of elements measured at the old Industrial Metals sites has been increased to ensure there is consistency across the Network. All 17 sites now monitor for As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Pt, V and Zn. Additionally, measurements are made for ambient vapour phase mercury concentrations at 13 sites.

(ii) The Rural Heavy Metals and Mercury Network

(Network managed and operated for Defra and the DAs by Centre for Ecology and Hydrology)

In 2003-4, the Rural Trace Element Monitoring Network was established as 10 primary sites across the UK. The PM_{10} fraction of particulates is collected weekly using Thermo FH95 single or FH95SEQ sequential samplers, together with weekly or 4-weekly collections of precipitation. In addition a further three secondary sites collect precipitation samples only and two more high elevation sites collect precipitation and cloud water samples.

Concentrations of As, Cd, Cr, Cu, Ni, Pb, Se, V, Zn, Al, Sc, Ti, Mn, Fe, Co, Rb, Sr, Mo, Sn, Sb, Ba and W in particulates, precipitation and cloud water are determined by accredited ICP-MS analysis at CEH Lancaster.

Elemental mercury ($Hg^{0)}$ makes up over 97% of the total atmospheric mercury burden. The remaining amount consists of reactive gaseous mercury (RGM) and particulate mercury (Hg^{P}). Speciated measurements of mercury are made at the Auchencorth Site using a state-of-the-art Tekran mercury speciation system, which measures RGM, Hg^{P} and Hg^{0}.

As concentrations of these species are so low (of the order of pg m^{-3} for RGM and Hg^{p}), very sensitive analytical equipment is required. The detector in the Tekran 2537A analyser employs Cold Vapour Atomic Fluorescence Spectroscopy (CVAFS). Elemental mercury is sampled and analysed for one hour, whilst RGM and Hg^{P} are collected on a KCl-coated denuder and particulate trap, respectively. During the following hour, the collected RGM and HgP are desorbed and analysed. Using this method, Hg^{0} is analysed with a temporal resolution of 5 minutes every other hour and hourly averages of RGM and Hg^{P} concentrations are obtained every other hour.

At the 10 primary sites, newly designed samplers have also been set up to collect Total Gaseous Mercury (TGM) in air (2-weekly) and in Mercury in precipitation (Monthly). Analysis of Total Gaseous Mercury is based on the system of Two-Stage Gold Amalgamation. Mercury is adsorbed onto gold-coated sand contained within a quartz cartridge and is desorbed by heating the cartridge to 500°C to release the trapped mercury. Desorption is carried out using a custom-built unit that interfaces with a Tekran 2537A analyser, used in off-line mode. Two sampling cartridges are used in series to detect any breakthrough of mercury from the first cartridge, which can be analysed if the capture efficiency of the first cartridge has been reduced.

Mercury in precipitation is analysed using a Cold Vapour Atomic Fluorescence Spectrometer (PSA Ltd) with a Analytical detection limit = 0.8ng l^{-1} (99% confidence, Controlled Reference Material NRCC-ORMS-2.)

A 3.6 The National Ammonia and Nitric Acid Monitoring Networks

(Managed and operated for Defra and the DAs by CEH- Centre for Ecology and Hydrology

i) The NAMN

The National Ammonia Monitoring Network (NAMN) was established with approximately 70 sites in 1996. Its objective is to quantify long-term temporal and spatial changes in air concentrations and deposition in gaseous NH_3. The monitoring provides a baseline in NH_3, which is necessary for examining responses to changes in the agricultural sector and to assess compliance with targets set by international agreements. Data from the network are also used to test the performance of an atmospheric chemistry and transport model, FRAME.

The main sources of NH_3 in the atmosphere are from the decomposition and volatilisation of animal wastes. Other sources include direct volatilisation from synthetic fertilizers (particularly urea), and a wide range of non-agricultural sources such as sewage, catalytic converters, wild animals and industrial processes. It is recognised that deposition of atmospheric NH_3 contributes to acidification and eutrophication processes, which can cause damage to sensitive ecosystems.

A 2-tiered approach was originally used in the network; this consisted of a baseline network of around 50 sites sampling ammonia using the active DELTA (DEnuder for Long-Term Atmospheric sampling) system - where power is available. A secondary network of passive diffusion tubes explored air concentration variability in high concentration areas, with the method calibrated at 10 sites against the DELTA approach. In both cases, sampling was performed on a monthly basis.

Further methodological improvements were introduced over time. In 1999, the DELTA method was extended to allow sampling of ammonium aerosol at all active sites. This was followed by the establishment of the Nitric Acid Monitoring Network at 12 of the active sites, using an extension of the DELTA method to additionally sample gaseous $HNO_3/SO_2/HCl$, aerosol $NO_3^-/SO_4^{2-}/Cl^-$ and the base cations $Ca^{2+}/Mg^{2+}/Na^+$, also on a monthly basis. In 2000, a new improved passive sampling method was developed and introduced; the Adapted Low-cost, Passive High Absorption (ALPHA) sampler (LOD = 0.02 µg NH_3 m^{-3}) replaced the less sensitive diffusion tube (LOD = 1 µg NH_3 m^{-3}) in the network.

Accompanying these changes has been an increase in the number of monitoring sites to 94, to improve the interpolated concentration field for NH_3; at the same time, there was a reduction in the number of sites monitoring NH_4^+, as this is a secondary pollutant with less spatial variability than NH_3.

There are currently 94 sites in the NAMN. At 57 of these sites, an active diffusion denuder methodology using the CEH DELTA (DEnuder for Long Term Atmospheric sampling) system is used to provide the main spatial and temporal patterns of NH_3 (and also NH_4^+ aerosol) across the UK. The high sensitivity ALPHA (Adapted Low-cost Passive High-Absorption) sampler is implemented at a further 49 sites to assess regional and local scale variability in air NH_3 concentrations in source regions.

To provide an ongoing validation of the ALPHA sampler, its performance is continuously assessed against the DELTA system at 12 sites within the network. The ALPHA sampler has also been tested in several international intercomparisons, for example the EC ECOMONT project, and was included in the CEN TC264/WG11 pilot study into diffusive samplers for NH_3. The number of DELTA sites where an extension of the method is used to additionally sample acid gases and aerosols as part of the Nitric Acid Monitoring network has also increased from 12 to 30 sites in January 2006.

Overall, the NAMN structure currently consists of:

Site type	Number
DELTA sites sampling gaseous NH_3	57
DELTA sites also sampling aerosol NH_4^+	43
DELTA sites also sampling gaseous HNO_3, SO_2, HCl and aerosol NO_3^-, SO_4^{2-}, Cl^-, K^+, Ca^{2+}, Mg^{2+} as part of the Nitric Acid Monitoring Network	30
ALPHA sites	49
Intercomparison sites with both DELTA & ALPHA samplers	12
Total number of sites	94

ii) The UK Nitric Acid Monitoring Network

The UK Nitric Acid Monitoring Network has been in operation since September 1999, providing data on nitric acid, particulate nitrate and other species as part of the UK acid deposition monitoring network. Monitoring is carried out at 12 sites, integrated with the UK National Ammonia Monitoring Network (NAMN). An extension of the DELTA system at the NAMN sites is used to additionally sample HNO_3 and related species (SO_2, HCl, NO_3^-,

SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+}), in parallel with monthly sampling of NH_3 and NH_4^+ at the 12 NAMN sites.

The aim of these measurements is to:

- Explore spatial patterns
- Compare results with dispersion models, seasonality and
- Contribute to national N deposition estimates.

In January 2006, the network was expanded from its present 12 sites to 30 sites. The drivers for the expansion of the programme are:

- Increasing use of the measurement data in, for example, Pollution Climate mapping and assessing Acid Deposition Processes
- The measurements of several components of particulate matter (NO_3-, SO_4--, Cl-, Na+, Mg_2+ and Ca_2+, together with NH^4+ from the closely integrated NAMN), thereby contributing to mass closure, which was one of the recommendations in the Defra's Air Quality Expert Group's report on Particulate Matter
- To reduce uncertainties in the calculation of national and regional deposition budgets, especially in upland areas which are sensitive to acid deposition
- Improve overall cost-effectiveness of the measurement programme.

Appendix 4- Analysis of statistically significant trends in UK air pollution levels

Here we summarise those measurement sites with over five years of measurements having statistically significant trends.

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
1,3-Butadiene µg m-3 / yr										
	Harwell	RURAL	Annual mean	1996	2005	-0.02	-0.02	-0.01	-0.95	10
	Harwell	RURAL	98 %ile	1996	2005	-0.04	-0.1	-0.04	-0.89	10
	Marylebone Rd London	ROADSIDE	Annual mean	1998	2005	-0.3	-0.2	-0.4	-0.98	8
	Marylebone Rd London	ROADSIDE	98 %ile	1998	2005	-0.8	-0.6	-1.1	-1.00	8
Benzene µg m-3 / yr										
	Harwell	RURAL	Annual mean	1995	2005	-0.1	-0.11	-0.06	-0.92	11
	Harwell	RURAL	98 %ile	1995	2005	-0.4	-0.48	-0.28	-0.92	11
	Marylebone Rd London	KERBSIDE	Annual mean	1998	2005	-1.4	-2.2	-0.6	-1.00	8
	Marylebone Rd London	KERBSIDE	98 %ile	1998	2005	-4.3	-6.4	-1.9	-1.00	8
Carbon Monoxide mg m-3 / yr										
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	-0.1	-0.1	-0.1	-0.95	14
	Belfast Centre	URBAN CENTRE	98 %ile	1992	2005	-0.3	-0.3	-0.2	-0.92	14
	Birmingham Centre	URBAN CENTRE	Annual mean	1992	2005	0	-0.1	0	-0.88	14
	Birmingham Centre	URBAN CENTRE	98 %ile	1992	2005	-0.2	-0.2	-0.1	-0.96	14
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	0	-0.1	0	-0.79	13
	Bristol Centre	URBAN CENTRE	98 %ile	1993	2005	-0.2	-0.2	-0.1	-0.91	13
	Cardiff Centre	URBAN CENTRE	Annual mean	1992	2005	0	-0.1	0	-0.85	14
	Cardiff Centre	URBAN CENTRE	98 %ile	1992	2005	-0.1	-0.2	-0.1	-0.96	14
	Glasgow City Chambers	URBAN BACKG.	Annual mean	1990	2005	-0.1	-0.1	0	-0.92	16
	Glasgow City Chambers	URBAN BACKG.	98 %ile	1990	2005	-0.2	-0.4	-0.2	-0.97	16
	Glasgow Kerbside	KERBSIDE	Annual mean	1997	2005	-0.1	-0.1	-0.1	-0.98	9
	Glasgow Kerbside	KERBSIDE	98 %ile	1997	2005	-0.3	-0.5	-0.1	-0.97	9
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	0	-0.1	0	-0.73	13
	Leeds Centre	URBAN CENTRE	98 %ile	1993	2005	-0.2	-0.2	-0.1	-0.82	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	0	-0.1	0	-0.65	12
	Leicester Centre	URBAN CENTRE	98 %ile	1994	2005	-0.1	-0.2	-0.1	-0.95	12
	London Bexley	SUBURBAN	Annual mean	1994	2005	0	0	0	-0.75	12
	London Bexley	SUBURBAN	98 %ile	1994	2005	-0.1	-0.2	-0.1	-0.88	12
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	0	-0.1	0	-0.71	14
	London Bloomsbury	URBAN CENTRE	98 %ile	1992	2005	-0.1	-0.2	-0.1	-0.79	14
	London Brent	URBAN BACKG.	98 %ile	1996	2005	-0.2	-0.3	-0.1	-0.95	10
	London Marylebone Rd	KERBSIDE	Annual Mean	1998	2005	-0.2	-0.3	-0.2	-0.93	8
	London Marylebone Rd	KERBSIDE	98 %ile	1998	2005	-0.7	-0.9	-0.3	-0.93	8
	London N. Kensington	URBAN BACKG.	98 %ile	1996	2005	-0.1	-0.3	-0.1	-0.9	10
	Manchester Piccadilly	URBAN CENTRE	98 %ile	1996	2005	0	-0.2	0	-0.8	10
	Manchester Town Hall	URBAN BACKG.	Annual mean	1992	2005	0	-0.1	0	-0.63	13
	Manchester Town Hall	URBAN BACKG.	98 %ile	1992	2005	-0.2	-0.2	-0.1	-0.93	13
	Middlesbrough	URBAN INDUST.	98 %ile	1995	2005	0	-0.1	0	-0.71	11
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	-0.1	-0.1	0	-0.93	14
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	-0.2	-0.2	-0.2	-0.98	14
	Sheffield Centre	URBAN CENTRE	Annual mean	1996	2005	0	0	0	-0.73	10
	Sheffield Centre	URBAN CENTRE	98 %ile	1996	2005	-0.1	-0.2	-0.1	-0.93	10
	Sheffield Tinsley	URBAN INDUST.	Annual mean	1992	2005	0	-0.1	0	-0.55	14
	Sheffield Tinsley	URBAN INDUST.	98 %ile	1992	2005	-0.1	-0.2	-0.1	-0.89	14

	Southampton Centre	URBAN CENTRE	Annual mean	1994	2005	-0.1	-0.1	0	-0.91	12
	Southampton Centre	URBAN CENTRE	98 %ile	1994	2005	-0.2	-0.3	-0.2	-0.96	12
	Swansea	URBAN CENTRE	Annual mean	1995	2005	0	0	0	-0.87	11
	Swansea	URBAN CENTRE	98 %ile	1995	2005	-0.2	-0.2	-0.1	-0.98	11
	Tower Hamlets Roadside	ROADSIDE	Annual mean	1996	2005	-0.1	-0.2	-0.1	-0.93	10
	Tower Hamlets Roadside	ROADSIDE	98 %ile	1996	2005	-0.6	-0.7	-0.4	-0.98	10
	West London	URBAN BACKG.	Annual mean	1990	2005	-0.1	-0.1	-0.1	-0.81	16
	West London	URBAN BACKG.	98 %ile	1990	2005	-0.3	-0.4	-0.2	-0.95	16
	Wolverhampton Centre	URBAN CENTRE	Annual mean	1996	2005	0	-0.1	0	-0.72	10
	Wolverhampton Centre	URBAN CENTRE	98 %ile	1996	2005	-0.1	-0.2	-0.1	-0.9	10

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
Nitrogen Dioxide µg m-3 / yr										
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	-1.1	-1.3	-0.8	-0.87	14
	Belfast Centre	URBAN CENTRE	98 %ile	1992	2005	-2	-3	-0.8	-0.65	14
	Billingham	URBAN INDUSTRIAL	Annual mean	1987	2005	-0.5	-0.9	-0.5	-0.76	19
	Billingham	URBAN INDUSTRIAL	98 %ile	1987	2005	-0.8	-2	-0.3	-0.57	19
	Birmingham Centre	URBAN CENTRE	Annual mean	1993	2005	-1.6	-1.9	-1	-0.88	13
	Birmingham Centre	URBAN CENTRE	98 %ile	1993	2005	-3	-4	-2	-0.81	13
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	-1.4	-1.5	-1	-0.95	13
	Bristol Centre	URBAN CENTRE	98 %ile	1993	2005	-2.4	-3.2	-1.6	-0.87	13
	Cardiff Centre	URBAN CENTRE	Annual mean	1992	2005	-1.3	-1.4	-0.7	-0.82	14
	Cardiff Centre	URBAN CENTRE	98 %ile	1992	2005	-2.4	-2.4	-1	-0.78	14
	Glasgow City Chambers	URBAN BACKG.	Annual mean	1987	2005	-0.1	-0.6	0	-0.55	19
	Haringey Roadside	ROADSIDE	Annual mean	1996	2005	-1.6	-2	-1	-0.84	10
	Haringey Roadside	ROADSIDE	98 %ile	1996	2005	-1.4	-7	-1.2	-0.71	10
	Harwell	RURAL	Annual mean	1996	2005	-0.5	-1.7	-0.3	-0.71	10
	Harwell	RURAL	98 %ile	1996	2005	-1.5	-4.6	-1	-0.81	10
	Ladybower	RURAL	Annual mean	1991	2005	-0.8	-0.9	-0.5	-0.88	15
	Ladybower	RURAL	98 %ile	1991	2005	-2.1	-3	-0.8	-0.78	15
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	-2	-2.6	-1.2	-0.88	13
	Leeds Centre	URBAN CENTRE	98 %ile	1993	2005	-3	-3.3	-0.9	-0.7	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	-1.3	-1.3	-0.7	-0.85	12
	Leicester Centre	URBAN CENTRE	98 %ile	1994	2005	-1.8	-2.5	0	-0.66	12
	London Bexley	SUBURBAN	Annual mean	1994	2005	-0.9	-1.5	-0.3	-0.76	12
	London Bexley	SUBURBAN	98 %ile	1994	2005	-2	-3.3	0	-0.63	12
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	-1.4	-1.6	0	-0.63	13
	London Bloomsbury	URBAN CENTRE	98 %ile	1992	2005	-3.2	-5.3	-0.7	-0.73	13
	London Brent	URBAN BACKG.	Annual mean	1996	2005	-1	-1.6	-0.5	-0.81	10
	London Marylebone Rd	KERBSIDE	Annual Mean	1998	2005	-43	-55	-32.3	-0.74	8
	London Marylebone Rd	KERBSIDE	98 %ile	1998	2005	-19	-28	-2.3	-0.83	8
	London N. Kensington	URBAN BACKG.	Annual mean	1996	2005	-0.6	-1.4	0	-0.65	10
	London Wandsworth	URBAN CENTRE	Annual mean	1996	2005	0.6	0	1	0.67	10
	Lullington Heath	RURAL	Annual mean	1991	2005	-0.4	-0.6	-0.3	-0.86	15
	Lullington Heath	RURAL	98 %ile	1991	2005	-1.5	-2.3	-1.1	-0.89	15
	Manchester Town Hall	URBAN BACKG.	Annual mean	1987	2005	-0.6	-1.1	-0.5	-0.77	19
	Manchester Town Hall	URBAN BACKG.	98 %ile	1987	2005	-2.8	-3.5	-1.3	-0.78	19
	Middlesbrough	URBAN INDUSTRIAL	Annual mean	1995	2005	-1	-1	-0.2	-0.72	11
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	-1.6	-2.5	-1.1	-0.91	14
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	-2.4	-6.3	-1.5	-0.8	14

	Rochester	RURAL	Annual mean	1996	2005	-0.4	-1.1	-0.4	-0.92	10
	Rochester	RURAL	98 %ile	1996	2005	-1.2	-2	-0.4	-0.94	10
	Sheffield Centre	URBAN CENTRE	Annual mean	1996	2005	-1.2	-2	-0.3	-0.7	10
	Sheffield Centre	URBAN CENTRE	98 %ile	1996	2005	-3	-5.7	-1.8	-0.84	10
	Sheffield Tinsley	URBAN INDUSTRIAL	Annual mean	1991	2005	-1.1	-1.8	-0.9	-0.91	15
	Sheffield Tinsley	URBAN INDUSTRIAL	98 %ile	1991	2005	-3.4	-4.3	-1.9	-0.89	15
	Southampton Centre	URBAN CENTRE	Annual mean	1994	2005	-1.2	-1.8	-0.9	-0.91	12
	Southampton Centre	URBAN CENTRE	98 %ile	1994	2005	-2.8	-4	-2.1	-0.91	12
	Walsall Alumwell	URBAN BACKG.	Annual mean	1987	2005	-0.8	-1.2	-0.5	-0.87	19
	Walsall Alumwell	URBAN BACKG.	98 %ile	1987	2005	-1.7	-2.4	-0.6	-0.75	19
	West London	URBAN BACKG.	Annual mean	1987	2005	-1.3	-1.7	-0.9	-0.89	19
	West London	URBAN BACKG.	98 %ile	1987	2005	-3.6	-5.4	-2.6	-0.88	19
	Wolverhampton Centre	URBAN CENTRE	Annual mean	1996	2005	-0.4	-2	-0.2	-0.69	10

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
Nitrogen Oxides µg m-3 / yr										
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	-3.1	-4	-1.5	-0.81	14
	Billingham	URBAN INDUSTRIAL	Annual mean	1987	2005	-2	-2.3	-1.3	-0.88	19
	Billingham	URBAN INDUSTRIAL	98 %ile	1987	2005	-7.6	-11.5	-4	-0.77	19
	Birmingham Centre	URBAN CENTRE	Annual mean	1993	2005	-3.8	-4.1	-3	-0.95	13
	Birmingham Centre	URBAN CENTRE	98 %ile	1993	2005	-16.4	-17.7	-9.7	-0.83	13
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	-3.9	-6.8	-2.3	-0.81	13
	Bristol Centre	URBAN CENTRE	98 %ile	1993	2005	-22.1	-32.4	-7.1	-0.76	13
	Cardiff Centre	URBAN CENTRE	Annual mean	1992	2005	-4	-4.7	-2	-0.83	14
	Cardiff Centre	URBAN CENTRE	98 %ile	1992	2005	-16.6	-21	-9.5	-0.85	14
	Glasgow City Chambers	URBAN BACKG.	Annual mean	1987	2005	-5.4	-5	-3.3	-0.87	19
	Glasgow City Chambers	URBAN BACKG.	98 %ile	1987	2005	-21.6	-32.5	-16.3	-0.86	19
	Haringey Roadside	ROADSIDE	Annual mean	1996	2005	-7.6	-11.8	-7.2	-0.98	10
	Haringey Roadside	ROADSIDE	98 %ile	1996	2005	-24.4	-48.3	-18.5	-0.93	10
	Harwell	RURAL	Annual mean	1996	2005	-0.8	-2.8	-0.6	-0.68	10
	Harwell	RURAL	98 %ile	1996	2005	-2.3	-13.6	-1.8	-0.65	10
	Ladybower	RURAL	Annual mean	1991	2005	-1	-1.4	-0.6	-0.87	15
	Ladybower	RURAL	98 %ile	1991	2005	-4.4	-6	-1.9	-0.83	15
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	-6.7	-8	-4.3	-0.92	13
	Leeds Centre	URBAN CENTRE	98 %ile	1993	2005	-25.6	-30.8	-6.8	-0.77	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	-2.6	-3.7	-1.2	-0.89	12
	Leicester Centre	URBAN CENTRE	98 %ile	1994	2005	-11.6	-20.1	-4.1	-0.76	12
	London Bexley	SUBURBAN	Annual mean	1994	2005	-3.8	-5	-1.3	-0.85	12
	London Bexley	SUBURBAN	98 %ile	1994	2005	-20	-33.9	-2.8	-0.64	12
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	-4.4	-6.3	-2.7	-0.83	14
	London Bloomsbury	URBAN CENTRE	98 %ile	1992	2005	-16.6	-20.7	-11	-0.86	14
	London Brent	URBAN BACKG.	Annual mean	1996	2005	-3.4	-5.5	-1	-0.88	10
	London Eltham	SUBURBAN	Annual mean	1996	2005	-3	-5	-1	-0.83	10
	London Eltham	SUBURBAN	98 %ile	1996	2005	-8.4	-34.5	-5.5	-0.81	10
	London N. Kensington	URBAN BACKG.	Annual mean	1996	2005	-2.6	-5	-1.3	-0.87	10
	London Wandsworth	URBAN CENTRE	Annual mean	1996	2005	-5.4	-9.5	-3	-0.9	10
	London Wandsworth	URBAN CENTRE	98 %ile	1996	2005	-17.6	-45.7	-4.5	-0.81	10
	Lullington Heath	RURAL	Annual mean	1991	2005	-0.5	-0.7	-0.3	-0.89	15
	Lullington Heath	RURAL	98 %ile	1991	2005	-2.4	-3.8	-2	-0.85	15

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
	Manchester Town Hall	URBAN BACKG.	Annual mean	1987	2005	-4.6	-4.9	-3.1	-0.93	19
	Manchester Town Hall	URBAN BACKG.	98 %ile	1987	2005	-17.3	-28.2	-13.4	-0.87	19
	Middlesbrough	URBAN INDUSTRIAL	Annual mean	1995	2005	-1.7	-2.6	-0.2	-0.67	11
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	-5.4	-7.4	-4.4	-0.95	14
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	-20.1	-31.5	-18.3	-0.9	14
	Rochester	RURAL	Annual mean	1996	2005	-0.4	-1.3	-0.2	-0.79	10
	Rochester	RURAL	98 %ile	1996	2005	-3.4	-10.8	0.2	-0.7	10
	Sheffield Centre	URBAN CENTRE	Annual mean	1996	2005	-5	-8.4	-2	-0.78	10
	Sheffield Centre	URBAN CENTRE	98 %ile	1996	2005	-15.8	-41.4	-12.6	-0.83	10
	Sheffield Tinsley	URBAN INDUSTRIAL	Annual mean	1991	2005	-7.4	-8.6	-5.9	-0.97	15
	Sheffield Tinsley	URBAN INDUSTRIAL	98 %ile	1991	2005	-22.4	-38.8	-13.3	-0.89	15
	Southampton Centre	URBAN CENTRE	Annual mean	1994	2005	-4.8	-5.7	-3	-0.96	12
	Southampton Centre	URBAN CENTRE	98 %ile	1994	2005	-20.9	-30	-9.3	-0.88	12
	Tower Hamlets Roadside	ROADSIDE	Annual mean	1996	2005	-15.8	-22.6	-13	-0.99	10
	Tower Hamlets Roadside	ROADSIDE	98 %ile	1996	2005	-47	-77.8	-34.5	-0.95	10
	Walsall Alumwell	URBAN BACKG.	Annual mean	1987	2005	-4.5	-5.9	-4	-0.95	19
	Walsall Alumwell	URBAN BACKG.	98 %ile	1987	2005	-24.7	-29.2	-14.8	-0.89	19
	West London	URBAN BACKG.	Annual mean	1987	2005	-6	-7.8	-5.4	-0.97	19
	West London	URBAN BACKG.	98 %ile	1987	2005	-23.7	-39.6	-18.1	-0.91	19
Ozone µg m-3 / yr										
	Aston Hill	RURAL	Annual mean	1987	2005	0.2	0	0.8	0.48	19
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	1.1	0	1	0.65	14
	Birmingham Centre	URBAN CENTRE	Annual mean	1992	2005	1.1	0.6	1.2	0.89	14
	Bottesford	SUBURBAN	Annual mean	1981	2005	0.5	0	0.7	0.54	25
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	0.9	0.1	1.2	0.72	13
	Bush Estate	RURAL	Annual mean	1986	2005	0.3	0	0.5	0.6	20
	Cardiff Centre	URBAN CENTRE	Annual mean	1992	2005	1.1	0.6	1.3	0.85	14
	Great Dun Fell	REMOTE	98 %ile	1987	2005	-1	-2.4	0.2	-0.56	15
	High Muffles	RURAL	Annual mean	1988	2005	0.4	0	0.7	0.52	18
	High Muffles	RURAL	98 %ile	1988	2005	-1.1	-2	0	-0.54	18
	Ladybower	RURAL	98 %ile	1989	2005	-1.6	-2.9	-0.4	-0.55	17
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	1	0.5	1.3	0.81	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	0.3	0	0.9	0.71	12
	London Bexley	SUBURBAN	Annual mean	1995	2005	0.5	0	1	0.75	11
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	0.6	0.3	0.7	0.84	14
	London Eltham	SUBURBAN	Annual mean	1996	2005	0.4	0	0.7	0.65	10
	London Haringey	URBAN CENTRE	Annual mean	1996	2005	1	0.5	1.6	0.81	10
	London Marylebone Rd	KERBSIDE	Annual Mean	1998	2005	0.6	0.3	1.0	0.93	8
	London N. Kensington	URBAN BACKG.	Annual mean	1996	2005	0.8	0.3	1.4	0.81	10
	London Wandsworth	URBAN CENTRE	Annual mean	1996	2005	0.8	0	1	0.73	10
	Lough Navar	REMOTE	98 %ile	1987	2005	-0.4	-0.7	0	-0.51	19
	Middlesbrough	URBAN INDUSTRIAL	Annual mean	1996	2005	0.4	0	1.6	0.66	10
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	0.8	0.8	1.3	0.87	12
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	1.1	0.4	2	0.74	12
	Strath Vaich	REMOTE	Annual mean	1987	2005	0.3	0	0.7	0.5	19
	Wolverhampton Centre	URBAN CENTRE	Annual mean	1996	2005	0.8	0.5	1.5	0.85	10

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
PM10 Particulate Matter µg m-3 / yr										
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	-1	-1.3	-0.9	-0.97	14
	Belfast Centre	URBAN CENTRE	98 %ile	1992	2005	-3.4	-6.4	-2.7	-0.89	14
	Birmingham Centre	URBAN CENTRE	Annual mean	1992	2005	-0.9	-1	-0.3	-0.77	14
	Birmingham Centre	URBAN CENTRE	98 %ile	1992	2005	-3	-4	-1.7	-0.87	14
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	-0.6	-1	-0.3	-0.84	13
	Bristol Centre	URBAN CENTRE	98 %ile	1993	2005	-2.1	-3.6	-1.6	-0.87	13
	Cardiff Centre	URBAN CENTRE	Annual mean	1993	2005	-0.7	-1.5	-0.2	-0.67	13
	Cardiff Centre	URBAN CENTRE	98 %ile	1993	2005	-2.3	-5.4	-1.3	-0.72	13
	Haringey Roadside	ROADSIDE	Annual mean	1996	2005	-0.6	-1	0	-0.75	10
	Haringey Roadside	ROADSIDE	98 %ile	1996	2005	-1.8	-3.7	-1	-0.77	10
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	-0.9	-1.2	-0.3	-0.75	13
	Leeds Centre	URBAN CENTRE	98 %ile	1993	2005	-4	-5	-0.6	-0.68	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	-0.4	-1	0	-0.65	12
	Leicester Centre	URBAN CENTRE	98 %ile	1994	2005	-1.7	-3.4	-0.3	-0.75	12
	London Bexley	SUBURBAN	Annual mean	1994	2005	-0.6	-1	-0.2	-0.76	12
	London Bexley	SUBURBAN	98 %ile	1994	2005	-2.2	-3.4	-0.9	-0.78	12
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	-1	-1.1	-0.5	-0.88	13
	London Bloomsbury	URBAN CENTRE	98 %ile	1992	2005	-3.9	-4.5	-2	-0.84	13
	London Brent	URBAN BACKG.	98 %ile	1996	2005	-1	-2	0	-0.64	10
	London N. Kensington	URBAN BACKG.	Annual mean	1996	2005	-0.4	-0.7	0	-0.7	10
	London N. Kensington	URBAN BACKG.	98 %ile	1996	2005	-1.2	-2.5	-0.3	-0.66	10
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	-1.1	-1.8	-1	-0.89	14
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	-4.3	-6	-2.5	-0.82	14
	Sheffield Centre	URBAN CENTRE	Annual mean	1996	2005	-0.6	-2	-0.4	-0.84	10
	Sheffield Centre	URBAN CENTRE	98 %ile	1996	2005	-1.2	-6	-0.6	-0.8	10
	Southampton Centre	URBAN CENTRE	Annual mean	1994	2005	-0.4	-0.5	0	-0.68	12
	Southampton Centre	URBAN CENTRE	98 %ile	1994	2005	-1.6	-2.6	-0.3	-0.74	12
	Swansea	URBAN CENTRE	Annual mean	1995	2005	-0.6	-1	-0.3	-0.76	10
	Swansea	URBAN CENTRE	98 %ile	1995	2005	-2.8	-4.4	-1.4	-0.77	10
PM2.5 Particulate Matter µg m-3 / yr										
No trends										
Sulphur Dioxide µg m-3 / yr										
Pollutant	**Site**	**Environment**	**Annual Parameter**	**Start Year**	**End Year**	**Slope**	**Low Range**	**High Range**	**Rho**	**No. of years**
	Barnsley 12	URBAN BACKG.	Annual mean	1994	2005	-1.7	-2.8	-1	-0.88	12
	Barnsley 12	URBAN BACKG.	98 %ile	1994	2005	-7.4	-10.6	-4.1	-0.81	12
	Belfast Centre	URBAN CENTRE	Annual mean	1992	2005	-4	-4.4	-2.8	-0.97	14
	Belfast Centre	URBAN CENTRE	98 %ile	1992	2005	-19.7	-19.2	-12	-0.98	14
	Belfast East	URBAN BACKG.	Annual mean	1990	2005	-5.4	-5.8	-4.7	-0.98	16
	Belfast East	URBAN BACKG.	98 %ile	1990	2005	-25.4	-30.7	-20	-0.96	16

Pollutant	Site	Environment	Annual Parameter	Start Year	End Year	Slope	Low Range	High Range	Rho	No. of years
	Birmingham Centre	URBAN CENTRE	Annual mean	1992	2005	-1.7	-2.2	-1.3	-0.99	14
	Birmingham Centre	URBAN CENTRE	98 %ile	1992	2005	-8.3	-10.5	-6.4	-0.99	14
	Bristol Centre	URBAN CENTRE	Annual mean	1993	2005	-1.1	-1.5	-1	-0.93	13
	Bristol Centre	URBAN CENTRE	98 %ile	1993	2005	-3.6	-6.3	-2.7	-0.95	13
	Cardiff Centre	URBAN CENTRE	Annual mean	1992	2005	-1.1	-1.3	-1	-0.98	14
	Cardiff Centre	URBAN CENTRE	98 %ile	1992	2005	-4.6	-5.3	-4	-0.97	14
	Harwell	RURAL	Annual mean	1996	2005	-0.2	-0.6	-0.1	-0.72	10
	Harwell	RURAL	98 %ile	1996	2005	-2.8	-4.3	-0.7	-0.88	10
	Ladybower	RURAL	Annual mean	1989	2005	-1.5	-1.7	-1	-0.93	17
	Ladybower	RURAL	98 %ile	1989	2005	-7	-9	-5.4	-0.94	17
	Leeds Centre	URBAN CENTRE	Annual mean	1993	2005	-1.6	-2	-1.3	-0.96	13
	Leeds Centre	URBAN CENTRE	98 %ile	1993	2005	-8.5	-11.3	-5.7	-0.92	13
	Leicester Centre	URBAN CENTRE	Annual mean	1994	2005	-1	-1.5	-0.9	-0.97	12
	Leicester Centre	URBAN CENTRE	98 %ile	1994	2005	-5.3	-6.3	-4.5	-0.98	12
	London Bexley	SUBURBAN	Annual mean	1994	2005	-1.1	-2	-0.6	-0.84	12
	London Bexley	SUBURBAN	98 %ile	1994	2005	-8.2	-10.2	-2.2	-0.81	12
	London Bloomsbury	URBAN CENTRE	Annual mean	1992	2005	-2.1	-2.3	-1.8	-0.98	14
	London Bloomsbury	URBAN CENTRE	98 %ile	1992	2005	-9.9	-10.6	-8.9	-0.98	14
	London Brent	URBAN BACKG.	Annual mean	1996	2005	-0.8	-1.3	0	-0.64	10
	London Brent	URBAN BACKG.	98 %ile	1996	2005	-2.2	-5.5	-1.6	-0.87	10
	London Eltham	SUBURBAN	Annual mean	1996	2005	-0.4	-1.3	-0.3	-0.83	10
	London Eltham	SUBURBAN	98 %ile	1996	2005	-1.2	-8.4	-1.2	-0.78	10
	London Marylebone Rd	KERBSIDE	Annual Mean	1998	2005	-1.4	-2.0	-1.5	-0.91	8
	London Marylebone Rd	KERBSIDE	98 %ile	1998	2005	-2.3	-5.3	-0.7	-0.91	8
	London N. Kensington	URBAN BACKG.	Annual mean	1996	2005	-0.6	-1.2	-0.5	-0.93	10
	London N. Kensington	URBAN BACKG.	98 %ile	1996	2005	-2.8	-6.4	-2.3	-0.94	10
	Lullington Heath	RURAL	Annual mean	1988	2005	-0.4	-0.5	-0.2	-0.88	15
	Lullington Heath	RURAL	98 %ile	1988	2005	-2	-2.8	-1.2	-0.91	15
	Middlesbrough	URBAN INDUSTRIAL	Annual mean	1995	2005	-1.2	-1.3	-1	-0.99	11
	Middlesbrough	URBAN INDUSTRIAL	98 %ile	1995	2005	-5.2	-6.8	-3.8	-0.96	11
	Newcastle Centre	URBAN CENTRE	Annual mean	1992	2005	-1.7	-1.7	-1	-0.95	14
	Newcastle Centre	URBAN CENTRE	98 %ile	1992	2005	-8.7	-8.4	-5	-0.98	14
	Rochester	RURAL	Annual mean	1996	2005	-0.4	-0.8	-0.3	-0.92	10
	Rochester	RURAL	98 %ile	1996	2005	-3.5	-6.1	-2.8	-0.99	10
	Sheffield Centre	URBAN CENTRE	Annual mean	1996	2005	-1.6	-2.7	-0.7	-0.87	10
	Sheffield Centre	URBAN CENTRE	98 %ile	1996	2005	-9.6	-11.7	-5.3	-0.99	10
	Southampton Centre	URBAN CENTRE	Annual mean	1994	2005	-0.6	-0.9	-0.3	-0.88	12
	Southampton Centre	URBAN CENTRE	98 %ile	1994	2005	-2.2	-3.6	-0.7	-0.78	12
	Sunderland	URBAN BACKG.	Annual mean	1993	2005	-1	-1.3	-0.7	-0.93	12
	Sunderland	URBAN BACKG.	98 %ile	1993	2005	-5.4	-7.5	-3.5	-0.97	12
	Swansea	URBAN CENTRE	Annual mean	1995	2005	-1.7	-2	-1	-0.94	11
	Swansea	URBAN CENTRE	98 %ile	1995	2005	-6.3	-8.4	-3.2	-0.95	11
	Wolverhampton Centre	URBAN CENTRE	Annual mean	1996	2005	-1	-2.3	-0.5	-0.77	10
	Wolverhampton Centre	URBAN CENTRE	98 %ile	1996	2005	-5.8	-8	-5	-0.95	10

All units are at 20'C
and 1013mb

Appendix 5- Listing of current UK, European and WHO Air Quality Criteria

Here we summarise the UK Air Quality Strategy Standards and Objectives, together with corresponding European Community Directive Limit and Target Values and World Health Organisation advisory Guidelines for the major pollutants.

Nitrogen Dioxide

Guideline Set By	Description		Criteria Based On	Value(1) / μgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	1-hour mean	0-95 (0-49)
		2		96-190 (50-99)
		3		191-286 (100-149)
	MODERATE	4	1-hour mean	287-381 (150-199)
		5		382-477 (200-249)
		6		478-572 (250-299)
	HIGH	7	1-hour mean	573-635 (300-332)
		8		636-700 (333-366)
		9		701-763 (367-399)
	VERY HIGH	10	1-hour mean	≥ 764 (≥ 400)
The Air Quality Strategy(2)	Objective for Dec. 31st 2005, for protection of human health		1-hour mean	200 (105) Not to be exceeded more than 18 times per calendar year.
Set in regulations(3) for all UK:	Objective for Dec. 31st 2005, for protection of human health		Annual mean	40 (21)
Not intended to be set in regulations:	Objective for Dec. 31st 2000, for protection of vegetation.		Annual mean NO_x (NO_x as NO_2)	30 (16)
European Community 1985 NO2 Directive (4) *Limit remains in force until fully repealed 01/01/2010.*	Limit Value		Calendar year of data: 98%ile of hourly means.	200 (105)
1st Daughter Directive(5)	Limit Value for protection of human health. To be achieved by Jan. 1st 2010		1-hour mean	200 (105) not to be exceeded more than 18 times per calendar year
	Limit Value for protection of human health. To be achieved by Jan. 1st 2010		Calendar year mean	40 (21)
	Limit Value (total NO_x) for protection of vegetation. To be achieved by Jul. 19th 2001		Calendar year mean	30 (16)
World Health Organisation(6) *(Non-Mandatory Guidelines)*	Health Guideline		1-hour mean	200
	Health Guideline		Annual mean	40

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb NO_2 = 1.91 $\mu g\ m^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Council Directive 85/203/EEC.
(5) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Sulphur Dioxide

Guideline Set By	Description		Criteria Based On	Value[(1)] / μgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	15-minute mean	0-88 (0-32)
		2		89-176 (33-66)
		3		177-265 (67-99)
	MODERATE	4	15-minute mean	266-354 (100-132)
		5		355-442 (133-166)
		6		443-531 (167-199)
	HIGH	7	15-minute mean	532-708 (200-266)
		8		709-886 (267-332)
		9		887-1063 (333-399)
	VERY HIGH	10	15-minute mean	≥ 1064 (≥ 400)
The Air Quality Strategy[(2)]	Objective for Dec. 31st 2005, for protection of human health.		15-minute mean	266 (100) Not to be exceeded > 35 times per calendar year.
Set in regulations[(3)] for all UK.	Objective for Dec. 31st 2004, for protection of human health		1-hour mean	350 (132) Not to be exceeded > 24 times per calendar year.
	Objective for Dec. 31st 2004, for protection of human health		24-hour mean	125 (47) Not to be exceeded > 3 times per calendar year.
Not intended to be set in regulations.	Objective for Dec. 31st 2000, for protection of vegetation.		Annual mean & winter (1st October – 31st March) mean	20 (8)
1st Daughter Directive[(4)]	Objective for Jan 1st 2005, for protection of human health		1-hour mean	350 (132) Not to be exceeded more than 24 times per calendar year.
	Objective for Jan 1st 2005, for protection of human health		Daily 24-hour mean	125 (47) Not to be exceeded more than 3 times per calendar year.
	Objective for Jul 19th 2001, for protection of vegetation.		Annual mean & winter (1st October – 31st March) mean	20 (8)
World Health Organisation[(5)]	Health Guideline		10-minute mean	500
(Non-Mandatory Guidelines)	Health Guideline		24-hour mean	125
	Health Guideline		Annual mean	50

(1) Conversions between μg m^{-3} and ppb are as used by the EC, i.e. 1ppb SO_2 = 2.66 μg m^{-3} at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(5)WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Ozone

Guideline Set By	Description		Criteria Based On	Value(1) / μgm^{-3} (ppb)
UK Government Air Pollution Index	LOW	1	Max 1-hour and 8-hour mean	0-32 (0-16)
		2		33-66 (17-32)
		3		67-99 (33-49)
	MODERATE	4	Max 1-hour and 8-hour mean	100-126 (50-62)
		5		127-152 (63-76)
		6		153-179 (77-89)
	HIGH	7	Max 1-hour and 8-hour mean	180-239 (90-119)
		8		240-299 (120-149)
		9		300-359 (150-179)
	VERY HIGH	10	Max 1-hour and 8-hour mean	≥ 360 (≥ 180)
The Air Quality Strategy(2) All UK. *Not currently set in regulations.*	Objective for Dec. 31st 2005		Daily max. running 8-hour mean	100 (50) Not to be exceeded more than 10 times per calendar year.
European Community 3rd Daughter Directive(4)	Target Value To be achieved by 3-year period beginning 2010.		Max. daily 8-hour mean.	120 $\mu g\ m^{-3}$ Not to be exceeded on more than 25 days per year, averaged over 3 years.
	Target Value for protection of vegetation. To be achieved by 5 years, beginning 2010		AOT40[5] calculated from 1h values May-July.	18,000 $\mu g\ m^{-3}$ h averaged over 5 years.
	Information threshold		1-hour mean	180
	Alert threshold		1-hour mean	240
World Health Organisation(6) *(Non-Mandatory Guidelines)*	Health Guideline		8-hour mean	120

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb O_3 = 2.00 $\mu g\ m^{-3}$ at 20^{o}C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Directive 92/72/EEC. To be repealed 9 Sep 2003.
(4) Directive (2002/3/EC)
(5) AOT40 statistic is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).
(7) Growing season is defined as April to September for WHO guidelines, but is daytime (0900-1500) April to September for UNECE guidelines.

Carbon Monoxide

Guideline Set By	Description		Criteria Based On	Value[1] / mg m^{-3} (ppm)
UK Government Air Pollution Index	LOW	1	8-hour mean	0-3.8 (0-3.2)
		2		3.9-7.6 (3.3-6.6)
		3		7.7-11.5 (6.7-9.9)
	MODERATE	4	8-hour mean	11.6-13.4 (10.0-11.5)
		5		13.5-15.4 (11.6-13.2)
		6		15.5-17.3 (13.3-14.9)
	HIGH	7	8-hour mean	17.4-19.2 (15.0-16.5)
		8		19.3-21.2 (16.6-18.2)
		9		21.3-23.1 (18.3-19.9)
	VERY HIGH	10	8-hour mean	≥ 23.2 (≥ 20)
The Air Quality Strategy[2,3] (Except Scotland)	Objective for Dec. 31st 2003		Max. Daily Running 8-hour mean	10 (8.6)
Scotland only[4]:	Objective for Dec. 31st 2003		Running 8-hour mean	10 (8.6)
European Community 2nd Daughter Directive[5]	Limit Value. To be achieved by Jan 1st 2005		Max. daily 8-hour mean	10 (8.6)
World Health Organisation[6] *(Non-Mandatory Guidelines)*	Health Guideline		15-minute mean	100
	Health Guideline		30-minute mean	60
	Health Guideline		1-hour mean	30
	Health Guideline		8-hour mean	10

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppm CO = 1.16 mg m^{-3} at 20^{o}C and 1013 mB, except where specified.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Air Quality (Scotland) Amendment Regulations 2002 (SSI 2002/297).
(5) Council Directive 2000/69/EC. Transposed into UK Air Quality Regulations in England by SI 2002/3117, in Scotland by SSI 2002/556, in Wales by SI 2002/3183 (W299), and by Statutory Rule 2002 (357) in Northern Ireland.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Benzene

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2,3] All UK	Objective for Dec. 31st 2003	Running annual mean	16.25 (5)
England[4] & Wales[5] only:	Objective for Dec. 31st 2010	Annual mean	5 (1.54)
Scotland[6] & Northern Ireland	Objective for Dec. 31st 2010	Running annual mean	3.25 (1.0)
European Community 2nd Daughter Directive[8]	Limit Value. To be achieved by Jan 1st 2010	Annual calendar year mean	5 (1.5)

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppb benzene = 3.25 μg m^{-3} at 20^{o}C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043)
(5) Air Quality (Amendment) (Wales) Regulations 2002 (SI 2002/3182 (W298))
(6) Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297)
(7) Council Directive 2000/69/EC. Transposed into UK Air Quality Regulations in England by SI 2002/3117, in Scotland by SSI 2002/556, in Wales by SI 2002/3183 (W299), and by Statutory Rule 2002 (357) in Northern Ireland.

1,3 Butadiene

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2,3] All UK	Objective for Dec. 31st 2003	Running annual mean	2.25 (1)

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppb benzene = 2.25 μg m^{-3} at 20^{o}C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1. & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).

Polycyclic Aromatic Hydrocarbons (PAH)

Guideline Set By	Description	Criteria Based On	Value / ngm^{-3}
The Air Quality Strategy[1] England, Wales, Scotland and Northern Ireland. *Not set in regulations.*	Objective for Dec. 31st 2010	Annual mean *(using B(a)P as an indicator)*	0.25

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.

Particulate Matter as PM_{10}

Guideline Set By	Description		Criteria Based On	Value / μgm^{-3}
UK Government Air Pollution Index	LOW	1	24-hour mean	0-16
		2		17-32
		3		33-49
	MODERATE	4	24-hour mean	50-57
		5		58-66
		6		67-74
	HIGH	7	24-hour mean	75-82
		8		83-91
		9		92-99
	V. HIGH	10	24-hour mean	≥ 100
The Air Quality Strategy(1) **Set in regulations for all UK(2).**	Objective for Dec. 31st 2004		24-hour mean	50 Not to be exceeded more than 35 times per calendar year.
	Objective for Dec. 31st 2004		Annual mean	40
Set in regulations Scotland only(3)	Objective for Dec. 31st 2010		24-hour mean	50 Not to be exceeded more than 7 times per calendar year.
	Objective for Dec. 31st 2010		Annual mean	18
The Air Quality Strategy(1) *Not set in regulations: London only*	Objective for Dec. 31st 2010		24-hour mean	50 Not to be exceeded more than 10 times per calendar year.
	Objective for Dec. 31st 2010		Annual mean	23
The Air Quality Strategy(1) *Not set in regulations: Rest of England, Wales, & Northern Ireland.*	Objective for Dec. 31st 2010		24-hour mean	50 Not to be exceeded more than 7 times per calendar year.
	Objective for Dec. 31st 2010		Annual mean	20
1st Daughter Directive(4) **STAGE 1 – Confirmed.**	Limit Value to be achieved by Jan 1st 2005		24-hour mean	50 Not to be exceeded more than 35 times per calendar year.
	Limit Value to be achieved by Jan 1st 2005		Annual mean	40
1st Daughter Directive(4) **STAGE 2 – To be confirmed.**	Limit Value to be achieved by Jan 1st 2010		24-hour mean	50 Not to be exceeded more than 7 times per calendar year.
	Limit Value to be achieved by Jan 1st 2010		Annual mean	20

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(2) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(3) Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297)
(4) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.

Lead (Pb)

Guideline Set By	Description	Criteria Based On	Value / μgm^{-3}
The Air Quality Strategy[1] **Set in regulations for all UK.**	Objective for Dec. 31st 2004	Annual mean	0.5 (= 500 ng m^{-3})
	Objective for Dec. 31st 2008	Annual mean	0.25 (= 250 ng m^{-3})
1st Daughter Directive (1999/30/EEC)[2]	Limit Value to be achieved by Jan 1st 2005	Annual mean	0.5 (= 500 ng m^{-3})
	Limit Value to be achieved by Jan 1st 2010 in the immediate vicinity of industrial sources	Annual mean	0.5 (= 500 ng m^{-3})
World Health Organisation[3] *(Non-Mandatory Guidelines)*	Health-Based Guideline	Annual Mean	0.5 (= 500 ng m^{-3})

(1) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(2) Council Directive 1999/30/EC
(3) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Metallic Elements Arsenic (As), Cadmium (Cd), Mercury (Hg) and Nickel (Ni), and hydrocarbon Benzo (a) Pyrene

Guideline Set By	Description	Criteria Based On	Value / ng m^{-3}
Daughter Directive (205/107/EC)	Target Value for As	Calendar year mean	6
	Target Value for Cd	Calendar year mean	5
	Target Value for Hg	Calendar year mean	Not set
	Target Value for Ni	Calendar year mean	20
	Target Value for B(a)P	Calendar year mean	1

Target values to be non-mandatory.

Description of UK Government Pollution Indices

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

Air Quality Regulations: Statutory Instruments

Date	Country	S.I. No.	Purpose
30/03/2000	England	SI 2000 No. 928	Inclusion of original Air Quality Strategy Objectives into regulations in England
19/07/2000	Wales	SI 2000 No. 1940 (W138)	Inclusion of original Air Quality Strategy Objectives into regulations in Wales
31/03/2000	Scotland	SSI 2000 No. 97	Inclusion of original Air Quality Strategy Objectives into regulations in Scotland
09/06/2001	Scotland	SSI 2001 No. 224	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for Scotland.
25/06/2001	UK	SI 2001 No. 2315	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for England.
17/07/2001	Wales	SI 2001 No. 2683 (W224)	Transposition of 1st Daughter Directive into Air Quality Limit Values Regulations for Wales.
08/03/2002	Northern Ireland	Statutory Rule 2002 (94)	Implementation of 1st Daughter Directive in NI.
11/06/2002	Scotland	SSI 2002 297	Amendment of Air Quality Regulations to include more stringent objectives for PM_{10}, CO and benzene, specifically for Scotland.
21/11/2002	Northern Ireland	Statutory Rule 2002 (357)	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for Northern Ireland
11/12/2002	England	SI 2002 No 3043	Amendment of Air Quality Regulations to include more stringent objectives for CO and benzene, in England.
16/12/2002	England	SI 2002 No 3117	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for England
17/12/2002	Scotland	SSI 2002 556	Transposition of 2nd Daughter Directive into Air Quality Limit Values Regulations for Scotland
17/12/2002	Wales	Welsh SI 2002 3182 (W298)	Amendment of Air Quality Regulations to include more stringent objectives for CO and benzene, in Wales
17/12/2002	Wales	Welsh SI 2002 3183 (W299)	Transposition of 1st and 2nd Daughter Directives into Air Quality Limit Values Regulations for Wales.

Appendix 6- Calculation methods, statistical methods and measurement uncertainty

Here we provide boring but essential information on measurement accuracy, trend calculation and the mathematical methods used to calculate measurement statistics.

A 6.1 Statement on Accuracy of Air Quality Measurements

The EU Air Quality Directives now specify a required level of data accuracy (uncertainty). The accuracy requirements for the various parameters are summarised in Table 1 below. Please note that there is also a requirement for 90% data capture in each year.

A common approach to determining measurement uncertainty for all pollutants is provided by a CEN (The European Centre for Standardisation) report entitled: ‘Air quality – approach to uncertainty estimation for ambient air reference methods’. CEN has produced a series of standards setting out how National Networks in Member States should operate analysers in order to meet the required uncertainty of ±15% for NO_2, SO_2, CO and O_3 and ±25% for benzene (at the 95% confidence level).

The standards include a set of performance characteristics against which analysers need to be assessed for official approval, as well as activities required for ongoing Quality Assurance and Control (QA/QC). Although the current situation is not entirely clear (for example, no analysers commonly used in the UK have been put through a complete set of performance tests), it is likely that the great majority of UK National Network measurements will meet the uncertainty requirement.

The situation with particulate measurements is more complicated. This is because of the wide scale use of analysers that do not conform to the EU Reference Method for PM_{10} monitoring. Much work is being undertaken- both within Member States and at the EU level- to assess the performance of the different analysers and techniques used for measurement of PM_{10}.

Table 1 – Measurement uncertainty objectives given in EU Air Quality Directives

Pollutant	Uncertainty for Continuous Measurement (listed as accuracy in the Directive)
NO_2, NO_X	15%
SO_2	15%
Particulate Matter	25%
CO	15%
Benzene	25%
O_3	15%

Note: The percentages given in the table are for individual measurements averaged over the period considered by the limit or target value, at concentrations close to the limit or target value, for a 95% confidence interval.

A 6.2 Calculation Methods

A 6.2.1 Introduction

The intention of this section is to provide all the information required to reproduce the statistics contained in this report from the original hourly dataset. This dataset is now widely available from the UK National Air Quality Archive on the World Wide Web- www.airquality.co.uk.

The definition of standard statistical functions, such as means, percentiles, regressions and standard errors can be obtained from a number of statistical references. A description of log-normal distributions and related statistics has also been provided elsewhere[28].

Various air quality guidelines and statistics are defined in the documentation published by the UK Government[2,10,11], the European Community[3,,29-31], the World Health Organisation[26,32-34] and The Expert Panel on Air Quality Standards (EPAQS) [18-25]. This section describes how these statistics are calculated from the original dataset. All exceedence statistics in this report are calculated using methods that are compliant with the requirements of each air quality standard.

Where the exact method of calculation of a statistic has not been precisely defined by the above bodies, a method has generally been chosen that leads to a more stringent air quality guideline.

These calculation methods have been developed over time and are not necessarily those that were used in previous reports of this series.

A 6.2.2 Definitions

Basic Reporting Unit

The basic reporting unit for the National automatic monitoring networks is the hourly average (the terms “mean” and “average” are taken to be equivalent in this report). All statistics of greater than one hour duration are based on hourly averages. For example, the annual mean is the arithmetic mean of the hourly means during the year. Hourly means that are invalid, for any reason, are ignored.

Hourly averages are derived from:

- At least three 15-minute averages per hour in the AURN
- 30-minutes of sampling in the Hydrocarbon Network

Although 15-minute averages are used in the UK National Air Quality standard for SO_2 and the WHO CO guidelines, 15-minute averages are not the basic reporting unit. Annual means, for example, based on 15-minute average may not be equal to those based on hourly averages since there may be, on occasion, insufficient 15-minute data to make a valid hourly mean. 15-minute data are only used to calculate hourly means and any statistic specifically related to 15-minute means.

Mass Units

The units that used to measure the concentrations are not always the same as those used to calculate and report statistics. For example, ozone is measured by the instrumentation in parts per billion (ppb) and the statistics are reported here in terms of the µg m^{-3} mass units. Particulate matter PM_{10}, on the other hand, is measured and reported in terms of µg m^{-3}.

To calculate statistics, therefore, the measured data are first converted into the reporting units, then the statistics are calculated. Comparison with any limit values are only performed in terms of mass units. This method will give slightly different results, due to rounding errors, to calculations using data in ppb and comparing with limit values converted into ppb.

Dates and Times

All data are recorded as Greenwich Mean Time (GMT). Please note that diurnal variations are calculated in local time.

Daily means are defined as midnight to midnight; 24-hour running means are means over any 24-hour period, for example 0800 to 0759.

Data Precision

All concentrations are recorded and reported to a number of decimal places that is greater than or equal to the measurement precision of individual hourly means. For example:

- Ozone is measured to 2 ppb and are reported to 1 ppb or 2 µg m^{-3}
- Benzene is measured to 0.1 ppb and are reported to 0.1 ppb or 0.3 µg m^{-3}

Note that 15-minutes means, where available, are also recorded to the same data precision as hourly means.

Percentiles

Percentiles of SO_2 daily means are calculated using the method described in the European Community SO_2 Directive[29]. All other percentiles use the European Community NO_2 Directive[30] method. For example: after sorting the data into ascending numerical order, the 98th percentiles are at the following ranks:

SO_2	0.98 times the number of valid means rounded up to the nearest integer
NO_2	0.98 times the number of valid means rounded to the nearest integer

For example, the 98th percentile of 365 daily means (rank 357.7) is the 8th highest concentration using the SO_2 Directive method and also the 8th highest concentration using the NO_2 Directive method.

Data Capture Threshold

A 75% data capture threshold is set for all short-term averages of up to the duration of a month. For example:

- An hourly mean requires at least three 15-minute means
- A monthly mean requires at least 75% of daily means and each daily mean requires at least 18 hours of data

Note that it is possible to have a month with 75% data capture for hourly means, but with less than 75% daily means.

Annual and seasonal statistics, such as the summer mean and the annual 98th percentile of hourly means, should be interpreted with respect to the quoted data capture. These statistics are generally not shown if the data capture is less than 25%. However, some short-term values such as the date of the annual maximum hourly mean are shown, since these may still be of interest.

Air Quality Standards and Guidelines

Air quality guidelines used in this report are those defined in the documentation published by the UK Government[2,10,11], the European Community[29-31], the World Health Organisation[26].

The following conversion factors from measured units to mass units defined in the EU Decision on Exchange of Information[6].

Conversion Factors Between ppb and $\mu g\ m^{-3}$ and ppm and $mg m^{-3}$

Pollutant	WHO 25°C and 1013mb	EC 20 °C and 1013mb
Ozone	1 ppb = 1.9622 $\mu g\ m^{-3}$	1 ppb = 1.9957 $\mu g\ m^{-3}$
Nitrogen dioxide	1 ppb = 1.8804 $\mu g\ m^{-3}$	1 ppb = 1.9125 $\mu g\ m^{-3}$
Carbon monoxide	1 ppm = 1.1447 mg m^{-3}	1 ppm = 1.1642 mg m^{-3}
Sulphur dioxide	1 ppb = 2.6163 $\mu g\ m^{-3}$	1 ppb = 2.6609 $\mu g\ m^{-3}$
Benzene	1 ppb = 3.189 $\mu g\ m^{-3}$	1 ppb = 3.243 $\mu g\ m^{-3}$
1,3-butadiene	1 ppb = 2.2075 $\mu g\ m^{-3}$	1 ppb = 2.2452 $\mu g\ m^{-3}$

Additional conversion factors used in the UK are as follows:

- NO_x in $\mu g\ m^{-3}$ is expressed as NO_2, i.e. (NO ppb + NO_2 ppb)* 1.91 = NO_x $\mu g\ m^{-3}$
- In the UK, gravimetric equivalent PM_{10} data are calculated from TEOM monitoring data by applying a conversion factor of 1.3

Note that the minimum data period that can be compared to a guideline is fifteen minutes, since this is currently the time resolution of most UK automatic data. The WHO 10-minute SO_2 guideline is not, therefore, reported.

Running Means

Wherever possible, running means, rather than simple means, are used for comparison with air quality standards.

For example: the Air Quality Standard CO 8-hour standard in this report is based on all possible 8-hour means during a year. Calculating all possible means can produce twenty-four possible exceedences every day. This is a more stringent method than taking simple, non-overlapping, means (e.g. three 8-hours means in a day).

Please note that in this report:

- The WHO 30-minute guideline is calculated as a running mean based on 15-minute averages
- The UK National Air Quality standard running annual means for benzene and 1,3-butadiene requires a 75% data capture. Newly established sites cannot, therefore, report the running annual mean.

Exceedence

An exceedence of an air quality guideline is defined in this report as a concentration **greater than** the guideline threshold. This definition was changed from "**greater than or equal"** the guideline threshold, in order to be consistent with EC Directives.

Exceedence Counting

The following method is used where an air quality guideline is based on an average:

1. Calculate the average
2. Apply the 75% data capture threshold
3. Round the average to the data precision
4. Compare with the guideline

For example: at stage 3, an 8-hour average ozone concentration of 100.4999 µg m^{-3} is rounded to 100 µg m^{-3}. This does not exceed the UK National Air Quality standard running 8-hour ozone mean of 100 µg m^{-3}.

However, if no rounding occurs, the concentration would exceed the standard. Also, if this value is the highest running 8-hour during the year, an anomaly would occur in the report since the maximum would be reported as 100 µg m^{-3} yet there would be an exceedence.

To calculate the number of days with an exceedence, the date (in GMT) of the last hour of the running mean is used.

Cumulative Frequency Distributions

Cumulative frequency distributions in this report are graphed on log-normal axes. A reasonably straight line indicates that pollutant concentrations are log-normally distribution and can be predicted from the geometric mean and the standard geometric deviation[29]. The y-axis shows the logarithm to base 10 of the percentile concentrations, while points on the x-axis are normally distributed.

The geometric mean and standard geometric mean are calculated by use of logarithms and, therefore, can only include concentrations greater than zero.

Diurnal Variations

Diurnal variations are the average concentration for each hour of day during the period of interest. Local time is used, rather than GMT, since this will more closely reflect the daily cycle of manmade emissions.

Long-Term Trends

Long-term trends reported here are based a non-parametric linear regression method[29] which has the following stages:

- The gradient is calculated by “Theil’s incomplete” method[37]
- The null hypothesis (i.e. the statistical significance of the trend) is tested by the Spearman’s rank correlation coefficient[38]
- The 95th confidence interval for the gradient is given by Kendall's Tau[39]

Values for the Spearman’s rank correlation coefficient used in this report are as published by Conover[36].

This method does not assume that the errors on the data points are normally distributed and is, therefore, more appropriate than simple linear regression by least squares. However, the results obtained have been demonstrated to be broadly similar[40].

Exponential regressions may be appropriate for some time series, e.g. SO_2 in London, but for the majority of cases a linear trend over recent years is of most interest. Only linear trends are provided in this report.

Trends are reported for sites where there are at least five valid measurements. A valid measurement requires a data capture of at least 50%.

Where a site has a statistically significant trend of more than five years, the five-year trend and the trend over the full monitoring period are reported. Ten-year trends are highlight in the summary table in Appendix 4.

Particulate measurements and conversion factors used in this report

With gaseous pollutants, it is possible to express concentrations as an amount fraction – the ratio of pollutant molecules to the total number of air molecules – for example, parts per billion (ppb). This is not possible for PM, and measurements are always given in units of particulate mass per unit volume of air (typically μgm^{-3}). When these units are used without specifying the temperature and pressure of the air, the same 'packet' of air will have a different concentration as these properties of the air change. The European legislation for PM measurement therefore requires that the air volume used must be at the same ambient air temperature and pressure as at the time of sampling. In practice, this means that appropriate corrections need to be made if the flow rate used to calculate the sampled volume is not based on the actual volume of sampled air.

Different measurement techniques, although nominally measuring the same PM, may treat the airstream in different ways, leading to significantly different results. For clarity, all mass measurements of PM_{10} and $PM_{2.5}$ in this report are expressed as $\mu g\ m^{-3}$ for both gravimetric and TEOM analysers.

The EU First Air Quality Daughter Directive (1999/30/EC) specifies that measurements of PM_{10} should be carried out using the reference method, as defined in European Standard EN12341. This standard refers to three sampling devices that may be used:

- Superhigh volume sampler – the WRAC (Wide Range Aerosol Classifier);
- High-volume sampler – the HVS PM10 sampler (68 $m^3\ h^{-1}$);
- Low-volume sampler – the LVS PM10 sampler (2.3 $m^3\ h^{-1}$).

None of these instruments can provide real-time (continuous hourly) measurements. As a result, the TEOM analyser is widely used in both the UK and throughout the rest of the world for measuring continuous concentrations of PM. The instrument is based on the principle that the frequency of oscillation of a glass, tapered tube (element) changes by an amount that is directly proportional to the mass of the tube Therefore, any change in mass of the tube, due to the deposition of particles onto a small filter affixed to one end, will result in a change in the resonant frequency that is proportional to the additional mass.

In order for the TEOM to be used as a USEPA-equivalent method for PM_{10} measurement, a default adjustment factor (1.03 * TEOM reading + 3 μgm^{-3}) must be applied to the raw data. This adjustment factor was derived to account for moisture equilibration differences between the TEOM and the HI-vol sample media. The adjustment factor was determined at sites where non-volatile PM dominated and is intended to reflect the filter character more than the PM. It is understood that USEPA has no general policy on the use of this empirical adjustment factor for PM2.5 measurements. All TEOM analysers in the UK measuring both PM_{10} and $PM_{2.5}$ are currently set up with this default adjustment factor included. In addition, TEOM analysers within the UK networks are set to report concentrations corrected to 293K and 101.3 kPa.

Due to the need to eliminate the effect of changing humidity on the mass measurement, the TEOM is required to maintain the sample filter at an elevated temperature. This has led to reported differences in concentrations of PM between the TEOM and the European reference sampler (Allen *et al*., 1997; APEG, 1999; Ayers *et al*., 1999; Soutar *et al*., 1999; Salter and Parsons, 1999; Cyrys *et al*., 2001; Williams and Bruckmann, 2001). This is largely attributed to the loss of volatile species such as ammonium nitrate. As an interim measure, a default 'scaling factor' (also known as correction factor) of 1.3 has been applied to all TEOM PM_{10} data reported here, as recommended by the EC Working Group on Particulate Matter (2001).

‘*Box and whisker’ plots:*

Box and whisker plots are used to illustrate measured concentrations at air quality monitoring stations around the UK and how they compare with the UK’s Air Quality Strategy Objectives. For each objective, the average concentration (of the appropriate metric) for all of the sites is shown, together with the highest concentration from that group of sites.

Data for each pollutant are obtained from the national networks. This is mainly from the Automatic Urban and Rural Network (AURN) but also from the Hydrocarbons Network, Heavy Metals Network and PAH Network where applicable to that pollutant. The data represent a broad range of monitoring environments including roadside and background sites. All data used in the calculations undergo a rigorous quality assurance procedure and are fully ratified prior to analysis.

The checked and validated data are used to calculate the appropriate metric (annual average, maximum daily running 8-hour concentration, and so on). The metrics presented generally correspond to those on which the legislation is based. This allows a direct comparison of measured levels against the objectives.

Some objectives allow for a specific number of permissible exceedences. It is more difficult to analyse progress against these objectives, because the metric provides no indication of air quality below the number of permissible exceedences. For this reason, an equivalent percentile is used. For example, the SO_2 15-minute objective allows up to 35 exceedences in a calendar year; the corresponding percentile would be 99.9% of 15-minute means. If this value is below the 266 μg m-3 objective, then there are fewer than the 35 permissible exceedences and the difference will provide an indication of how far below the objective the measured values are. This allows us to meaningfully average concentrations from a range of sites and to compare them directly against the objective.

Data capture statistics are used to screen out sites where the volume of data is too low to provide meaningful comparisons against the legislative objectives. A data capture threshold of 75% has been used for this purpose, below which data are omitted from the analysis.

When the data have been screened to include only those sites with 75% or more, the data range is sorted in order to group sites into their respective countries. The average and maximum concentrations are then calculated for the appropriate group of sites to which specific objectives apply. These are presented in simple box and whisker (‘cricket bat’ plots), where the bar represents the average concentration of all the sites in the range and the whisker represents the site with the highest concentration. These can also be presented in simple line charts to show the same information in a time series - as in Figure 37 in this report.

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The National Atmospheric Emissions Inventory:
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The Defra air quality information web resource:
www.defra.gov.uk/environment/airquality/index.htm

The Scottish Executive Air Quality pages:
www.scotland.gov.uk/Topics/Environment/Pollution/16215/4561

The Welsh Assembly Government Environment link:
www.wales.gov.uk/subienvironment/index.htm

The Northern Ireland Department of Environment:
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