AIR QUALITY IN LONDON 2001

THE NINTH REPORT OF THE LONDON AIR QUALITY NETWORK

KING'S College LONDON

University of London

Environmental Research Group
School of Health and Life Sciences
King's College London
December 2002

ACKNOWLEDGEMENTS AND CONTACTS

The London Air Quality Network is a unique and valuable resource whose continued development would not have been possible without the support of the local authorities in London and the Home Counties, the Association of London Government, London's Health Authorities and the Association of London Environmental Health Managers. The kind support of the Department of the Environment, Food and Rural Affairs and the Greater London Authority is also gratefully acknowledged.

The production of this report has truly been a team effort, which has been undertaken by staff who are both dedicated and committed to their work. Further information can be gained through the following contacts.

THE ENVIRONMENTAL RESEARCH GROUP:

Air Quality Monitoring

Timothy Baker	Ben Barratt
Hima Chouhan	Lynette Clapp
Gary Fuller*	David Green
Paul Johnson	Daniel Marsh
Ellie Norris	Ana Rowan
David Young	

Air Quality Management

Sean Beevers	David Carslaw
Steve Hedley*	John Smith

Emissions

Martin Cranfield*	Gloria Esposito
Hamish Lodge	

Computing

Robert Hepburn*	Andrew Mackay

Administration, Finance and Support

Mandy Cue*	Maria Lavender*
Wendy Rowlands	

Director of Environmental Research Group

Prof. Frank Kelly

* Suggested first point of contact within each team.

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FOREWORD
KEN LIVINGSTONE – MAYOR OF LONDON

I am heartened to see the continued fall in annual mean network concentrations of oxides of nitrogen, carbon monoxide, sulphur dioxide and fine particles (PM_{10}). This indicates that strategies the GLA, government and London boroughs have put in place are having an effect in reducing emissions, which in turn is having a positive impact on air quality. I am concerned though about the continued rise in ozone concentrations and I have written to both the UK government and EU to develop Europe-wide strategies to reduce the formation of ground level ozone. Reductions of ozone precursors need to be done at a regional level.

Two pollutants, nitrogen dioxide and fine particles (PM_{10}), currently exceed the National Air Quality Objectives and are predicted to do so by their respective target dates.

There are now technologies available that give some hope of radically reducing PM_{10} concentrations in the near future. For example, particulate traps fitted to the exhausts of larger diesel vehicles can reduce PM_{10} emissions by up to 95%.

Apart from the use of three-way catalytic converters on petrol vehicles, developments in technologies to reduce emissions of oxides of nitrogen are, however, less advanced which is why concentrations of nitrogen dioxide are falling only gradually. Future predictions indicate that large parts of London will still exceed the annual mean national objective by 2005.

Gas use in buildings is a major source of oxides of nitrogen (which is converted to nitrogen dioxide in air). At present, however, gas or electricity are the only options available for this purpose on a mass scale. Gas is already seen as a clean fuel and largely replaced solid fuel as a source of power, which was much more polluting. These emissions are predicted to increase in the future as London's population increases up to 2016 and, proportionally, is likely to become more prominent as the emissions from traffic is reduced. Without a change in technology – for example using hydrogen fuel cells to power buildings – nitrogen dioxide emissions are expected to continue to grow from this source.

My Air Quality Strategy was published in September 2002. It sets what can be done by London boroughs, businesses and individuals to improve air quality in London and so decrease the impact on people's health and quality of life and I encourage everyone to do all they can to reduce pollution emissions in London.

There is no one single measure that will achieve our goals; major gains will only happen by everyone acting collectively so that concentrations of nitrogen dioxide and PM_{10} are steadily reduced. For example, it is technically feasible for a large proportion of older diesel vehicles to be converted to meet a Euro II engine standard plus a reduced pollution certificate; this reduces emissions of particles even further.

I am pleased that ERG is continuing to collate air pollution data for London and that the number of monitoring sites included in the network increased last year. It is important that as much data as possible is collected across London as it will be used to assess the impact of new measures as well as indicate how well those measures have brought about air quality improvements.

Ken Livingstone
Mayor of London

January 2003

INTRODUCTION

FRANK J KELLY - PROF. OF ENVIRONMENTAL HEALTH & DIRECTOR OF ERG

Welcome to the ninth annual report of the London Air Quality Network (LAQN), the largest and most comprehensive regional monitoring network in Europe. Since its inception in 1993 the network has expanded each year and 2001 was no exception, with the addition of many new sites and an increase in the extent of monitoring at some existing sites.

Data in the current report includes eight different pollutants and provides an overview of air quality in London during 2001 and, for comparison, a summary of the data generated over the last 5 years. The report is important both as a stand-alone document for comparison with other cities, and as part of the ongoing annual air pollution record for London. This publication is an essential resource for anyone interested in air quality matters, especially those working at local and national levels who are developing policies to help reduce the level of air pollution.

As in 2000, London did not experience many significant pollution incidents during 2001. With the exception of ozone, medium term trends continue to indicate improvements in the concentrations of the majority of pollutants. However, London clearly still suffers from major air quality problems and attainment of the Air Quality Strategy Objectives will be very challenging for many parts of the Capital. In recognition of this, new tighter UK daily mean PM_{10} standards proposed for 2010 (50 µg m^{-3}, with up to 7 exceedences per year) have been weakened for London where an additional 3 exceedence days per year will be permitted.

In response to these on going air quality difficulties, 2002 saw the launch of the Mayor's Air Quality Strategy in which a range of measures is outlined to help improve the quality of London air. The LAQN will be an essential instrument for monitoring the impact of the measures in this Strategy and action being taken at a Borough level

The current annual report includes, for the first time, annual mean NO_X measurements for each NO_2 monitoring site in the LAQN as previously requested. Furthermore, this annual report provides gas measurements expressed as mass per unit volume and the report also contains a discussion of the uncertainty associated with air quality measurements

With data dissemination in mind, the LAQN website www.erg.kcl.ac.uk was launched in 2000. Over the last 12 months this has become an indispensable communication tool for the LAQN. The website provides summaries of air pollution across the LAQN and a number of tools to allow users to analyse and plot data. As expected, this resource has proved to be of real benefit to the public and researchers with an interest in the quality of air in London. Plans are in place to identify funding to further develop this valuable resource during 2003.

In November 2002 the ERG, relocated to a new monitoring control room and offices near Waterloo. Coupled with the move we have made substantial investment in IT systems and the organisation is in a much better position to manage further growth and integration of air pollution monitoring and modelling in the South East of the UK. In addition, this move represented an important step in the further integration of ERG into King's College London as a partner in the Air Pollution & Health initiative. Already the combined expertise of the enlarged group is providing exciting new opportunities for research on London's air quality and its health impact.

2002, the year of production of this report, witnessed the 50th anniversary of the Great London Smog. At the commemorative meeting held at the London School of Hygiene & Tropical Medicine one of the plenary talks focussed on the development and usefulness of the LAQN. As a member of ERG it was gratifying to see the level of interest shown by international colleagues in this unique resource that we have in London. Clearly, the monitoring of air pollution fulfils a central role in the understanding of air quality. Moreover, high quality data are essential for the air quality review and assessment process, providing a sound basis for determining whether air quality objectives are being achieved.

This report undoubtedly contains some encouraging information. It also highlights how much more needs to be done at all levels - by individuals, local councils and Government - to combat air pollution. It is therefore imperative that all relevant parties work together to this end. The LAQN is an excellent example of an effective working partnership between local authorities, Government and academia.

Professor Frank Kelly
Director ERG.

EXECUTIVE SUMMARY

This report summarises the results of the air pollution monitoring carried out by the London Air Quality Network (LAQN) during 2001.

During 2001 the LAQN continued to expand with data available from an additional eleven monitoring sites.

Network annual mean concentrations have been analysed for the period November 1996 to December 2002.

- Network annual mean NO_2 has declined by around 10 % overall. NO_2 concentrations have been largely stable since the start of 2001 and provisional measurements for 2002 suggest a slight increase. Overall NO_X concentrations have fallen by 29%.
- Network annual mean O_3 shows an overall rise of around 25 %.
- Network annual mean CO, SO_2 and PM_{10} show marked overall decreases. However, the rate of decline has slowed substantially since the start of 2000.

The report also analyses the number of PM_{10} exceedence days at three sites since 1994, clearly showing the effect of past episodes and the difficulty of achieving the PM_{10} daily mean objective at the Marylebone Road kerbside site.

Each of the pollutants monitored by the LAQN during 2001 has been compared to the Air Quality Strategy (AQS) Objectives (DETR 2000a, DETR 2000b).

- The CO objective was exceeded at the kerbside site Redbridge 2.
- The annual mean objective for NO_2 was exceeded at the majority of kerbside and roadside sites. The objective was also exceeded at many inner London background sites and those in west London. Around one quarter of the area of Greater London exceeded the objective.
- The incident based objective for NO_2 was exceeded at kerbside sites at Marylebone Road, Redbridge 2 and Redbridge 3. The objective was also exceeded at the roadside sites Kensington & Chelsea 3 and Brent 2.
- The O_3 objective was exceeded at sixteen outer London sites.
- The PM_{10} incident based objective was exceeded at ten sites.
- The annual mean objective for PM_{10} was exceeded at the kerbside site in Marylebone Road and the roadside site Bexley 4.
- All LAQN sites met the objectives for SO_2.

For the first time, the LAQN Annual Report presents measurements as mass per unit volume in addition to volume mixing ratios. To further assist air pollution modellers the report also includes annual mean measurements for NO_X. Hydrocarbon measurements undertaken by the LAQN and national networks have also been included in more detail.

A measurement cannot be used with confidence unless its uncertainty can be estimated allowing it to be seen in context. Estimates of uncertainty produced by calculation and audit suggest an uncertainty of ±10 % as a good working figure to be considered when comparing measurements to AQS Objectives and EU Limit Values. This, however, does not imply a ±10 % uncertainty for those objectives that are determined by exceeding a threshold on a given number of occasions.

AIR QUALITY IN 2001

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1.1 Background

The purpose of this report is to review air quality in London during 2001. Measurements have been analysed with specific reference to the Air Quality Strategy (AQS) Objectives (DETR, 2000a, DETR 2000b). Full details of the sites in the London Air Quality Network (LAQN) in 2001 are presented in Appendix 1 and the detailed monitoring results are presented in Appendix 3. Details of pollution incidents during the year can be found in the quarterly reports for 2001.

The LAQN was formed in 1993 to co-ordinate and improve air pollution monitoring in London. At the end of December 2002, thirty-one London Boroughs were supplying data to the LAQN. Increasingly, these data are being supplemented with measurements from local authorities around London, thereby allowing an overall perspective of air pollution in South East England. The LAQN is operated and managed by the Environmental Research Group (ERG) at King's College London on the basis of each borough funding the monitoring activities in its own area. The ERG is contracted by the Department of the Environment, Food and Rural Affairs (DEFRA) to maintain sixteen of the LAQN sites as affiliate sites to the UK Automatic Urban and Rural Network (AURN). This DEFRA support assists the operation of the overall LAQN.

The combined London, Hertfordshire & Bedfordshire and Kent networks produce a detailed perspective of air pollution in London and the Home Counties. This perspective is unique within the UK and is an increasingly important resource to quantify air pollution in London, supporting the boroughs and the Greater London Authority in meeting the challenges of the AQS.

The LAQN is able to report measurements from an additional 11 monitoring sites during 2001. Several sites received equipment enhancements during the year. The principal site changes are listed in Appendix 1.

Analysis of LAQN measurements has been augmented by measurements from the directly funded DEFRA sites in London. These six sites provide further information concerning pollution in central and west London. Hourly and 15 minute mean measurements from these sites have been obtained from the DEFRA National Air Quality Archive and included within the LAQN database.

In response to requests from air pollution modellers this annual report also includes annual mean NO_X measurements for each NO_2 monitoring site in the LAQN. Building upon the precedent of the quarterly reports for 2001, this report chiefly reports gas measurements expressed as mass per unit volume (μgm^{-3} and mgm^{-3}) using conversion factors at 20 ^OC and 1.03 KPa as suggested in the Draft Guidance LAQM.TG(02) (DEFRA 2002) NO_X measurements are reported as NO_2 equivalent. Hydrocarbon measurements undertaken by the LAQN and national networks have also been included in more detail.

The latest air pollution measurements for London can be viewed on the LAQN web site. The site has graphical summaries of air pollution across the LAQN, details of the monitoring sites, background information about air pollution and tools to allow the user to analyse and plot measurement data. The Internet site, shown in *Figure 1*, may be found at www.erg.kcl.ac.uk

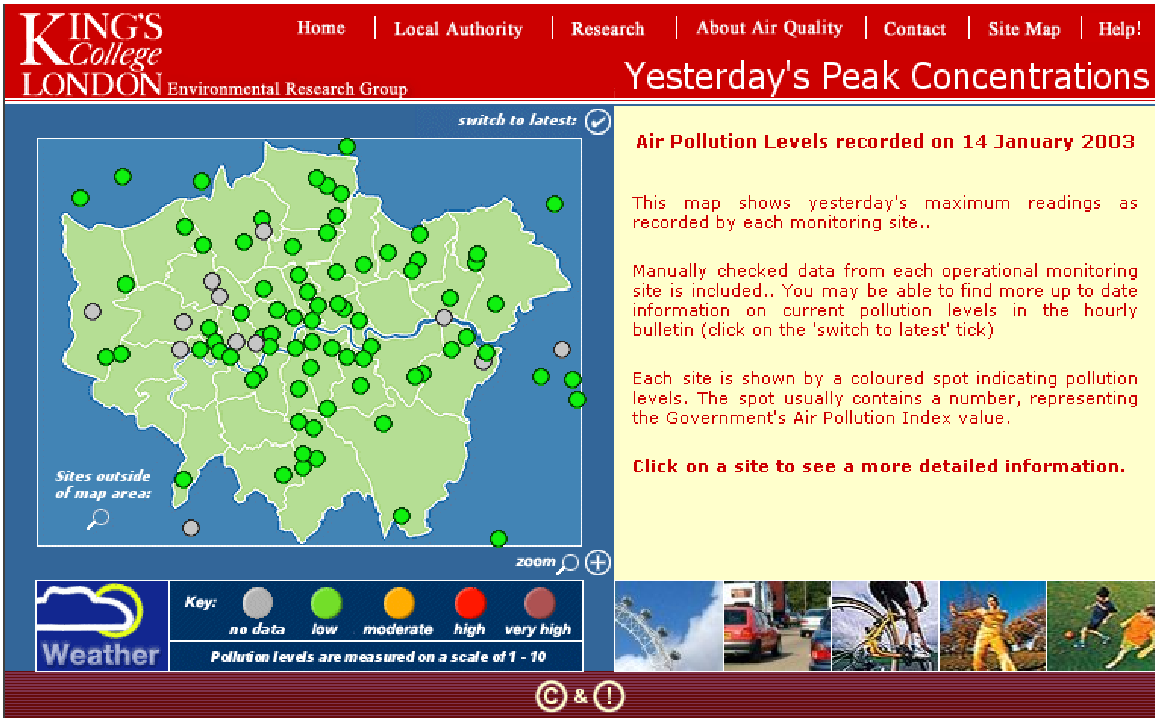

Figure 1 The LAQN Internet site; www.erg.kcl.ac.uk

1.2 Discussion of Results

1.2.1 Measurement Uncertainty and Presentation

Comparisons of 2001 results with national and international guidelines and standards are shown in Appendix 3.

When examining pollution measurements it is important to consider the location of the monitoring site e.g. kerbside, urban background, rural, etc., and the measurement quality. The site type and quality assurance standard for each site are listed in Appendix 1. Sites are divided into quality standards. Data from sites affiliated to the Automatic Urban and Rural Network (AURN) and London Standard sites have traceabilty to national metrological standards, whereas for the locality standard sites there is insufficient information to demonstrate such traceability.

No scientific measurement is absolutely accurate or absolutely precise. The combination of accuracy and precision is termed the uncertainty. In order to place results in context, the uncertainty associated with each result has to be considered. Estimates of the uncertainty associated with air quality measurement are discussed in the 1996 LAQN Annual Report (SEIPH-ERG, 1996) and are also addressed in Chapter 2. It is reasonable to assume a working uncertainty of around 10 % (2σ) when discussing high values and long-term means of CO, NO_2, O_3 and SO_2 measured at London Standard sites. This is justified on the basis of both mathematical modelling and equipment performance tests. However, due to the statistical distribution of the data, a 10 % uncertainty in measurements does not imply a 10 % uncertainty in the number of exceedences of an objective. The calculation of uncertainty in the number of exceedences has to be based on an analysis of the dataset for each individual site. Error bars have been used to indicate the range of uncertainty in the figures below. The uncertainty associated with the measurement of PM_{10} is more complex due to the nature of the pollutant.

The LAQN measurements are subject to two quality assurance processes. Initially, measurements are validated when they are collected using the best calibration and instrument performance information available at the time. Measurements are retrospectively examined during the ratification process, using long term instrument histories and the results of further quality checks. Hence the final ratified measurements in this report for 2001 will differ from those initially published via our fax and Email dissemination services, on the Internet and in quarterly reports.

The final and definitive data sets for the AURN affiliated sites are published by DEFRA.

Each of the pollutants monitored by the LAQN in 2001 is discussed below in terms of its spatial distribution and in comparison with the AQS Objectives. Many objectives require data representative of the whole year. If insufficient data are available, then comparison with the objective is not possible. This, for example, may be the case for sites installed during the year or those that experienced serious and prolonged instrument failure. A data capture objective of 90 % is recommended in LAQM.TG(02) (DEFRA 2002) in line with EU Directive requirements. Additionally sites with a data capture between 75 % and 90 % have been included in the following comparisons and are indicated with an asterisk in each figure.

1.2.2 Relative Results 1995 to 2001

During 2001 there were no major pollution incidents as seen in previous years. For example, during 1991, 1994 and 1997 London experienced significant winter pollution incidents. Furthermore, a prolonged secondary particulate episode occurred during 1996 and the hot summer of 1995 produced substantial photochemistry.

Data from November 1995 to December 2002 have been analysed to place the results from 2001 in context. Annual means from November 1996 have been calculated, at monthly intervals, in an attempt to eliminate seasonal effects. Note that the mean value for a particular date represents that for the preceding 12 months e.g. the value calculated for November 1996 represents the mean between November 1995 and November 1996. To provide a perspective across the network as a whole, the mean from each of the long term sites has been averaged to produce a LAQN network mean. The LAQN network mean has been normalised to 100 % for each pollutant as at November 1996 to illustrate relative change. Measurements from roadside and background sites have been used. However, due to data availability, a different set of sites has been used for each pollutant. Four sites have been used for the PM_{10} calculation, five for CO, six for O_3 and SO_2, and twelve for NO_X and NO_2. It should be noted that data from 2002 are provisional and subject to ratification. The provisional LAQN network means for 2002 have also been affected by the closure of the 3 long term monitoring sites in Sutton during May 2002 and the basis of the analysis will be redesigned during 2003 to take account for this. The annual means are shown in Figure 2 and Figure 3.

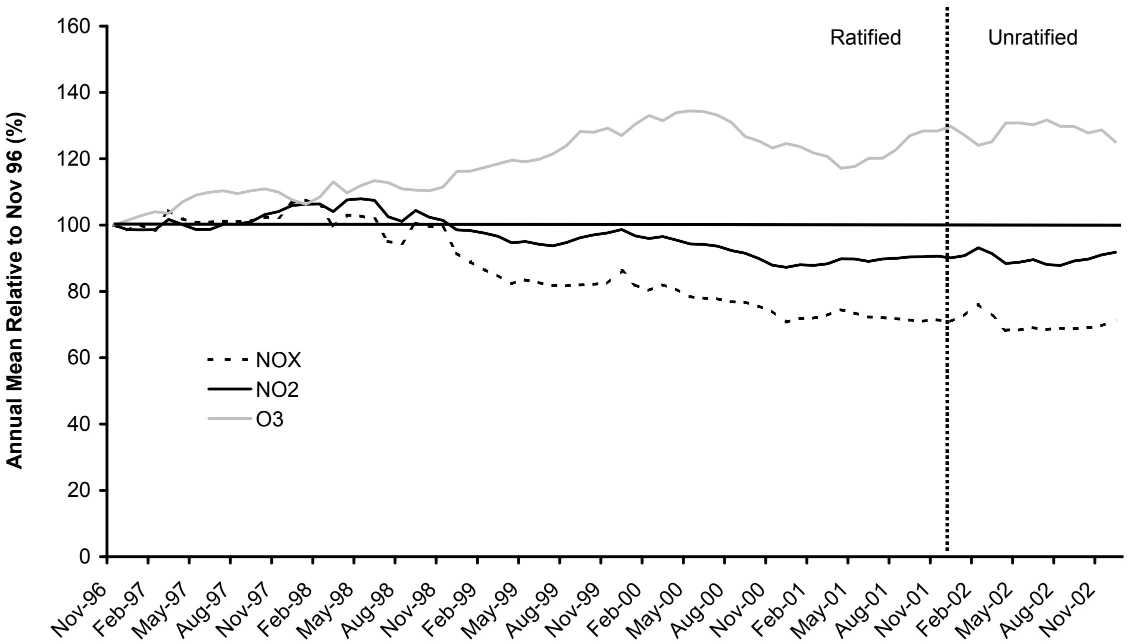

Figure 2 Relative Annual LAQN Mean for O_3, NO_X and NO_2.

Figure 2 shows a fall of around 29 % in the NO_X concentration over the period November 1996 to December 2002. This is very likely the result of reduced NO_X emissions due to technological changes in the vehicle fleet. The effects of pollution incidents during winter 1997 can also be seen in the NO_X concentration; causing a rise in concentration at this time and a consequential fall during winter 1998 as this incident drops from the rolling annual mean. NO_X concentrations declined during 2000 but have remained relatively stable since.

LAQN annual mean NO_2 initially shows a rise due to pollution incidents in winter 1997. The NO_2 mean fell during 1998 only to rise again during 1999. Previous analysis of the network annual mean NO_2 has not shown any overall trend. However, during 2000 NO_2 concentrations showed a substantial decline of around 10 %. NO_2 concentrations have been largely stable since the start of 2001 and provisional measurements for 2002 suggest a slight increase. Overall there has been a reduction of approximately 10 % in annual mean NO_2 concentration during the period November 1996 to December 2002. This will be encouraging to air quality managers. It is difficult to determine the NO_2 reduction that is due to emissions reduction and that due to favourable meteorological conditions. For instance, it is likely that the exceptionally unsettled conditions during late 2000 led to a temporary reduction in both NO_X and NO_2.

The O_3 concentration in Figure 2 shows an overall rise of 25 % during the period November 1996 to December 2002.

Figure 3 shows that LAQN annual means for CO, SO_2 and PM_{10} fell relatively rapidly from November 1996 to late 1999. From the start of 2000 the rate of decline has been more modest. The apparent step change in the provisional annual mean SO_2 from mid 2002 is due to the closure of the Sutton 1 site and does not represent a change in ambient conditions.

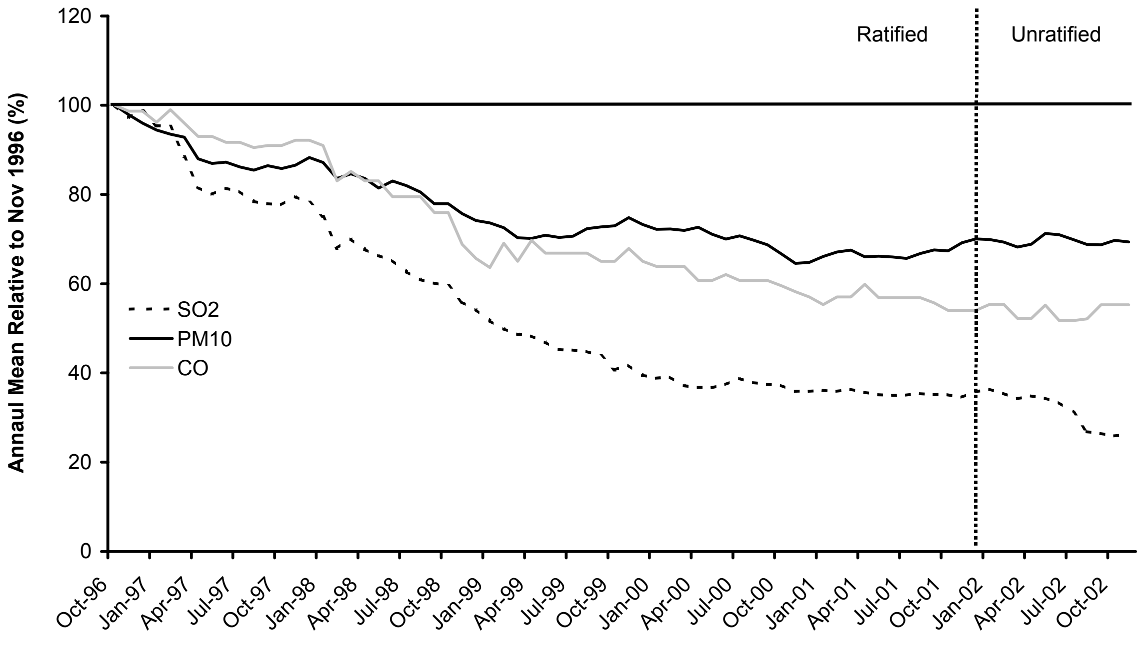

Figure 3 Relative Annual LAQN Mean for CO, PM_{10} and SO_2

AQS Objectives vary in their averaging time from annual means to shorter incident based objectives of a day or less. The shorter averaging time objectives are important for local air quality management; this is especially the case with PM_{10}. These incident based objectives show more variation between sites, and from year to year, than that exhibited by annual means. It is therefore difficult to summarise the network wide trends with reference to these objectives.

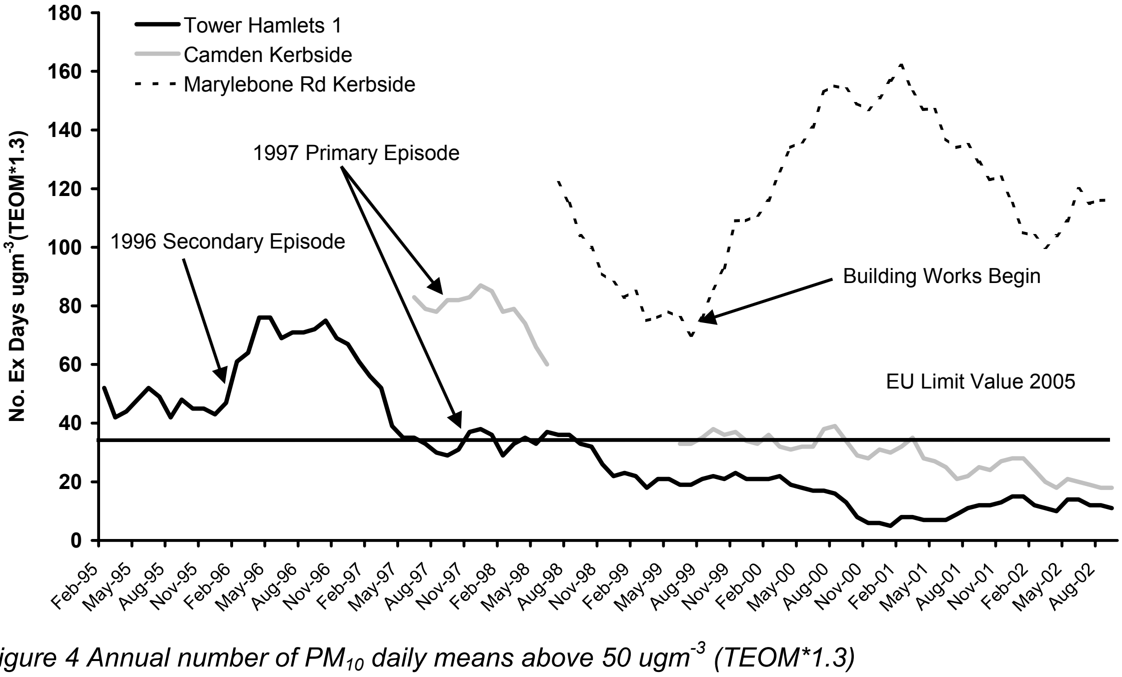

*Figure 4 Annual number of PM_{10} daily means above 50 ugm^{-3} (TEOM*1.3)*

Figure 4 shows the annual number of daily mean PM_{10} measurements above 50 μgm^{-3} (TEOM*1.3) (calculated at monthly intervals) at 3 LAQN sites; the long term background site Tower Hamlets 1, and the kerbside sites Camden 1 and Marylebone Road. The long term measurements from Tower Hamlets 1 exhibit an overall downward trend from around 50 exceedence days in 1995 to around 10 days in 2002. During 1995 the Tower Hamlets site exceeded the objective, which implies widespread exceedences throughout London. The situation deteriorated in spring 1996 due to the significant secondary episode at this time. As a consequence 76 exceedence days were measured in the year ending April 1996; greater than double the 2005 objective of 35 days. A repetition of such an episode would clearly provide significant challenges for air quality management. The additional exceedence days caused by the spring 1996 episode leave the running count in spring 1997. Other events affecting the number of exceedence days include the primary episode of winter 1997 and the unsettled weather in late 2000. The site has consistently achieved the objective since August 1998.

The number of exceedence days at the Camden 1 kerbside site follows a similar trend to Tower Hamlets 1 with additional exceedence days due to local traffic emissions. The Camden 1 site has been constantly below the objective since spring 2001. The similar downward trend of these sites reflects a reduction in secondary and primary PM_{10} emissions whilst the convergence of exceedence days illustrates the reduction in traffic emissions of primary PM_{10}.

The situation at the Marylebone Road kerbside site is more severe with the site measuring between two and greater than four times the permitted exceedence days. Marylebone Road has also been affected by PM_{10} from local building works that has masked any overall trend. Achieving the objective at this site by 2005 will clearly be very difficult.

1.2.3 Carbon Monoxide

CO emissions within the LAQN area are dominated by road transport sources.

The highest rolling 8 hour means were measured at kerbside and roadside sites with the AQS Objective of 10 mgm^{-3} (8.6 ppm) being exceeded at the kerbside site Redbridge 2 on 9 occasions. This site is located on a traffic island in the centre of a busy junction. Results from this site and from the Bromley kerbside site (now closed) suggest that CO concentrations close to busy, congested junctions may be higher than previously thought (SEIPH-ERG, 1999; Lonsdale *et al*, 1998).

1.2.4 Nitrogen Dioxide

NO_2 is largely a secondary pollutant formed by the oxidation of NO. In the LAQN area, road transport is the dominant source of NO_X. This is reflected in the general distribution of NO_2, with the highest concentrations in 2001 being measured at roadside and central London locations. Lower concentrations are observed at background, suburban and rural areas.

The AQS stipulates two objectives for NO_2: an annual mean of 40 μgm^{-3} (21 ppb) and an incident based objective of 200 μgm^{-3} (104.6 ppb), as an hourly mean, not to be exceeded more than 18 times per year. Provisional annual mean NO_2 concentration across London for 2001 is shown in Figure 5. It is likely that predicted NO_2 concentrations are overestimated around Heathrow due to uncertainties in the NO_X emissions at the airport. Elsewhere there are slight differences between the mapped results and those measured at the individual background monitoring sites, although these are within the variation that would be expected for individual sites and are within the limits of measurement uncertainty.

Figure 5 shows two main concentration centres focused on central London and the area around Heathrow Airport. The NO_2 objective is exceeded at almost all areas in inner London. The measurements alongside roads in central London are almost twice the objective. The objective is also exceeded along trunk roads in outer London, the M25 and main roads in the suburban boroughs. Elevated background concentrations can also be seen around the trunk road network and in suburban ‘town’ centres such as Kingston, Sutton, Croydon and Romford.

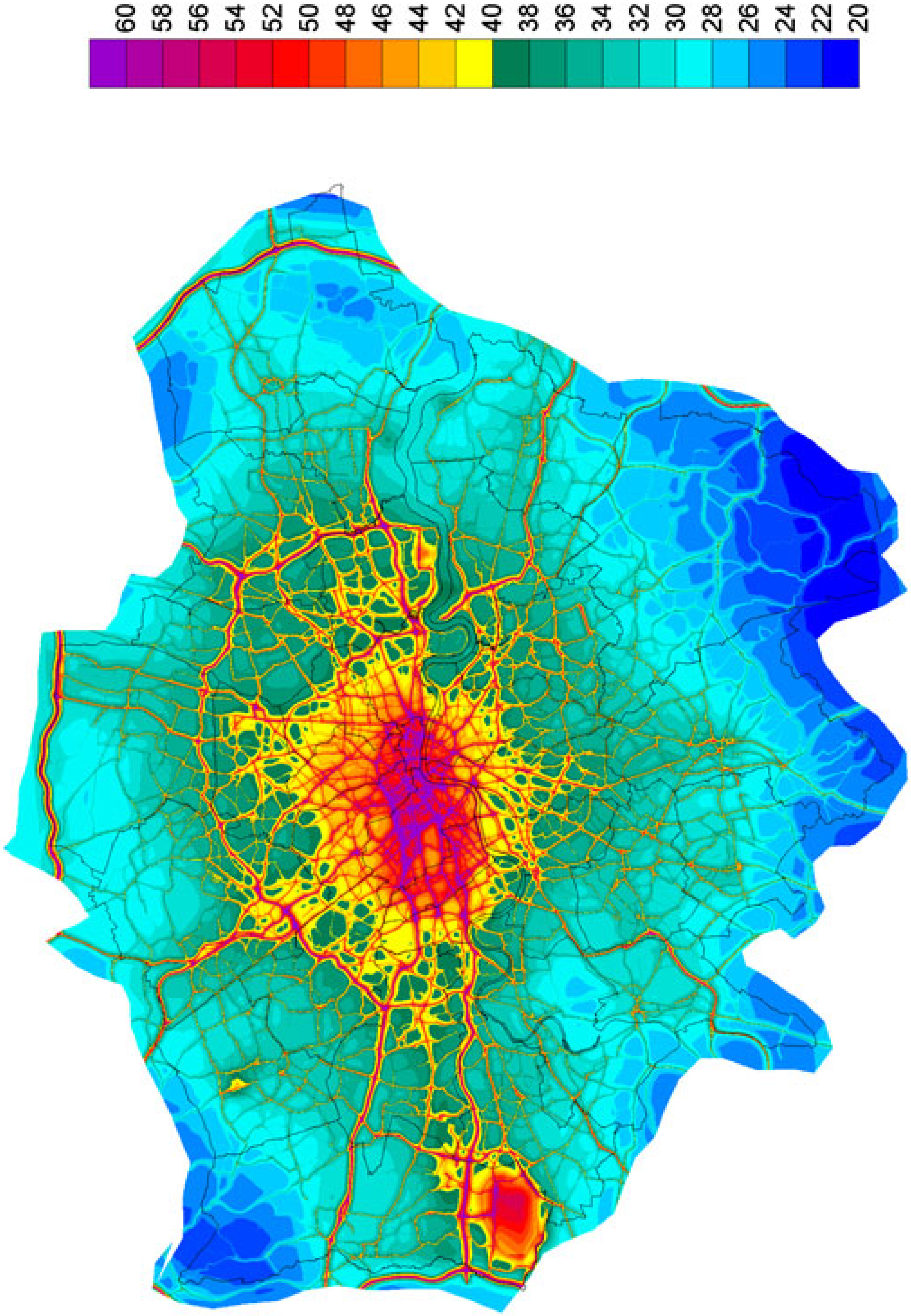

Figure 5 Provisional Annual Mean NO_2 Concentrations 2001 (μgm^{-3}).

Figure 6 and Figure 7 show the annual mean NO_2 at the background sites across the network that have achieved greater than 75 % data capture. Sites with a data capture between 75 % and 90 % have been included in the following comparisons and are indicated with an asterisk in each figure. The distribution of annual means reflects that in Figure 5. The highest annual means were measured at Heathrow (56 μgm^{-3}) and at sites in inner London including Southwark 1 (54 μgm^{-3}), West London and Wandsworth 2 (52 μgm^{-3}). Background sites exceeding the objective are largely in inner and west London.

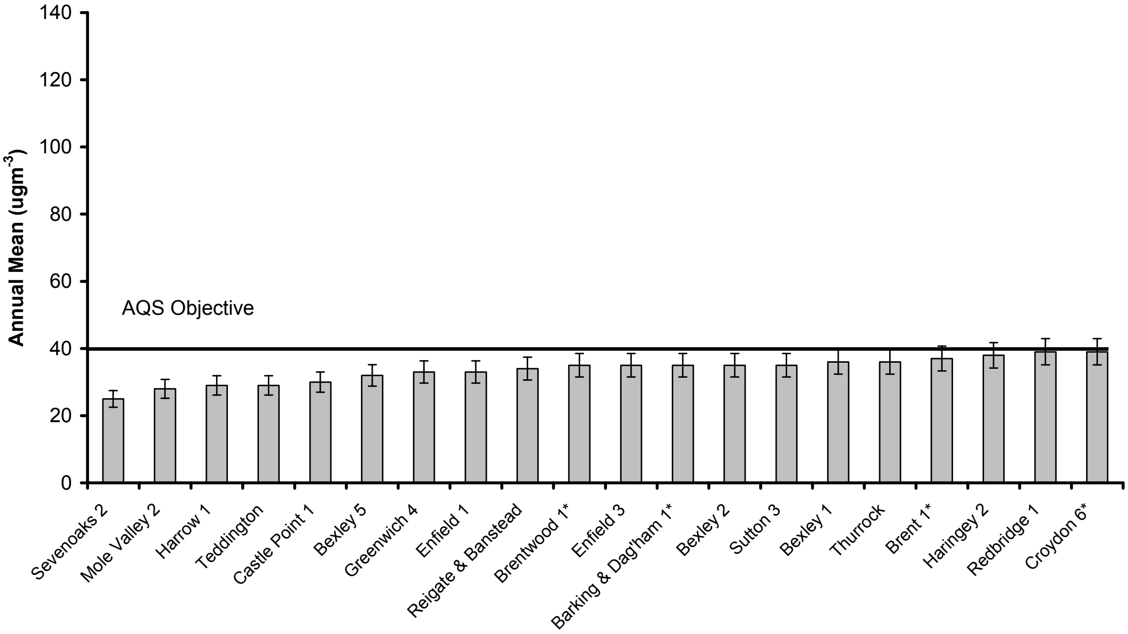

Figure 6 Background Annual Mean NO_2 (2001)

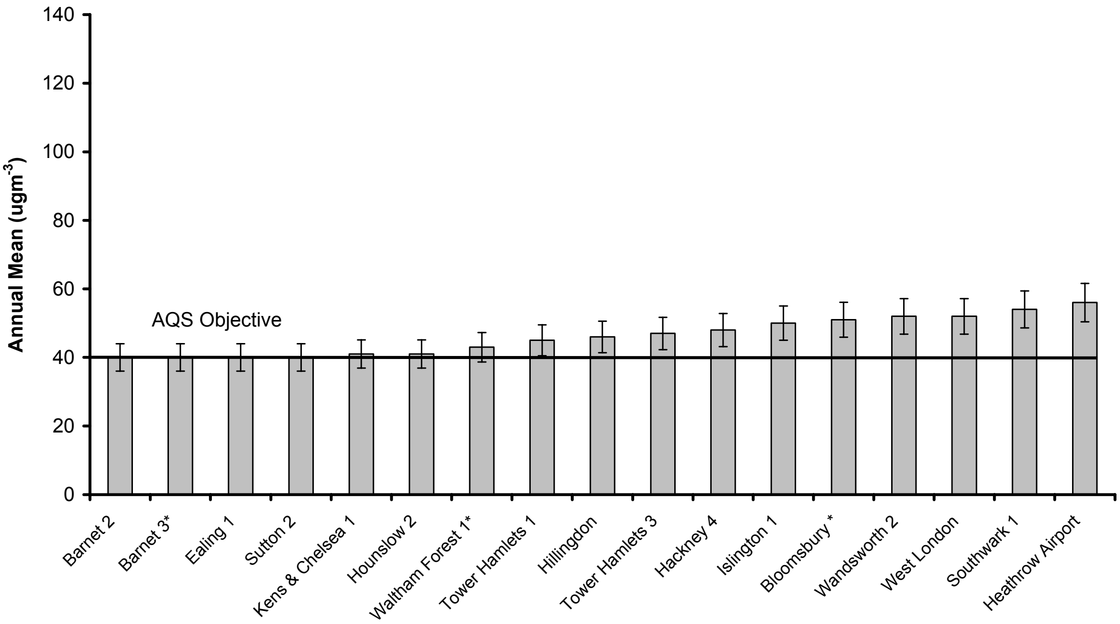

Figure 7 Background Annual Mean NO_2 (2001)

The annual mean NO_2 at kerbside and roadside sites is shown in Figure 8 and Figure 9. The highest annual mean NO_2 was measured at the Redbridge 2 site, which is located on a traffic island in the middle of a busy junction where public exposure is transient. All kerbside and roadside sites exceeded the AQS annual mean objective.

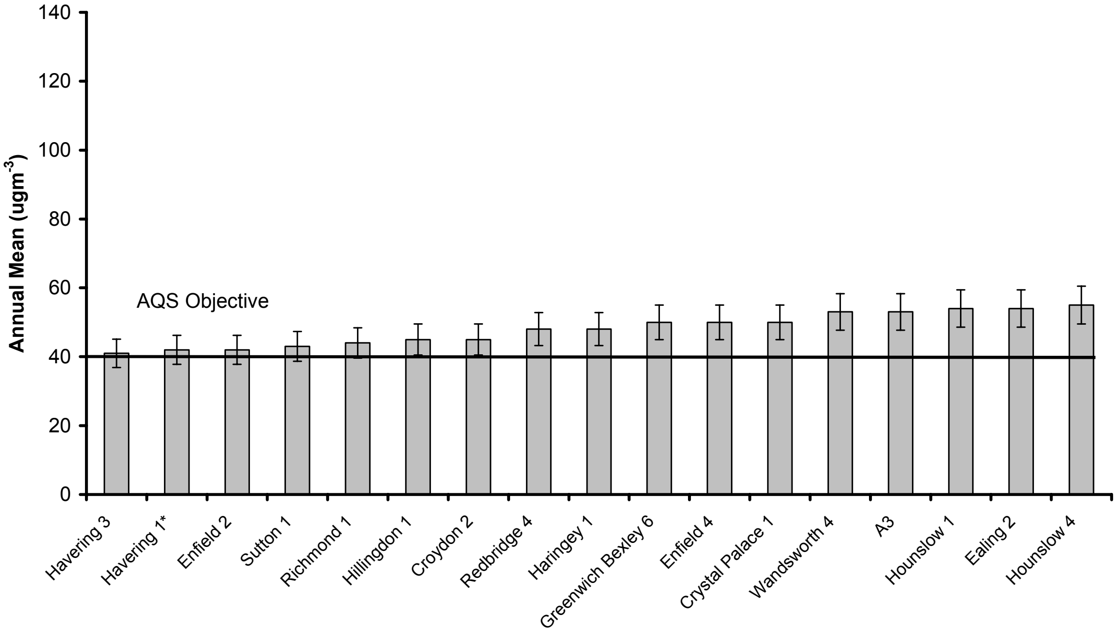

Figure 8 Kerbside and Roadside Annual Mean NO_2 (2001)

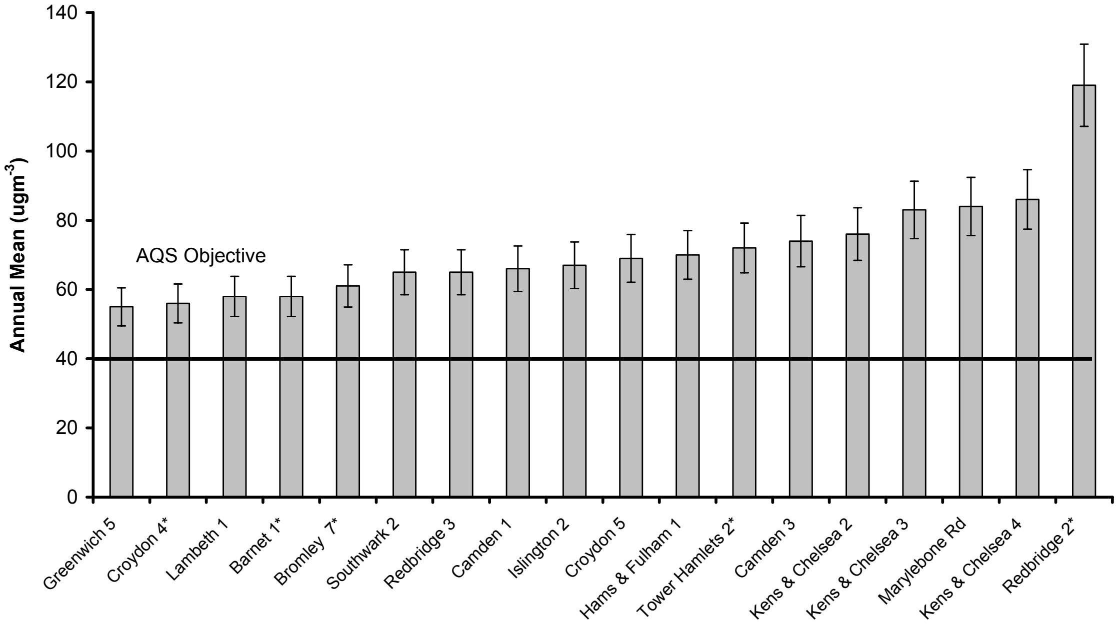

Figure 9 Kerbside and Roadside Annual Mean NO_2 (2001)

The AQS also has an incident based objective for NO_2. Measurements during 2001 are compared to this objective in Figure 10 for the sites that approached the objective during the year. The kerbside site Redbridge 2 measured 826 exceedences. This site is located on a traffic island in the middle of a busy junction where public exposure is transient. The objective was also exceeded at the kerbside sites at Marylebone Road and Redbridge 3 and at the roadside site Kensington & Chelsea 3. The objective was also exceeded at Brent 2, beside the North Circular Road, on the basis of a data capture of only 41 %. Within the limits of measurement uncertainty, 5 further roadside sites may have exceeded the objective; Kensington and Chelsea 4, Tower Hamlets 2, Croydon 5, Hammersmith and Fulham 1 and Kensington and Chelsea 2 (Cromwell Road).

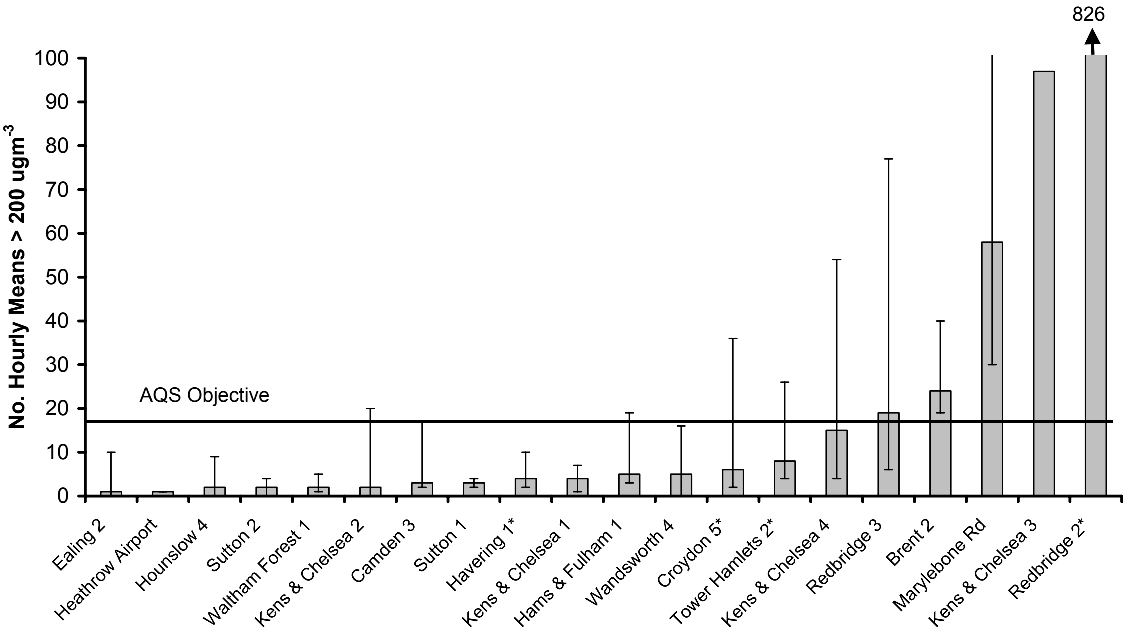

Figure 10 AQS Incident Based Objective for NO_2 (2001)

1.2.5 Ozone

O_3 is a seasonal pollutant with the highest concentrations being measured during the summer months. It is also a regional pollutant, with episodes extending over many hundreds of kilometres. O_3 exhibits significant local variation caused by the scavenging effect of NO close to NO_X emission sources, e.g. at the roadside. Exceedences of health-based standards are therefore not expected at roadside and kerbside sites and O_3 monitoring is not generally undertaken in these locations. Results from the LAQN are shown in Figure 11.

The AQS Objective is 100 μgm^{-3} (50 ppb), measured as a rolling 8 hour mean, which should not be exceeded on more than 10 days per year. The AQS Objective was exceeded at 16 LAQN background sites in outer London and in towns in South East England. Three further sites measured a possible exceedence within the limits of uncertainty.

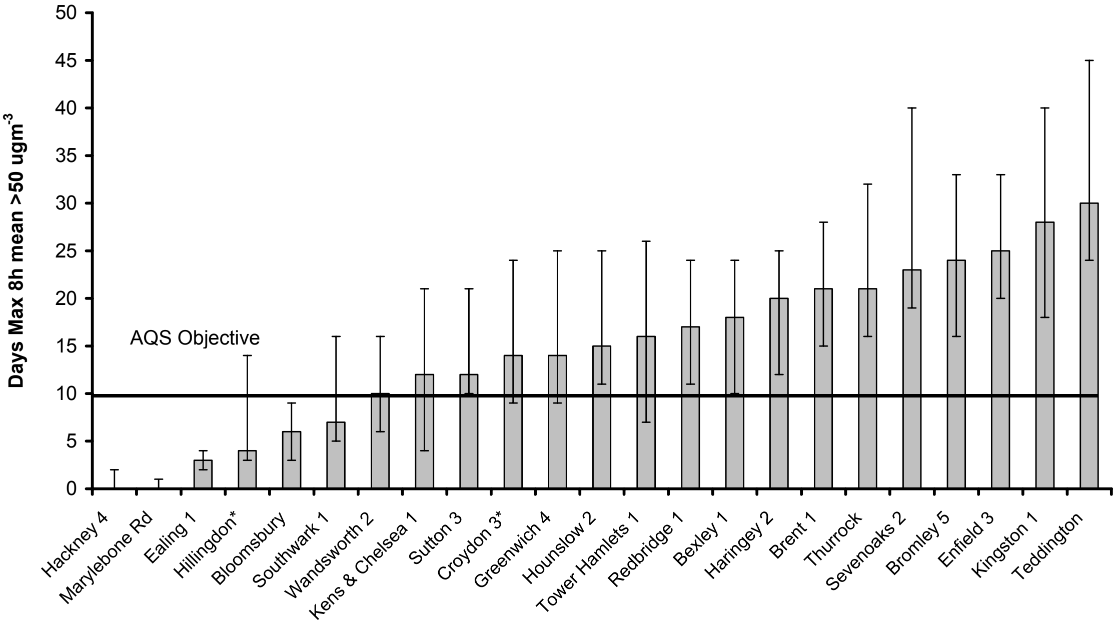

Figure 11 AQS O_3 Objective (2001)

1.2.6 PM_{10}

There are two AQS Objectives for PM_{10}. These are in line with the EU Daughter Directive Stage 1 Limit Value for PM_{10}. The AQS has an incident based objective of 50 μgm^{-3}, measured as a daily mean, not to be exceeded on more than 35 days per year, and an annual mean objective of 40 μgm^{-3}.

PM_{10} poses many measurement challenges. DETR (1999) recommends that a correction factor of 1.3 be applied to TEOM results for comparison to the AQS Objective. TEOM results from 2001, calculated on this basis, are shown in Figure 12 to Figure 15.

Beta Attenuation Monitors (BAM) are also used on the LAQN to measure PM_{10}. BAM measurements are shown in black in Figure 12 to Figure 15. Research at Marylebone Road (Green, 1999) sought to compare the results from TEOM, 'gravimetric' and BAM instruments. The BAM instrument tested produced higher results than the 'gravimetric' method at this location during the test period. However, no correction factor has been applied to the BAM measurements. Due to these methodological differences it has not been possible to make an uncertainty estimate for PM_{10} measurements.

PM_{10} concentrations associated with Guy Fawkes Night 2001 were the highest measured during the last 7 years and led to widespread exceedence days (Fuller and Johnson 2002). Several sites were affected by local PM_{10} sources during 2001; principally the Bexley 4 site which is regularly affected by PM_{10} arising from vehicles accessing nearby industrial sites.

During 2001 the PM_{10} AQS incident based objective was exceeded at 11 sites. This is shown in Figure 12 and Figure 13.

The annual mean AQS Objective is shown in Figure 14 and Figure 15. The AQS annual mean objective was only exceeded at the kerbside site Marylebone Road and the roadside site Bexley 4.

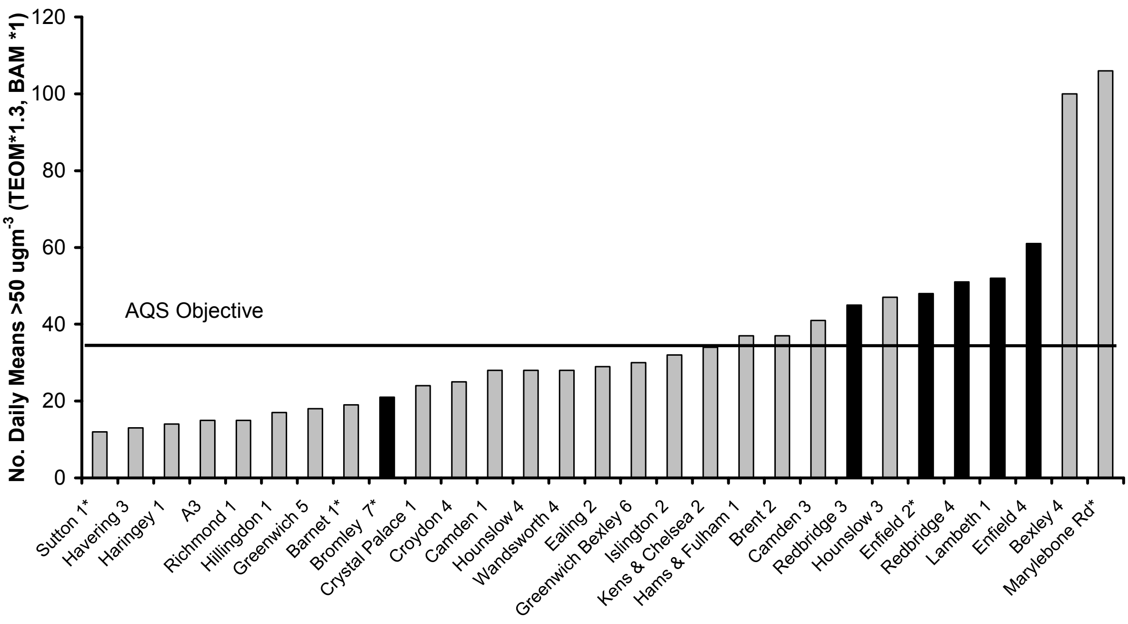

Figure 12 AQS Incident Based Objective for PM_{10} at Road and Kerbside Sites (2001). BAM Sites are shown in Black.

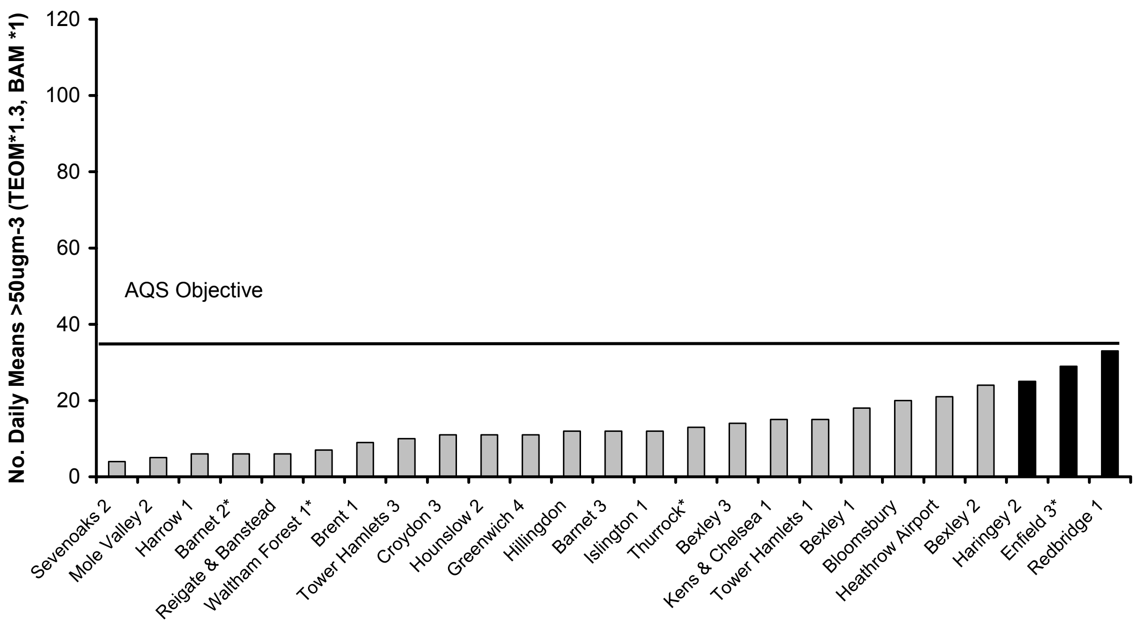

Figure 13 AQS Incident Based Objective for PM_{10} at Background Sites (2001). BAM Sites are shown in Black

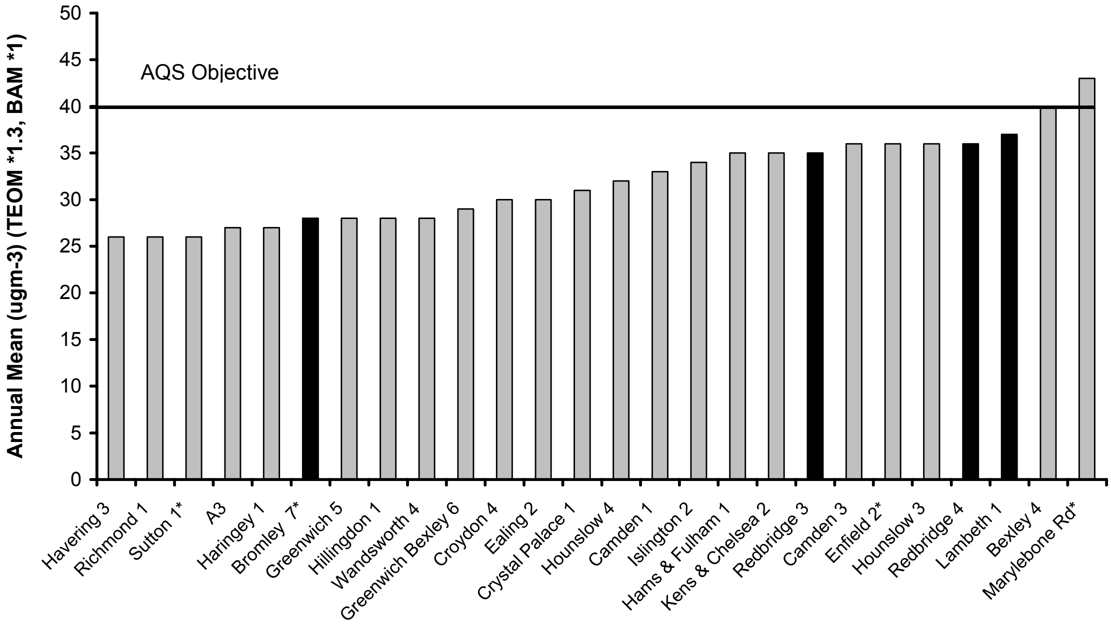

Figure 14 AQS PM_{10} Annual Mean Objective at Kerbside and Roadside Sites (2001)

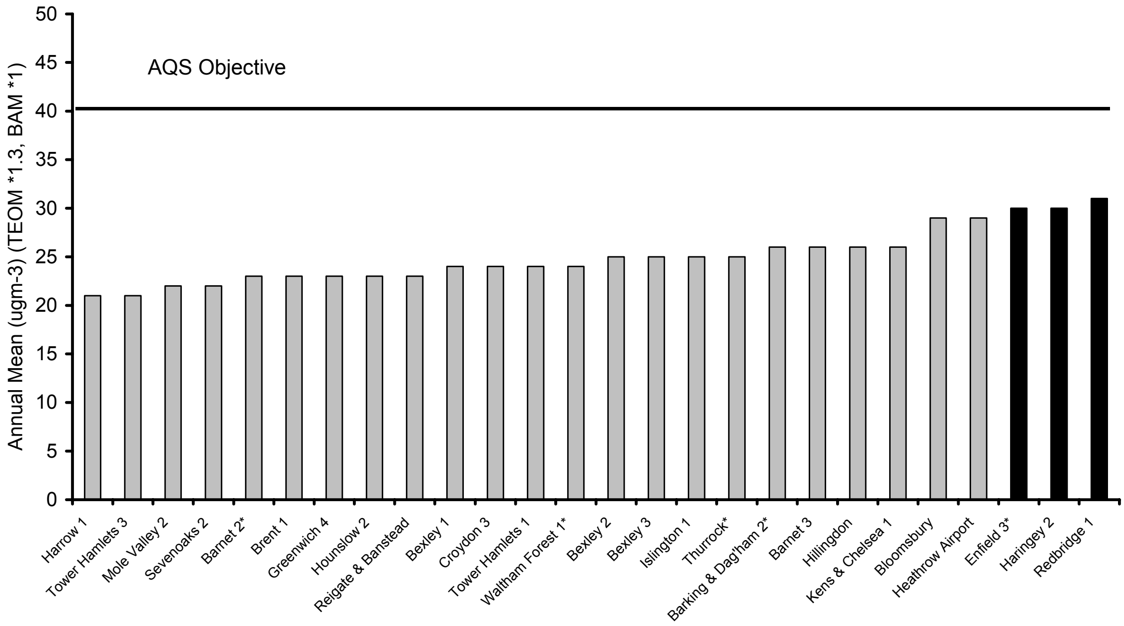

Figure 15 AQS PM_{10} annual mean objective at background sites (2001).

1.2.7 $PM_{2.5}$

$PM_{2.5}$ is a finer fraction of PM_{10} and $PM_{2.5}$ is not currently included in the AQS. The Expert Panel on Air Quality Standards (EPAQS 2000) has considered $PM_{2.5}$ and concluded that health evidence does not justify a separate $PM_{2.5}$ standard at this time. However, measurements of $PM_{2.5}$ are essential to the understanding of PM_{10}. Co-located measurements of PM_{10} and $PM_{2.5}$ are especially useful, providing valuable data for modelling PM_{10} in London and South East England (Fuller *et al* 2002). Co-located measurements are undertaken at several sites in the LAQN including the roadside sites Bromley 7 and Ealing 2, at Marylebone Road (where the $PM_{2.5}$ sampler is in a roadside position), and at the suburban sites Bexley 2 and Bexley 3. Co-located measurements are also undertaken at the Bloomsbury urban background site and $PM_{2.5}$ alone is measured at Hackney. Figure 16 shows the annual mean $PM_{2.5}$ for all sites attaining 90% data capture (no correction factor has been applied). The majority of PM_{10} measured at each site is $PM_{2.5}$ The ratio of $PM_{2.5}$ to PM_{10} is greatest at roadside sites, as might be expected from the higher proportion of primary particulate emissions at these locations. The fraction of PM_{10} that is $PM_{2.5}$ ranges between 58 % at Bexley 3 to 76 % at Marylebone Road.

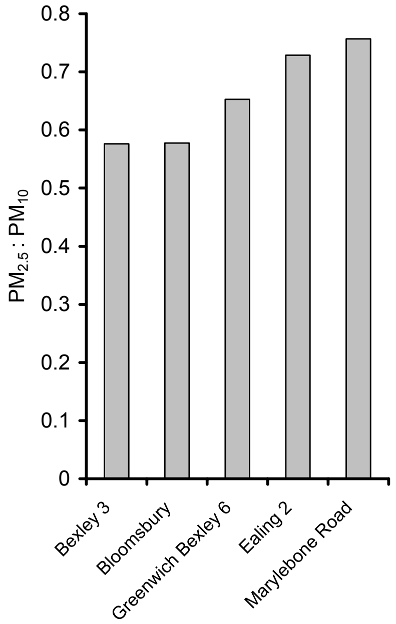

Figure 16 Ratio of Annual Mean $PM_{2.5}$ to PM_{10} (2001)

1.2.8 Sulphur Dioxide

The distribution of SO_2 concentrations in 2001 provides further evidence of the influence of both road traffic and industrial point sources. Road traffic sources are the main factor influencing annual mean concentrations, whereas industrial point sources produce short term high values due to plume grounding. This is discussed in Air Quality in London in 1995, The Third Report of the London Air Quality Network (SEIPH-ERG, 1996). The annual mean concentrations of SO_2 do not vary to any substantial degree over the network.

The 15 minute mean AQS Objective for SO_2, based on 35 exceedences of 350 μgm^{-3} (100 ppb), was not approached at any site in the network. Six sites measured exceedence periods; Bexley 1, Enfield 3, Enfield 4, Lambeth 1, Tower Hamlets 3 and Thurrock 1. The largest number of exceedence periods (10) was measured at Tower Hamlets 3 and were due to local source. The hourly and daily mean objectives were not exceeded.

1.2.9 Benzene and 1,3 Butadiene

The main atmospheric source of benzene is the distribution and combustion of petrol, whereas 1,3 butadiene is mainly derived from petrol combustion. Both benzene and 1,3 butadiene are measured at the kerbside at Marylebone Road and at the roadside at Tower Hamlets 2. During 2001 the annual means were below the AQS objectives for 2003. Both pollutants are also measured by the National Hydrocarbon Network at Haringey 1 where the AQS Objectives for benzene was comfortably met.

King's College London

University of London

Quality Assurance, Quality Control and Uncertainty in Air Quality Measurements

QUALITY ASSURANCE, QUALITY CONTROL AND UNCERTAINTY IN AIR QUALITY MEASUREMENTS

2.0 Introduction

The purpose of this section is to explain the quality assurance and quality control methods used to produce the air quality measurements in this and future reports, and to discuss the uncertainty typically associated with each result.

2.1 Importance of Quality Assurance / Quality Control

Quality assurance (QA) and quality control (QC) procedures are essential to air quality monitoring to ensure that the measurements are accurate and reliable.

To achieve this the QA/QC standard must therefore ensure;

- consistency in time so that data can be fairly compared from day to day, or from year to year, thereby enabling trends to be assessed.
- consistency between sites so that data from one site can be compared to its neighbours.
- that data are accurate and traceable to National and International Standards to allow measurements to be compared to air quality objectives, limit values and measurements produced by other networks.
- that uncertainty is kept to a minimum and quantifiable to put results in context; to judge whether a change or difference is significant and a reflection of a real effect, or is an artefact of a variation in the measurement method.

QA/QC are central to the running of air quality monitoring networks. Quality assurance procedures must be implemented and quality control checks made to measure their effectiveness. Procedures must therefore be defined that cover every aspect of the measurement process from the choice of equipment and site through to calibration procedures and the processing of data. A measurement cannot be used with confidence, or seen in context, unless its uncertainty can be estimated.

2.2 Quality Assurance and Quality Control Standards

The principal components of a QA/QC standard for air quality monitoring are discussed below.

2.2.1 Equipment Selection

Equipment must be capable of achieving the aims of the monitoring exercise. To ensure this, the analysers used at each site may be subjected to a system of type testing where the performance of an example analyser is assessed. The performance of other peripheral and ancillary equipment; such as the sampling system, chart recorders and data loggers, should also be specified.

2.2.2 Site Selection

A site must be placed in a location representative of its monitoring aims and be free from interfering local sources. Consistent site selection allows meaningful comparison to be made between different sites and different site types. Site selection also needs to address practical and safety issues.

2.2.3 Regular Calibration

Regular calibration is necessary to quantify response characteristics and to ensure adequate performance of analysers. Tests are usually zero and single point spans. The calibration gases employed must be traceable to National Standards.

2.2.4 Equipment Performance Audit

Equipment performance audits should carried out to undertake in depth tests that may not be economically or practically undertaken during regular calibrations.

2.2.5 Intercalibration

By taking a single calibration source around each of the sites in a network, an assessment of the consistency of results between each site can be made. Intercalibration can also act as a check on the regular calibrations and regular calibration gas sources.

2.2.6 Measurement Validation

Measurements are processed and checked, ideally each day, to ensure that faults are identified rapidly and the measurements are as accurate as possible given the information currently available.

2.2.7 Measurement Ratification

Validated measurements are re-examined and recalculated in blocks of 3 or 6 months. Additional information is taken into account including the calibration continuity and the results of performance audits. Equipment performance can be interpolated between calibration checks allowing a more accurate calculation of pollution measurements.

2.2.8 Equipment Maintenance, Repair and Service

Preventative maintenance and servicing by a competent organisation is necessary to ensure the consistency of performance and undertake repair in case of equipment failure. High data capture is necessary to ensure that results are representative of varying ambient conditions.

2.2.9 Organisation Separation

It can be desirable to have an independent QA/QC unit to define and oversee the implementation of a QA/QC standard. This division of responsibilities is employed on the AURN. Alternatively, an independent organisation may be employed to carry out equipment performance audits and intercalibrations.

QA/QC in the LAQN

Poor and inconsistent QA/QC in local authority air pollution measurements was one of the key drivers behind the formation of the LAQN and the publication of the London Standard in 1993 (Beevers *et al* 1993). The LAQN has promoted good QA/QC practice in London and the vast majority of sites now have demonstrable traceabilty to National Metrological Standards. For AURN affiliated sites this is achieved as part of the QA/QC for that network. QA/QC procedures elsewhere on the LAQN are very similar to those of the AURN.

The traceability of each measurement to National Metrological Standards is provided by regular calibration with traceable gas sources and independent site equipment audits undertaken by the National Physical Laboratory (NPL) and AEAt plc. As in the AURN, the QA/QC procedure involves the real time scaling and validation of measurements according to the most recent good calibration and retrospective ratification using audit results and the establishment of equipment calibration histories.

Nationally, QA/QC guidelines for local authority air pollution measurement have been have outlined as part of the Guidelines for Local Authority Air Quality Management (DEFRA 2002). At a European level,QA/QC procedures for measuring air pollution against the EU Limit values are being drawn up by the European Committee for Standardisation (CEN) Technical Committee CEN / TC 264 (eg CEN 2001).

2.3 Uncertainty Associated with Air Quality Data

Uncertainty is associated with every type of measurement. Errors may be random or systematic affecting precision and accuracy respectively.

For example, consider the simple task of measuring the length of a piece of wood using a ruler. If repeated a number of times, using the same ruler, this would produce different results induced by a variety of sources such as the exact position of the end of the wood and ruler and human judgement. This would produce a spread of results about a mean figure with random errors. Repeating the measurements many times over, and averaging the results, may reduce this effect.

The ruler used for the measurement is simply a set of marks along a fairly straight edge, determined from a template established from another ruler which will have been produced from another ruler and so on until the ruler is (hopefully) traceable to the primary standard metre. Errors will be involved at each production stage. The more stages, the greater the uncertainty associated with the accuracy of the ruler. If the marks on the ruler are wider spaced than they should be, then this type of error will remain no matter how many times the measurement is repeated. This is a systematic error that will affect the accuracy of the measurement.

The uncertainty associated with a measurement is a combination of both accuracy and precision. A QA method should ensure that uncertainty is kept to a practical minimum and the expected error should be specified.

The measurement of air quality is, however, complex with accuracy and precision errors being introduced from a large number of sources.

2.4 Estimates of Uncertainty

Estimates of uncertainty can be made by calculation and by testing. Estimates of uncertainty for LAQN measurements are discussed below. A maximum uncertainty of 15 % is required for assessment of the EU Limit Values for NO_2, SO_2, CO and O_3 (e.g. 2000/69/EC) at the limit value concentration.

2.4.1 Calculation

Ratified measurement uncertainty has recently been calculated for 16 of the affiliated AURN sites in London by NPL. Based on actual or representative measurements, the estimated uncertainty (2σ) lies between 8 % and 15 % at the EU Limit Value, with the majority of datasets being between 9 % and 12 % (Woolley *et al* 2002).

Calculated estimates of uncertainty are discussed in the AUN Site Operator's manual (Bower *et al* 1996). Accuracy and precision have been calculated by reviewing the calibration chain and looking at measured instrument characteristics, both in service and in laboratory conditions. Some factors are readily quantifiable whist others are more difficult to assess. Accuracy estimates for the AURN (2σ) are between 8 % (for CO) and 11 % for (NO_2 and O_3).

The ERG has calculated estimates of best possible accuracy for typical analysers used to measure CO, NO_X and SO_2 in the LAQN. The measurement uncertainty is estimated at 5 % to 7 % (2σ) at high concentrations. Several operational factors have not been included and these figures are likely to be under estimates. The pollutants examined by the ERG are the simple inorganic species. The uncertainty associated with NO_2 is more complex since it is not measured directly in a chemiluminescent NO_X analyser.

2.4.2 Calculation of PM_{10} Uncertainty

PM_{10} poses many measurement challenges.

Rather than comprising a single, defined chemical compound, the composition of PM_{10} varies with location, time of year and meteorological conditions. PM_{10} can be considered to comprise of primary particulates (mainly emitted from local sources), secondary particulates (mainly from distant sources), and coarse particulates whose origin can be local or distant. It is therefore not possible to produce a calibration source for PM_{10} measurement equipment and their accuracy cannot be measured. However, the main instrument components are routinely calibrated. These components include mass flow controller and TEOM mircrobalances.

The variation in composition also affects each measurement technique differently and therefore each measurement technique produces systematically different results. The EU Daughter Directive is based on a ‘gravimetric’ method where PM_{10} is collected on a filter that is then weighed in a laboratory (CEN, 1998). There is ample evidence to suggest that the most common measurement methodology employed in the UK, the TEOM, produces a result lower than the ‘gravimetric’ method (APEG, 1999; Green 1999; Green *et al*., 2000). DETR (1999) suggests that a correction factor of 1.3 be applied to TEOM results for comparison to the AQS Objective, although it is acknowledged that this correction factor may be both seasonally and locality dependent.

Although it is not possible to provide good estimates of the uncertainty associated with PM_{10} measurements, PM_{10} measurements by TEOM show good correlation across all of the air quality networks managed by the ERG in South East England. Furthermore, these relationships have been consistent since 1995 (Fuller *et al* 2001). TEOM measurements may therefore be used with confidence to show changes in the concentration of the PM_{10} components measured by this technique, and to compare measurements at different sites.

Co-location experiments have been used to measure the precision of TEOM measurements in the field. The TEOM precision from these tests has been found to be around $4\mu gm^{-3}$ (Bower *et al* 1996).

2.4.3 Measurements of Uncertainty

The majority of non AURN sites in the LAQN, and neighbouring ERG operated networks, are subject to audit and calibration on a twice yearly basis by NPL. Allowing for obvious analyser faults, the recent audit results from gas analysers suggest that an accuracy ±10 % is being achieved at around 90 % of sites for validated measurements. The uncertainty (2σ) in the accuracy of validated measurements is around 17 % across the network as a whole, but analyser outliers adversely affect this. It must be remembered that the audit process itself has an uncertainty, expanding the estimates of the overall measurement uncertainty, although there is no evidence of overall test or network bias.

Results from the audits are used for measurement ratification, reducing measurement uncertainties in the final dataset. This suggests that uncertainties (2σ) of better than ±10 % are being achieved at the vast majority of sites and supports the uncertainty estimates derived by calculation.

2.4.4 Implications of Uncertainty in Air Quality Results

The previous paragraphs discuss how uncertainty is a combination of accuracy and precision.

Precision will have significant affect at low concentrations with short averaging times. If measurements are averaged over a longer period the effects of precision errors, assumed to be random, reduce and the affect of the accuracy becomes more significant. Similarly, at high concentrations the accuracy is of greater significance.

Air quality monitoring results are typically reported as comparisons to AQS Objectives or EU Limit Values. These mainly relate to relatively high measurements, measurements averaged over a long period, or a combination of both. In all of these cases it is the accuracy that is most significant in determining the overall uncertainty. The estimates of uncertainty produced by calculation and audit suggest an uncertainty of ±10 % as a good working figure to be considered when comparing measurements to AQS Objectives and EU Limit Values.

Standards and guidelines based on a specified number of exceedences are affected differently due to the distribution of the data. A ±10 % uncertainty in air quality measurement does not correspond to a ±10 % uncertainty in the number of exceedences. This uncertainty range is dependent on the distribution of the results. The range is different for each site and is often far greater than 10 % of the number of exceedence days. This distribution will have a substantial effect on the inter-annual variability of exceedence statistics.

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LAQN MONITORING SITES 2001

APPENDIX 1: LAQN MONITORING SITES 2001

A.1.0 Details of Monitoring Sites

The following tables detail the pollution monitoring sites in the LAQN at the end of 2001. The start date of each site is shown along with the pollutants monitored and the data quality. In some cases a monitoring site was not operating during 2001. The availability of data from a site is indicated in the tables below.

Specific information for each site is available on our web site; www.erg.kcl.ac.uk

Sites are divided into a number of categories dependent on their location;

- Kerbside sites are those with sampling locations within 1 m of the kerbside and with a sampling height of 3 m or less.
- Roadside sites are those with sampling locations within 1-5 m of the roadside and with a sampling height of 3 m or less.
- Urban background sites are located to represent pollution conditions in the centre of an urban area. Sampling locations are away from the influence of individual pollution sources; 25 m from major roads for example.
- Suburban sites are typical of residential locations on the edge of a build up area. Sampling locations are away from the influence of individual pollution sources; 25 m from major roads for example.

A.1.1 Kerbside Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Barnet 1	Dec 98		•			**T**		**Yes**	**
Bromley 4	Feb 96	Closed Jul 1998							
Camden 1	Apr 96		•			**T**		**Yes**	** **A1**
Marylebone Road	Jun 97	•	•	•	•	**TG**	•#	**Yes**	** **A1**
Redbridge 2	Dec 99	•	•					**Yes**	*
Redbridge 3	Dec 99		•			**B**		**Yes**	*
Richmond 5	Feb 01	•	•	•	•	**T**		**Yes**	**

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A1= Affiliated to UK AURN – Ratified Data supplied to LAQN by NPL - final data set published by DEFRA
A2= Affiliated to UK AURN – final data set published by DEFRA
 # = The $PM_{2.5}$ sampler is located in a roadside position.

A.1.2 Roadside Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Bexley 4	May 99		(●)			**T**		**Yes**	**
Brent 2	Jun 01		●	●		**T**		**Yes**	**
Bromley 7	July 98	●	●			**B**	**B**	**Yes**	*/****A1**
Camden 3	Apr 00		●			**T**		**Yes**	**
Croydon 2	Sept 94		●					**Yes**	**
Croydon 4	Sept 99		●	●		**T**		**Yes**	**
Croydon 5	Oct 00		●					**Yes**	**
Crystal Palace	Oct 99	●	●	●		**T**		**Yes**	**
Ealing 2	Sept 96	●	●			**T**	**T**	**Yes**	**
Ealing 4	Dec 98	Closed Mar 99							
Ealing 5	Mar 99		●	●		**T**		**Yes**	**
Enfield 2	Jan 98	●	●			**B**		**Yes**	**
Enfield 4	Mar 00		●	●		**B**		**Yes**	**
Greenwich 5	Sept 97		●			**T**		**Yes**	*
Greenwich Bexley	Oct 00		●			**T**	**T**	**Yes**	**
Hams & Fulham 1	Aug 99		●	●		**T**		**Yes**	**
Haringey 1	Dec 94		●	●		**T**		**Yes**	** **A1**
Haringey 3	Apr 99		●	●		**B**		**Yes**	**
Havering 1	Dec 95		●					**Yes**	**
Havering 3	Dec 98		●	●		**T**		**Yes**	**
Hillingdon 1	Sept 99		●			**T**		**Yes**	**
Hounslow 1	Apr 93	●	●		(●)			**Yes**	** **A1**
Hounslow 3	Mar 99					**T**		**Yes**	**
Hounslow 4	Aug 99		●	●		**T**		**Yes**	**
Islington 2	Jul 00	●	●			**T**		**Yes**	**
Ken & Chelsea 2	May 98					**T**		**Yes**	**
Ken & Chelsea 3	Mar 00		●					**Yes**	**
Ken & Chelsea 4	Sep 00		●					**Yes**	**

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A1= Affiliated to UK AURN – Ratified Data supplied to LAQN by NPL - final data set published by DEFRA
A2= Affiliated to UK AURN – final data set published by DEFRA

A.1.2 Roadside Sites (continued)

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Kingston 2	Apr 96		●			**T**		**No**	
Lambeth 1	Sep 00		●	●		**B**		**Yes**	∗
Lambeth 2	Dec 01		●	●		**B**		**Yes**	∗
Redbridge 4	Dec 99	●	●	●		**B**		**Yes**	∗
Richmond 1	Jun 00		●			**T**		**Yes**	∗∗
Southwark 2	Oct 94	●	●	●		**T**		**Yes**	∗/∗∗**A1**
Sutton 1	May 95	●	●	●		**T**		**Yes**	∗∗ **A1**
Tower Hamlets 2	Mar 94	●	●					**Yes**	∗∗ **A1**
Wandsworth 1	Sept 94	Closed Mar 1996							
Wandsworth 4	Feb 98	●	●			**T**		**Yes**	∗∗
Waltham Forest 2	Jul 98		●	●		**T**		**Yes**	∗
Westminster 2	Jun95	Last data 1995							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, ∗Locality Standard, ∗∗Traceability to National Standards
A1= Affiliated to UK AURN – Ratified Data supplied to LAQN by NPL - final data set published by DEFRA
A2= Affiliated to UK AURN – final data set published by DEFRA

A.1.3 Urban Background Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Barnet 2	Aug 00		●			**T**		**Yes**	**
Barnet 3	Aug 00		●			**T**		**Yes**	**
Brent 1	Aug 95	●	●	●	●	**T**		**Yes**	* **A2**
Brent 3	Dec 01		●	●		**T**		**Yes**	**
Bromley 1	Jan 93	Closed Feb 96							
Castle Point	May 96		●	●				**Yes**	**
City of London 1	Oct 01		●	●	●			**Yes**	*
Croydon 3	May 96				●	**T**		**Yes**	**
Ealing 1	Mar 95	(●)	●	●	●			**Yes**	**
Enfield 3	Nov 98	●	●	●	●	**B**		**Yes**	**
Greenwich 4	Sept 93		●	●	●	**T**		**Yes**	** **A1**
Hackney	Oct 93	●	●		●		**T**	**Yes**	*/****A1**
Heathrow	Mar 99	●	●			**T**		**Yes**	*
Hillingdon (O)	Oct 94	Last Data Apr 95							
Ken & Chelsea 1	Mar 95	●	●	●	●	**T**		**Yes**	****A1**
Islington 1	Sep 94	(●)	●			**T**		**Yes**	**
Lambeth 3	Dec 01		●	●		**B**		**Yes**	*
Lewisham	Jan 95		●	●	●			**Yes**	****A1**
Mole Valley 3	Oct 01		●			**T**		**Yes**	**
Redbridge 1	Dec 99		●		●	**B**		**Yes**	*
Sevenoaks 2	Feb 98	●	●	●	●	**T**		**Yes**	**
Southwark 1	Mar 93	●	●	●	●			**Yes**	****A1**
Thurrock	Feb 95	●	●	●	●	**T**		**Yes**	***A2**
Tower Hamlets 1	Jan 94		●	●	●	**T**		**Yes**	**
Tower Hamlets 3	Oct 99		●	●		**T**		**Yes**	**
Waltham Forest 1	Jul 98		●	●		**T**		**Yes**	**
Wandsworth 2	Oct 94	●	●	●	●			**Yes**	****A1**
Westminster 1	Jan 93	Last Data 1996							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, *Locality Standard, **Traceability to National Standards
A1= Affiliated to UK AURN – Ratified Data supplied to LAQN by NPL - final data set published by DEFRA
A2= Affiliated to UK AURN – final data set published by DEFRA

A.1.4 Suburban Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Bark & Dag 1	Sep 1993		●	●				**Yes**	∗∗
Bark & Dag 2	Oct 99					**T**		**Yes**	∗∗
Bexley 1	Jan 93	●	●	●	●	**T**		**Yes**	∗**A2**
Bexley 2	Jan 98		●			**T**	**T**	**Yes**	∗∗
Bexley 3	Jan 98					**T**	**T**	**Yes**	∗∗
Bexley 5	Nov 99	●	●	●				**Yes**	∗∗
Brentwood 1	Aug 95		●					**Yes**	∗∗
Bromley 5	Mar 96				●			**Yes**	∗∗
Croydon 6	Jan 01		●					**Yes**	∗∗
Enfield 1	Jul 95		●					**Yes**	∗∗
Haringey 2	Apr 96		●		●	**B**		**Yes**	∗∗**A1**
Havering 2	Apr 98	Closed Nov 2000							
Harrow	Apr 99		●	●		**T**		**Yes**	∗∗
Hounslow 2	Apr 99		●	●	●	**T**		**Yes**	∗∗
Kingston 1	Mar 96				●			**Yes**	∗∗
Mole Valley 2	Apr 97		●			**T**		**Yes**	∗∗
Reigate & Bans 1	Jul 00		●			**T**		**Yes**	∗∗
Richmond 2	Apr 01		●			**T**		**Yes**	∗∗
Sutton 2	May 95		●					**Yes**	∗∗
Sutton 3	May 95		●		●			**Yes**	∗∗**A1**
Wandsworth 3	Oct 94	Closed Nov 2000							

A.1.5 Rural Sites

	Start	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$	Data	Quality
Mole Valley 1	Mar 96	Closed Mar 1999							
S'oaks Scudders H	Sept 95	Closed Sept 1997							

Key: T =TEOM, B=Beta Attenuation, G= Gravimetric, ∗Locality Standard, ∗∗Traceability to National Standards
A1= Affiliated to UK AURN – Ratified Data supplied to LAQN by NPL - final data set published by DEFRA
A2= Affiliated to UK AURN – final data set published by DEFRA

A.1.6 Principal Site Changes During 2001

- A NO_2 analyser was temporarily installed at the Bexley 4 roadside site. The analyser was operated from July to October as part of a local PM_{10} source apportionment study.

- The Brent 2 site joined the LAQN during June. The site monitors NO_2, SO_2 and PM_{10} (TEOM). The site is located in the grounds of the IKEA store and is strategically placed alongside a residential section of the A406 North Circular.

- Brent 3, an urban background site in Harlesden, joined the network at the start of December. The site monitors NO_2, SO_2 and PM_{10} (TEOM). The site will provide valuable information about air pollution in the borough and increase the LAQN's spatial resolution in north west London.

- The Brentwood suburban site rejoined the LAQN in April 2002. Ratified measurements from 1999 to 2002 have been made available to the LAQN database thereby maintaining the continuity of this site in the network. Measurements from 2001 are published in this report.

- City of London 1 joined the network during October. The site is in an urban background location on the roof of an office building and measures NO_2, O_3 and SO_2. Although new to the LAQN the site has operated for around 10 years. The site was installed as part of National Power's Thameside Network but has been operated by the Corporation of London in recent years. Urban background sites in central London will be essential to the understanding of the capital's most serious urban air pollution problems.

- The Croydon 6 site joined the network during January. The site is located on a quiet residential street and is designed to monitor the impact of a new gas fired power station in the borough. The site is funded by Croydon Energy Ltd. The traffic volumes in the adjacent street are low and the site has been classified as suburban.

- An SO_2 analyser was installed at the Hammersmith and Fulham roadside site during May.

- Lambeth 2 roadside site became part of the LAQN at the end of December. The site is situated on Vauxhall Cross and will provide valuable measurements to assess the pollution concentrations alongside major roads in inner London. The site is also on the boundary of the Mayor's congestion charging zone. The site measures NO_2, SO_2 and PM_{10} (BAM).

- Lambeth 3 urban background site also joined the LAQN during December. The site is located in Loughborough Junction and will provide valuable information about air pollution in the borough, increasing the LAQN's spatial resolution in south London. The site measures NO_2, SO_2 and PM_{10} (BAM).

- The Mole Valley 3 site began operation during October. The site is located in an urban background location in the centre of Dorking and measures NO_2 and PM_{10} (TEOM). The site will provide valuable measurements to support the air quality review and assessment process in the district and will complement the existing Mole Valley 2 site in nearby Lower Ashtead. The influence of London's air pollution extends far beyond the M25. Sites such as Mole Valley 3 are essential to characterise air pollution in the south east as a whole. Furthermore, the site will assist in the understanding of pollution in towns in the South East England. This will for instance assist in differentiating between urban and airport pollution measured at the nearby Reigate and Banstead site, adjacent to Gatwick Airport.

- The Richmond 2 suburban site became operational at the start April. The site is located in Barnes Wetlands Centre and monitors NO_2 and PM_{10} (TEOM). The site will be especially useful in assessing the influence of emissions from inner London, Heathrow and the A4/M4 on background concentrations in the east of the borough and in west London.

- A PM_{10} (TEOM) instrument was installed at the Southwark 2 roadside site during August.

- The Richmond 5 site joined the LAQN in February. The site is located in a kerbside location in Twickenham and monitors CO, NO_X, O_3, PM_{10} (TEOM) and SO_2. Uniquely, the site contains two NO_X analysers to investigate the difference in NO_2 concentration at two different sampling heights.

- Measurements from the Waltham Forest 2 site have been retrospectively ratified and are now available to the LAQN database. Measurements from the first 10 months of 2001 are published in this report. It is hoped that the site will become fully integrated into the LAQN during 2003. The site monitors NO_X, SO_2 and PM_{10} (TEOM) and is located in a roadside location on Grove Green Road (A106) in the south of the borough. The site is near the M11 and A12.

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DEFRA DIRECTLY FUNDED SITES

APPENDIX 2: DEFRA DIRECTLY FUNDED SITES

A.2.0 Roadside Sites

	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$
A3	●	●			T	
Cromwell Rd	●	●	●		#	

A.2.1 Background Sites

	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$
Bloomsbury	●	●	●	●	T	T
Hillingdon	●	●	●	●	T	
Teddington		●	●	●		
Westminster	●	●	●	●	G	
West London	●	●				

# Reported as LAQN site Kensington & Chelsea 2.
T = TEOM. G = Gravimetric.

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SUMMARY OF RESULTS

APPENDIX 3: SUMMARY OF MONITORING RESULTS

A.3.0 Carbon Monoxide

Carbon Monoxide	Type	Capture Rate (%)	Days Moderate and Above
A3	R	98	0
Bexley 1	U	96	0
Bexley 5	S	90	0
Bloomsbury	U	93	0
Brent 1	U	99	0
Bromley 7	R	95	0
Crystal Palace 1	R	96	0
Ealing 2	R	96	0
Enfield 2	R	95	0
Enfield 3	U	94	0
Hackney 4	U	90	0
Heathrow Airport	U	93	0
Hillingdon	S	94	0
Hounslow 1	R	97	0
Islington 2	R	97	0
Kens & Chelsea 1	U	92	0
Kens & Chelsea 2	R	97	0
Marylebone Rd	K	96	0
Redbridge 2	K	91	0
Redbridge 4	R	87	0
Richmond 5	K	34	0
Sevenoaks 2	U	87	0
Southwark 1	U	97	0
Southwark 2	R	92	0
Sutton 1	R	98	0
Thurrock	U	95	0
Tower Hamlets 2	R	98	0
Wandsworth 2	U	95	0
Wandsworth 4	R	97	0
West London	U	98	0
Westminster	U	45	0

Carbon Monoxide	Type	No occurrences of rolling 8hr mean >=10mgm^{-3} (8.6ppb)	Achieved
A3	R	0	YES
Bexley 1	U	0	YES
Bexley 5	S	0	YES
Bloomsbury	U	0	YES
Brent 1	U	0	YES
Bromley 7	R	0	YES
Crystal Palace 1	R	0	YES
Ealing 2	R	0	YES
Enfield 2	R	0	YES
Enfield 3	U	0	YES
Hackney 4	U	0	YES
Heathrow Airport	U	0	YES
Hillingdon	S	0	YES
Hounslow 1	R	0	YES
Islington 2	R	0	YES
Kens & Chelsea 1	U	0	YES
Kens & Chelsea 2	R	0	YES
Marylebone Rd	K	0	YES
Redbridge 2	K	9	NO
Redbridge 4	R	0	NA
Richmond 5	K	0	NA
Sevenoaks 2	U	0	NA
Southwark 1	U	0	YES
Southwark 2	R	0	YES
Sutton 1	R	0	YES
Thurrock	U	0	YES
Tower Hamlets 2	R	0	YES
Wandsworth 2	U	0	YES
Wandsworth 4	R	0	YES
West London	U	0	YES
Westminster	U	0	NA

A.3.1 Nitrogen Oxides

Nitrogen Oxides	Type	Capture Rate (%)
A3	R	97
Barking & Dag'ham 1	S	85
Barnet 1	K	75
Barnet 2	U	95
Barnet 3	U	89
Bexley 1	U	94
Bexley 2	S	98
Bexley 4	R	28
Bexley 5	S	93
Bloomsbury	U	87
Brent 1	U	89
Brent 2	R	41
Brent 3	U	13
Brentwood 1	U	87
Bromley 7	R	88
Camden 1	K	99
Camden 3	R	96
Castle Point 1	U	99
City of London 1	U	21
Croydon 2	R	99
Croydon 4	R	75
Croydon 5	R	87
Croydon 6	S	79
Crystal Palace 1	R	96
Ealing 1	U	99
Ealing 2	R	98
Ealing 5	R	31
Enfield 1	S	94
Enfield 2	R	96
Enfield 3	U	94
Enfield 4	R	95
Greenwich 4	U	97
Greenwich 5	R	96
Greenwich Bexley 6	R	96

Nitrogen Oxides	Type	Capture Rate (%)
Hackney 4	U	94
Hammersmith & Fulham 1	R	93
Haringey 1	R	98
Haringey 2	S	92
Haringey 3	R	18
Harrow 1	U	95
Havering 1	R	87
Havering 3	R	94
Heathrow Airport	U	93
Hillingdon	S	96
Hillingdon 1	R	96
Hounslow 1	R	95
Hounslow 2	S	95
Hounslow 4	R	91
Islington 1	U	95
Islington 2	R	97
Kens & Chelsea 1	U	96
Kens & Chelsea 2	R	96
Kens & Chelsea 3	K	97
Kens & Chelsea 4	R	95
Lambeth 1	R	96
Lambeth 2	R	3
Lambeth 3	U	3
Lewisham 1	U	45
Marylebone Rd	K	94
Mole Valley 2	S	98
Mole Valley 3	U	20
Redbridge 1	U	98
Redbridge 2	K	87
Redbridge 3	R	98
Redbridge 4	R	95
Reigate & Banstead	U	99
Richmond 1	R	94
Richmond 2	S	60
Richmond 5	K	31

Nitrogen Oxides	Type	Capture Rate (%)
Sevenoaks 2	U	95
Southwark 1	U	97
Southwark 2	R	92
Sutton 1	R	99
Sutton 2	U	98
Sutton 3	S	93
Teddington	U	94
Thurrock	U	96
Tower Hamlets 1	U	96
Tower Hamlets 2	R	87
Tower Hamlets 3	U	95
Waltham Forest 1	U	86
Waltham Forest 2	R	57
Wandsworth 2	U	99
Wandsworth 4	R	96
West London	U	95
Westminster	U	35

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 μgm^{-3}
A3	R	96	184
Barking & Dag'ham 1	S	33	63
Barnet 1	K	95	180
Barnet 2	U	39	75
Barnet 3	U	45	86
Bexley 1	U	36	68
Bexley 2	S	34	66
Bexley 4	R	36	69
Bexley 5	S	28	53
Bloomsbury	U	57	109
Brent 1	U	32	61
Brent 2	R	162	310
Brent 3	U	104	198
Brentwood 1	U	31	58
Bromley 7	R	86	165
Camden 1	K	106	203
Camden 3	R	101	193
Castle Point 1	U	24	46
City of London 1	U	73	140
Croydon 2	R	93	177
Croydon 4	R	70	135
Croydon 5	R	128	245
Croydon 6	S	44	85
Crystal Palace 1	R	80	154
Ealing 1	U	44	85
Ealing 2	R	84	161
Ealing 5	R	71	135
Enfield 1	S	31	59
Enfield 2	R	47	90
Enfield 3	U	34	64
Enfield 4	R	65	124
Greenwich 4	U	32	61
Greenwich 5	R	65	125
Greenwich Bexley 6	R	96	183

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 μgm^{-3}
Hackney 4	U	57	108
Hammersmith & Fulham 1	R	117	223
Haringey 1	R	62	119
Haringey 2	S	36	69
Haringey 3	R	89	171
Harrow 1	U	26	50
Havering 1	R	54	104
Havering 3	R	58	111
Heathrow Airport	U	74	142
Hillingdon	S	63	121
Hillingdon 1	R	76	146
Hounslow 1	R	77	147
Hounslow 2	S	43	82
Hounslow 4	R	90	171
Islington 1	U	48	92
Islington 2	R	106	203
Kens & Chelsea 1	U	39	75
Kens & Chelsea 2	R	109	208
Kens & Chelsea 3	R	126	240
Kens & Chelsea 4	R	135	259
Lambeth 1	R	76	145
Lambeth 2	R	58	111
Lambeth 3	U	49	94
Lewisham 1	U	55	106
Marylebone Rd	K	175	335
Mole Valley 2	S	27	52
Mole Valley 3	U	45	86
Redbridge 1	U	40	76
Redbridge 2	R	186	355
Redbridge 3	K	92	176
Redbridge 4	K	62	118
Reigate & Banstead	U	31	59
Richmond 1	R	52	99
Richmond 2	S	21	40
Richmond 5	K	53	101

Nitrogen Oxides	Type	Annual Mean NO_X ppb	Annual Mean NO_X as NO_2 μgm^{-3}
Sevenoaks 2	U	25	47
Southwark 1	U	58	111
Southwark 2	R	92	175
Sutton 1	R	60	114
Sutton 2	U	43	82
Sutton 3	S	34	65
Teddington	U	27	53
Thurrock	U	41	78
Tower Hamlets 1	U	40	76
Tower Hamlets 2	R	120	230
Tower Hamlets 3	U	46	87
Waltham Forest 1	U	41	77
Waltham Forest 2	R	49	94
Wandsworth 2	U	71	135
Wandsworth 4	R	65	123
West London	U	50	95
Westminster	U	44	84

A.3.2 Nitrogen Dioxide

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
A3	R	97	0
Barking & Dag'ham 1	S	85	0
Barnet 1	K	75	0
Barnet 2	U	95	0
Barnet 3	U	89	0
Bexley 1	U	94	0
Bexley 2	S	98	0
Bexley 4	R	28	0
Bexley 5	S	93	0
Bloomsbury	U	87	0
Brent 1	U	89	0
Brent 2	R	41	2
Brent 3	U	13	0
Brentwood 1	U	87	0
Bromley 7	R	88	0
Camden 1	K	99	0
Camden 3	R	96	1
Castle Point 1	U	99	0
City of London 1	U	21	0
Croydon 2	R	99	0
Croydon 4	R	75	0
Croydon 5	R	87	0
Croydon 6	S	79	0
Crystal Palace 1	R	96	0
Ealing 1	U	99	0
Ealing 2	R	98	0
Ealing 5	R	31	0
Enfield 1	S	94	0
Enfield 2	R	96	0
Enfield 3	U	94	0
Enfield 4	R	95	0
Greenwich 4	U	97	0
Greenwich 5	R	96	0
Greenwich Bexley 6	R	96	0

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
Hackney 4	U	94	0
Hammersmith & Fulham 1	R	93	0
Haringey 1	R	98	0
Haringey 2	S	92	0
Haringey 3	R	18	0
Harrow 1	U	95	0
Havering 1	R	87	0
Havering 3	R	94	0
Heathrow Airport	U	93	1
Hillingdon	S	96	0
Hillingdon 1	R	96	0
Hounslow 1	R	95	0
Hounslow 2	S	95	0
Hounslow 4	R	91	0
Islington 1	U	95	0
Islington 2	R	97	0
Kens & Chelsea 1	U	96	0
Kens & Chelsea 2	R	96	0
Kens & Chelsea 3	R	97	2
Kens & Chelsea 4	R	95	0
Lambeth 1	R	96	0
Lambeth 2	R	3	0
Lambeth 3	U	3	0
Lewisham 1	U	45	0
Marylebone Rd	K	94	0
Mole Valley 2	S	98	0
Mole Valley 3	U	20	0
Redbridge 1	U	98	0
Redbridge 2	R	87	31
Redbridge 3	R	98	0
Redbridge 4	R	95	0
Reigate & Banstead	U	99	0
Richmond 1	R	94	0
Richmond 2	S	60	0
Richmond 5	R	31	0

Nitrogen Dioxide	Type	Capture Rate (%)	Days moderate and above
Sevenoaks 2	U	95	0
Southwark 1	U	97	0
Southwark 2	R	92	0
Sutton 1	R	99	0
Sutton 2	U	98	0
Sutton 3	S	93	0
Teddington	U	94	0
Thurrock	U	96	0
Tower Hamlets 1	U	96	0
Tower Hamlets 2	R	87	0
Tower Hamlets 3	U	95	0
Waltham Forest 1	U	86	0
Waltham Forest 2	R	57	0
Wandsworth 2	U	99	0
Wandsworth 4	R	96	0
West London	U	95	0
Westminster	U	35	0

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40 μgm^{-3}	Achieved
A3	R	28	53	NO
Barking & Dag'ham 1	S	18	35	NA
Barnet 1	K	30	58	NA
Barnet 2	U	21	40	NO
Barnet 3	U	21	40	NA
Bexley 1	U	19	36	YES
Bexley 2	S	18	35	YES
Bexley 4	R	19	36	NA
Bexley 5	S	17	32	YES
Bloomsbury	U	27	51	NA
Brent 1	U	19	37	NA
Brent 2	R	34	65	NA
Brent 3	U	35	67	NA
Brentwood 1	U	18	35	NA
Bromley 7	R	32	61	NA
Camden 1	K	34	66	NO
Camden 3	R	39	74	NO
Castle Point 1	U	15	30	YES
City of London 1	U	31	59	NA
Croydon 2	R	24	45	NO
Croydon 4	R	29	56	NA
Croydon 5	R	36	69	NA
Croydon 6	S	21	39	NA
Crystal Palace 1	R	26	50	NO
Ealing 1	U	21	40	NO
Ealing 2	R	28	54	NO
Ealing 5	R	26	51	NA
Enfield 1	S	17	33	YES
Enfield 2	R	22	42	NO
Enfield 3	U	19	35	YES
Enfield 4	R	26	50	NO
Greenwich 4	U	17	33	YES
Greenwich 5	R	29	55	NO
Greenwich Bexley 6	R	26	50	NO

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40 μgm^{-3}	Achieved
Hackney 4	U	25	48	NO
Hammersmith & Fulham 1	R	37	70	NO
Haringey 1	R	25	48	NO
Haringey 2	S	20	38	YES
Haringey 3	R	32	60	NA
Harrow 1	U	15	29	YES
Havering 1	R	22	42	NA
Havering 3	R	22	41	NO
Heathrow Airport	U	29	56	NO
Hillingdon	S	24	46	NO
Hillingdon 1	R	24	45	NO
Hounslow 1	R	28	54	NO
Hounslow 2	S	21	41	NO
Hounslow 4	R	29	55	NO
Islington 1	U	26	50	NO
Islington 2	R	35	67	NO
Kens & Chelsea 1	U	22	41	NO
Kens & Chelsea 2	R	40	76	NO
Kens & Chelsea 3	R	43	83	NO
Kens & Chelsea 4	R	45	86	NO
Lambeth 1	R	30	58	NO
Lambeth 2	R	28	54	NA
Lambeth 3	U	26	50	NA
Lewisham 1	U	27	52	NA
Marylebone Rd	K	44	84	NO
Mole Valley 2	S	14	28	YES
Mole Valley 3	U	17	33	NA
Redbridge 1	U	20	39	YES
Redbridge 2	K	62	119	NA
Redbridge 3	K	34	65	NO
Redbridge 4	R	25	48	NO
Reigate & Banstead	U	18	34	YES
Richmond 1	R	23	44	NO
Richmond 2	S	15	29	NA
Richmond 5	K	24	45	NA

Nitrogen Dioxide	Type	Annual Mean less than 21ppb	Annual Mean less than 40 μgm^{-3}	Achieved
Sevenoaks 2	U	13	25	YES
Southwark 1	U	28	54	NO
Southwark 2	R	34	65	NO
Sutton 1	R	23	43	NO
Sutton 2	U	21	40	NO
Sutton 3	S	18	35	YES
Teddington	U	15	29	YES
Thurrock	U	19	36	YES
Tower Hamlets 1	U	23	45	NO
Tower Hamlets 2	R	38	72	NA
Tower Hamlets 3	U	24	47	NO
Waltham Forest 1	U	23	43	NA
Waltham Forest 2	R	25	47	NA
Wandsworth 2	U	27	52	NO
Wandsworth 4	R	28	53	NO
West London	U	27	52	NO
Westminster	U	23	44	NA

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm^{-3} (104.6ppb)	Achieved
A3	R	0	YES
Barking & Dag'ham 1	S	0	NA
Barnet 1	K	0	YES
Barnet 2	U	0	YES
Barnet 3	U	0	NA
Bexley 1	U	0	YES
Bexley 2	S	0	YES
Bexley 4	R	0	NA
Bexley 5	S	0	YES
Bloomsbury	U	0	NA
Brent 1	U	0	NA
Brent 2	R	24	NO
Brent 3	U	0	NA
Brentwood 1	U	0	NA
Bromley 7	R	0	NA
Camden 1	K	0	YES
Camden 3	R	3	YES
Castle Point 1	U	0	YES
City of London 1	U	0	NA
Croydon 2	R	0	YES
Croydon 4	R	0	NA
Croydon 5	R	6	NA
Croydon 6	S	1	NA
Crystal Palace 1	R	0	YES
Ealing 1	U	0	YES
Ealing 2	R	1	YES
Ealing 5	R	0	NA
Enfield 1	S	0	YES
Enfield 2	R	0	YES
Enfield 3	U	0	YES
Enfield 4	R	0	YES
Greenwich 4	U	0	YES
Greenwich 5	R	0	YES

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm^{-3} (104.6ppb)	Achieved
Greenwich Bexley 6	R	0	YES
Hackney 4	U	0	YES
Hammersmith & Fulham 1	R	5	YES
Haringey 1	R	0	YES
Haringey 2	S	0	YES
Haringey 3	R	0	NA
Harrow 1	U	0	YES
Havering 1	R	4	NA
Havering 3	R	0	YES
Heathrow Airport	U	1	YES
Hillingdon	S	0	YES
Hillingdon 1	R	0	YES
Hounslow 1	R	0	YES
Hounslow 2	S	0	YES
Hounslow 4	R	2	YES
Islington 1	U	0	YES
Islington 2	R	0	YES
Kens & Chelsea 1	U	4	YES
Kens & Chelsea 2	R	2	YES
Kens & Chelsea 3	R	97	NO
Kens & Chelsea 4	R	15	YES
Lambeth 1	R	0	YES
Lambeth 2	R	0	NA
Lambeth 3	U	0	NA
Lewisham 1	U	0	NA
Marylebone Rd	K	58	NO
Mole Valley 2	S	0	YES
Mole Valley 3	U	0	NA
Redbridge 1	U	0	YES
Redbridge 2	K	826	NA
Redbridge 3	K	19	NO
Redbridge 4	R	0	YES
Reigate & Banstead	U	0	YES

Nitrogen Dioxide	Type	No more than 18 occurrences of hourly mean >=200µgm^{-3} (104.6ppb)	Achieved
Richmond 1	R	0	YES
Richmond 2	S	0	NA
Richmond 5	K	0	NA
Sevenoaks 2	U	0	YES
Southwark 1	U	0	YES
Southwark 2	R	0	YES
Sutton 1	R	3	YES
Sutton 2	U	2	YES
Sutton 3	S	0	YES
Teddington	U	0	YES
Thurrock	U	0	YES
Tower Hamlets 1	U	0	YES
Tower Hamlets 2	R	8	NA
Tower Hamlets 3	U	0	YES
Waltham Forest 1	U	2	NA
Waltham Forest 2	R	0	NA
Wandsworth 2	U	0	YES
Wandsworth 4	R	5	YES
West London	U	0	YES
Westminster	U	0	NA

A.3.3 Ozone

Ozone	Type	Capture Rate (%)	Days moderate and above
Bexley 1	U	96	30
Bloomsbury	U	97	13
Brent 1	U	99	28
Bromley 5	S	97	33
City of London 1	U	17	0
Croydon 3	S	89	23
Ealing 1	U	93	6
Enfield 3	U	90	32
Greenwich 4	U	99	30
Hackney 4	U	58	4
Haringey 2	S	98	27
Hillingdon	S	79	14
Hounslow 2	S	96	27
Kens & Chelsea 1	U	97	27
Kingston 1	S	99	38
Lewisham 1	U	0	-
Marylebone Rd	K	96	1
Redbridge 1	U	96	26
Richmond 5	K	34	13
Sevenoaks 2	U	97	39
Southwark 1	U	96	18
Sutton 3	S	99	25
Teddington	U	98	46
Thurrock	U	96	35
Tower Hamlets 1	U	98	25
Wandsworth 2	U	99	21
Westminster	U	44	8

Ozone	Type	No more than 10 days where maximum rolling 8hr mean >=100μgm^{-3} (50ppb)	Achieved
Bexley 1	U	18	NO
Bloomsbury	U	6	YES
Brent 1	U	21	NO
Bromley 5	S	24	NO
City of London 1	U	0	NA
Croydon 3	S	14	NA
Ealing 1	U	3	YES
Enfield 3	U	25	NO
Greenwich 4	U	14	NO
Hackney 4	U	0	NA
Haringey 2	S	20	NO
Hillingdon	S	4	NA
Hounslow 2	S	15	NO
Kens & Chelsea 1	U	12	NO
Kingston 1	S	28	NO
Lewisham 1	U	-	NA
Marylebone Rd	K	0	YES
Redbridge 1	U	17	NO
Richmond 5	K	6	NA
Sevenoaks 2	U	23	NO
Southwark 1	U	7	YES
Sutton 3	S	12	NO
Teddington	U	30	NO
Thurrock	U	21	NO
Tower Hamlets 1	U	16	NO
Wandsworth 2	U	10	YES
Westminster	U	6	NA

A.3.4 PM_{10}

PM_{10}	Type	Instrument	Capture Rate (%)	Days moderate and above
A3	R	T	97	12
Barking & Dag'ham 2	S	T	72	12
Barnet 1	K	T	73	9
Barnet 2	U	T	81	5
Barnet 3	U	T	99	7
Bexley 1	U	T	96	10
Bexley 2	S	T	99	17
Bexley 3	S	T	96	8
Bexley 4	R	T	98	89
Bloomsbury	U	T	97	9
Brent 1	U	T	98	5
Brent 2	R	T	50	12
Brent 3	U	T	16	0
Bromley 7	R	B	88	40
Camden 1	K	T	99	14
Camden 3	R	T	98	24
Croydon 3	S	T	96	8
Croydon 4	R	T	90	13
Crystal Palace 1	R	T	98	11
Ealing 2	R	T	94	20
Ealing 5	R	T	45	3
Enfield 2	R	B	79	72
Enfield 3	U	B	87	45
Enfield 4	R	B	69	91
Greenwich 4	U	T	97	5
Greenwich 5	R	T	98	12
Greenwich Bexley 6	R	T	96	19
Hammersmith & Fulham 1	R	T	92	15
Haringey 1	R	T	99	9
Haringey 2	S	B	91	39
Haringey 3	R	B	18	17
Harrow 1	U	T	99	2
Havering 3	R	T	96	9
Heathrow Airport	U	T	93	13

PM_{10}	Type	Instrument	Capture Rate (%)	Days moderate and above
Hillingdon	S	T	97	8
Hillingdon 1	R	T	93	10
Hounslow 2	S	T	96	6
Hounslow 3	R	T	98	24
Hounslow 4	R	T	92	16
Islington 1	U	T	99	8
Islington 2	R	T	96	17
Kens & Chelsea 1	U	T	96	12
Kens & Chelsea 2	R	T	99	17
Lambeth 1	R	B	95	79
Lambeth 2	R	B	3	2
Lambeth 3	U	B	3	2
Marylebone Rd	K	T	89	49
Mole Valley 2	S	T	98	3
Mole Valley 3	U	T	19	0
Redbridge 1	U	B	97	54
Redbridge 3	R	B	96	74
Redbridge 4	R	B	97	77
Reigate & Banstead	U	T	99	7
Richmond 1	R	T	93	11
Richmond 2	S	T	15	0
Richmond 5	K	T	33	1
Sevenoaks	U	T	97	2
Southwark 2	R	T	38	7
Sutton 1	R	T	86	5
Thurrock	U	T	76	9
Tower Hamlets 1	U	T	98	10
Tower Hamlets 3	U	T	94	6
Waltham Forest 1	U	T	75	5
Waltham Forest 2	R	T	59	3
Wandsworth 4	R	T	99	13

Instrument type; T = TEOM, B = BAM.

PM_{10}	Type	Instrument	No more than 35 days where daily mean >=50µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
A3	R	T	15	YES
Barking & Dag'ham 2	S	T	15	NA
Barnet 1	K	T	19	NA
Barnet 2	U	T	6	NA
Barnet 3	U	T	12	YES
Bexley 1	U	T	18	YES
Bexley 2	S	T	24	YES
Bexley 3	S	T	14	YES
Bexley 4	R	T	100	NO
Bloomsbury	U	T	20	YES
Brent 1	U	T	9	YES
Brent 2	R	T	37	NO
Brent 3	U	T	0	NA
Bromley 7	R	B	21	NA
Camden 1	K	T	28	YES
Camden 3	R	T	41	NO
Croydon 3	S	T	11	YES
Croydon 4	R	T	25	YES
Crystal Palace 1	R	T	24	YES
Ealing 2	R	T	29	YES
Ealing 5	R	T	8	NA
Enfield 2	R	B	48	NA
Enfield 3	U	B	29	YES
Enfield 4	R	B	61	NO
Greenwich 4	U	T	11	YES
Greenwich 5	R	T	18	YES
Greenwich Bexley 6	R	T	30	YES
Hammersmith & Fulham 1	R	T	37	NO
Haringey 1	R	T	14	YES
Haringey 2	S	B	25	YES
Haringey 3	R	B	12	NA
Harrow 1	U	T	6	YES
Havering 3	R	T	13	YES

PM_{10}	Type	Instrument	No more than 35 days where daily mean >=50µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Heathrow Airport	U	T	21	YES
Hillingdon	S	T	12	YES
Hillingdon 1	R	T	17	YES
Hounslow 2	S	T	11	YES
Hounslow 3	R	T	47	NO
Hounslow 4	R	T	28	YES
Islington 1	U	T	12	YES
Islington 2	R	T	32	YES
Kens & Chelsea 1	U	T	15	YES
Kens & Chelsea 2	R	T	34	YES
Lambeth 1	R	B	52	NO
Lambeth 2	R	B	1	NA
Lambeth 3	U	B	1	NA
Marylebone Rd	K	T	106	NA
Mole Valley 2	S	T	5	YES
Mole Valley 3	U	T	2	NA
Redbridge 1	U	B	33	YES
Redbridge 3	K	B	45	NO
Redbridge 4	R	B	51	NO
Reigate & Banstead	U	T	6	YES
Richmond 1	R	T	15	YES
Richmond 2	S	T	3	NA
Richmond 5	K	T	2	NA
Sevenoaks 2	U	T	4	YES
Southwark 2	R	T	7	NA
Sutton 1	R	T	12	NA
Thurrock	U	T	13	NA
Tower Hamlets 1	U	T	15	YES
Tower Hamlets 3	U	T	10	YES
Waltham Forest 1	U	T	7	NA
Waltham Forest 2	R	T	7	NA
Wandsworth 4	R	T	28	YES

Instrument type; T = TEOM, B = BAM.

PM_{10}	Type	Instrument	Annual Mean less than 40µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
A3	R	T	27	YES
Barking & Dag'ham 2	S	T	26	NA
Barnet 1	K	T	32	NA
Barnet 2	U	T	23	NA
Barnet 3	U	T	26	YES
Bexley 1	U	T	24	YES
Bexley 2	S	T	25	YES
Bexley 3	S	T	25	YES
Bexley 4	R	T	40	NO
Bloomsbury	U	T	29	YES
Brent 1	U	T	23	YES
Brent 2	R	T	38	NA
Brent 3	U	T	20	NA
Bromley 7	R	B	28	NA
Camden 1	K	T	33	YES
Camden 3	R	T	36	YES
Croydon 3	S	T	24	YES
Croydon 4	R	T	30	YES
Crystal Palace 1	R	T	31	YES
Ealing 2	R	T	30	YES
Ealing 5	R	T	26	NA
Enfield 2	R	B	36	NA
Enfield 3	U	B	30	NA
Enfield 4	R	B	42	NA
Greenwich 4	U	T	23	YES
Greenwich 5	R	T	28	YES
Greenwich Bexley 6	R	T	29	YES
Hammersmith & Fulham 1	R	T	35	YES
Haringey 1	R	T	27	YES
Haringey 2	S	B	30	YES
Haringey 3	R	B	37	NA
Harrow 1	U	T	21	YES
Havering 3	R	T	26	YES
Heathrow Airport	U	T	29	YES

PM_{10}	Type	Instrument	Annual Mean less than 40µgm^{-3} (TEOM *1.3, BAM *1)	Achieved
Hillingdon	S	T	26	YES
Hillingdon 1	R	T	28	YES
Hounslow 2	S	T	23	YES
Hounslow 3	R	T	36	YES
Hounslow 4	R	T	32	YES
Islington 1	U	T	25	YES
Islington 2	R	T	34	YES
Kens & Chelsea 1	U	T	26	YES
Kens & Chelsea 2	R	T	35	YES
Lambeth 1	R	B	37	YES
Lambeth 2	R	B	36	NA
Lambeth 3	U	B	30	NA
Marylebone Rd	K	T	43	NA
Mole Valley 2	S	T	22	YES
Mole Valley 3	U	T	24	NA
Redbridge 1	U	B	31	YES
Redbridge 3	K	B	35	YES
Redbridge 4	R	B	36	YES
Reigate & Banstead	U	T	23	YES
Richmond 1	R	T	26	YES
Richmond 2	S	T	29	NA
Richmond 5	K	T	28	NA
Sevenoaks 2	U	T	22	YES
Southwark 2	R	T	31	NA
Sutton 1	R	T	26	NA
Thurrock	U	T	25	NA
Tower Hamlets 1	U	T	24	YES
Tower Hamlets 3	U	T	21	YES
Waltham Forest 1	U	T	24	NA
Waltham Forest 2	R	T	26	NA
Wandsworth 4	R	T	28	YES

Instrument type; T = TEOM, B = BAM.

A.3.5 $PM_{2.5}$

$PM_{2.5}$	Type	Instrument	Capture Rate (%)	Annual Mean μgm^{-3}
Bexley 2	S	T	37	13
Bexley 3	S	T	98	11
Bloomsbury	U	T	87	13
Bromley 7	R	B	75	20
Ealing 2	R	T	99	17
Greenwich Bexley 6	R	T	75	15
Hackney 4	U	T	92	17
Marylebone Road	R	T	90	26

A.3.6 Sulphur Dioxide

Sulphur Dioxide	Type	Capture Rate (%)	Days moderate and above
Barking & Dag'ham 1	S	94	0
Bexley 1	U	95	2
Bexley 5	S	94	0
Bloomsbury	U	92	0
Brent 1	U	99	0
Brent 2	R	44	0
Brent 3	U	16	0
Castle Point 1	U	98	0
City of London 1	U	18	0
Croydon 4	R	84	0
Crystal Palace 1	R	93	0
Ealing 1	U	99	0
Ealing 5	R	44	0
Enfield 3	U	94	1
Enfield 4	R	96	1
Greenwich 4	U	97	0
Hammersmith & Fulham 1	R	54	0
Haringey 1	R	93	0
Haringey 3	R	19	0
Harrow 1	U	91	0
Havering 3	R	97	0
Hillingdon	S	80	0
Hounslow 2	S	81	0
Hounslow 4	R	93	0
Kens & Chelsea 1	U	97	0
Kens & Chelsea 2	R	95	0
Lambeth 1	R	96	1
Lambeth 2	R	3	0
Lambeth 3	U	3	0
Lewisham 1	U	45	0
Marylebone Rd	K	84	0
Redbridge 4	R	94	0
Richmond 5	K	31	0
Sevenoaks 2	U	97	0

Sulphur Dioxide	Type	Capture Rate (%)	Days moderate and above
Southwark 1	U	97	0
Southwark 2	R	91	0
Sutton 1	R	97	0
Teddington	U	98	0
Thurrock	U	97	2
Tower Hamlets 1	U	97	0
Tower Hamlets 3	U	93	4
Waltham Forest 1	U	88	0
Waltham Forest 2	R	8	0
Wandsworth 2	U	90	0
Westminster	U	44	0

Sulphur Dioxide	Type	No more than 35 occurrences of 15min mean >=350µgm^{-3} (100ppb)	Achieved
Barking & Dag'ham 1	S	0	YES
Bexley 1	U	4	YES
Bexley 5	S	0	YES
Bloomsbury	U	0	YES
Brent 1	U	0	YES
Brent 2	R	0	NA
Brent 3	U	0	NA
Castle Point 1	U	0	YES
City of London 1	U	0	NA
Croydon 4	R	0	YES
Crystal Palace 1	R	0	YES
Ealing 1	U	0	YES
Ealing 5	R	0	NA
Enfield 3	U	2	YES
Enfield 4	R	1	YES
Greenwich 4	U	0	YES
Hammersmith & Fulham 1	R	0	NA
Haringey 1	R	0	YES
Haringey 3	R	0	NA
Harrow 1	U	0	YES
Havering 3	R	0	YES
Hillingdon	S	0	NA
Hounslow 2	S	0	NA
Hounslow 4	R	0	YES
Kens & Chelsea 1	U	0	YES
Kens & Chelsea 2	R	0	YES
Lambeth 1	R	1	YES
Lambeth 2	R	0	NA
Lambeth 3	U	0	NA
Lewisham 1	U	0	NA
Marylebone Rd	K	0	NA
Redbridge 4	R	0	YES
Richmond 5	K	0	NA

Sulphur Dioxide	Type	No more than 35 occurrences of 15min mean >=350µgm^{-3} (100ppb)	Achieved
Sevenoaks 2	U	0	YES
Southwark 1	U	0	YES
Southwark 2	R	0	YES
Sutton 1	R	0	YES
Teddington	U	0	YES
Thurrock	U	2	YES
Tower Hamlets 1	U	0	YES
Tower Hamlets	U	10	YES
Waltham Forest 1	U	0	NA
Waltham Forest 2	R	0	NA
Wandsworth 2	U	0	YES
Westminster	U	0	NA

A.3.7 Benzene

Benzne	Type	Instrument	Capture Rate (%)
Haringey 1	R	PS	100
Marylebone Road	K	GC	85
Tower Hamlets 2	R	GC	85

Benzne	Type	Instrument	Annual Mean less than 16.25 μgm^{-3}	Achieved
Haringey 1	R	PS	2.6	YES
Marylebone Road	K	GC	4.6	NA
Tower Hamlets 2	R	GC	4.9	NA

Instrument Type: PS = Pumped sampler GC = Gas Chromatograph.

A.3.8 1,3 Butadiene

1,3 Butadiene	Type	Instrument	Capture Rate (%)
Haringey 1	R	PS	0
Marylebone Road	K	GC	85
Tower Hamlets 2	R	GC	85

A.3.9 Benzene

Benzne	Type	Instrument	Annual Mean less than 2.25 μgm^{-3}	Achieved
Haringey 1	R	PS	-	NA
Marylebone Road	K	GC	1.1	NA
Tower Hamlets 2	R	GC	0.83	NA

Instrument Type: PS = Pumped sampler GC = Gas Chromatograph.

KING'S College LONDON

University of London

AIR QUALITY STRATEGY OBJECTIVES &
UK AIR QUALITY INFORMATION SYSTEM

APPENDIX 4: AIR QUALITY STRATEGY OBJECTIVES & UK AIR QUALITY INFORMATION SYSTEM

The following objectives are set out in the Air Quality Regulations 2000 for the purposes of Local Air Quality Management.

Pollutant	Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 $\mu g/m^3$ (5 ppb)	Running Annual Mean	31 Dec 2003
1, 3 Butadiene	2.25 $\mu g/m^3$ (1 ppb)	Running Annual Mean	31 Dec 2003
Carbon Monoxide	11.6 $\mu g/m^3$ (10 ppb)	Running 8 hour mean	31 Dec 2003
Lead	0.5 $\mu g/m^3$ 0.25 $\mu g/m^3$	Annual Mean Annual Mean	31 Dec 2003 31 Dec 2008
Nitrogen Dioxide (provisional)	200 $\mu g/m^3$ (105 ppb) not to be exceeded more than 18 times a year 40 $\mu g/m^3$ (21 ppb)	1 hour mean Annual Mean	31 Dec 2005 31 Dec 2005
Particles (PM_{10})	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 Dec 2004 31 Dec 2004
Sulphur Dioxide	350 $\mu g/m^3$ (132 ppb) not to be exceeded more than 24 times a year 125 $\mu g/m^3$ (47 ppb) not to be exceeded more than3 times a year 266 $\mu g/m^3$ (100 ppb) not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31 Dec 2004 31 Dec 2004 31 Dec 2005

The following objectives are not included in the Air Quality Regulations 2000 for the purposes of Local Air Quality Management.

Pollutant	Objective		Date to be achieved by
	Concentration	Measured as	
Objectives for the protection of human health			
Ozone (provisional)	100 µg/m³ (50 ppb) not to be exceeded more than 10 times per year	Daily maximum of running 8 hour mean	31 Dec 2005
Objectives for the protection of vegetation and ecosystems			
Nitrogen Oxides (assuming NO_X is taken as NO_2)	30 µg/m³ (16 ppb)	Annual mean	31 Dec 2000
Sulphur Dioxide	20 µg/m³ (8 ppb) 20 µg/m³ (8 ppb)	Annual Mean Winter Mean (1 Oct- 31 Mar)	31 Dec 2000 31 Dec 2000

DETR, 2000; The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

DETR, 2000; Air Quality Regulations 2000.

The 'descriptors' applied to air pollution concentrations are defined by the UK Air Quality Information system.

Pollutant / Band	LOW	MODERATE	HIGH	VERY HIGH
Air Quality Index	**1 -3**	**4-6**	**7-9**	**10**
Sulphur Dioxide	below 100ppb, averaged over 15 minutes	100ppb, averaged over 15 minutes	200ppb, averaged over 15 minutes	400ppb, averaged over 15 minutes
Ozone	below 50ppb, as an 8 hour running average	50ppb, as an 8 hour running average or 50ppb averaged over one hour	90 ppb, averaged over one hour	180 ppb, averaged over one hour
Carbon Monoxide	below 10 ppm, as an 8 hour running average	10 ppm, as an 8 hour running average	15 ppm, as an 8 hour running average	20 ppm, as an 8 hour running average
Nitrogen Dioxide	below 150 ppb, averaged over one hour	150 ppb, averaged over one hour	300 ppb, averaged over one hour	400 ppb, averaged over one hour
PM_{10} Particles (by TEOM)	below 50 ug/m^3, as a 24 hour running average	50 ug/m^3, as a 24 hour running average	75 ug/m^3, as a 24 hour running average	100 ug/m^3, as a 24 hour running average