Air Quality In London 2005 and mid 2006 – Briefing

Gary Fuller and David Green - 28th July 2006

Introduction

This document provides a briefing on the air quality concentrations measured by the London Air Quality Network (LAQN) during 2005 calendar year and for the 12 months ending June 2006. Measurements for these periods have been compared to the UK Air Quality Strategy (AQS) Objectives. Measurements from the first half of 2006 have also been compared to the short term AQS Objectives for NO_2 and PM_{10}.

It must be stressed that this analysis is based on provisional data. At the time of writing around 80% of 2005 measurements were ratified. Measurements from DEFRA directly funded sites in London were available up the end of March 2006 only.

Final measurement datasets for 2005 and 2006 will be published in the forthcoming LAQN annual reports for each year, which will also contain additional analysis.

The London Air Quality Network

The LAQN was formed in 1993 to coordinate and improve air pollution monitoring in London. Currently, 30 London boroughs are supplying measurements to the LAQN. Increasingly, these data are being supplemented by measurements from local authorities surrounding London, thereby providing 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 (KCL). Each borough funds air quality monitoring in its own area. The Department of Environment, Food and Rural Affairs (DEFRA) funds KCL to operate the Marylebone Road site and to maintain 14 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. Further monitoring sites have been supported by Transport for London to provide measurements to inform the assessment of the Congestion Charging Scheme.

Analysis of LAQN measurements has been augmented by measurements from the directly-funded DEFRA sites in London. These 6 sites provide further information concerning pollution in central and west London. Measurements from DEFRA sites were provided by AEAT plc from the National Air Quality Archive and are included within the LAQN database.

To understand air pollution in London it is necessary to understand air pollution in the surrounding area and vice-versa. To support this understanding the LAQN also includes sites in Berkshire, Essex, Kent and Surrey. A more complete picture of air pollution in south east England can be obtained from the combined results of the LAQN, the Kent Air Quality Monitoring Network (KAQMN), the Hertfordshire and Bedfordshire Air Pollution Monitoring Network (HBAPMN) and the Sussex Air Quality Steering Group (SAQSG) network. Measurements from these networks are available from KCL.

Hourly updated measurements from the LAQN and neighbouring networks are published by KCL on the Internet at:

www.londonair.org.uk

Carbon Monoxide

All LAQN sites achieved the AQS Objective for CO during 2005 and during the year ended June 2006. Annual mean CO concentrations reduced rapidly during the late 1990's (Fuller, Johnson and Buchanan 2006) and have been relatively stable since 2002.

Nitrogen Dioxide

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} (105 ppb), as an hourly mean, not to be exceeded more than 18 times per year.

Annual Mean

During 2005, the annual mean NO_2 Objective was exceeded at all kerbside and roadside monitoring sites in London. The only kerbside or roadside LAQN site to achieve the Objective was Thurrock 3 in Essex. This represents deterioration on the 2004 position when 2 outer London roadsides sites; Enfield 2 and Havering 3 met the Objective.

During 2005, the annual mean NO_2 Objective was also exceeded at background sites in inner London and at Heathrow Airport.

During the 12 months up to the end of June 2006, the annual mean NO_2 Objective was exceeded at all kerbside and roadside monitoring sites in London except Hillingdon 2, Waltham Forest 3 and the Richmond mobile site during its Twickenham deployment. Each of these sites had insufficient ratified measurements during 2005 for a valid calculation of the annual mean. The attainment of the Objective at these sites does not therefore imply a change in pollution concentrations but is instead an artefact of the increased availability of measurements. During the 12 months up to the end of June 2006, the Thurrock 3 roadside site again achieved the Objective.

Comparing the measurements for 2005 with those for the year ending June 2006, the majority of sites had changes of around +/- 4 μgm^{-3}. Such changes in annual mean NO_2 concentration can be expected as part of the ratification process and it may therefore be premature to draw conclusions in respect individual sites. However the total number of sites with increased annual mean concentration (24) is almost twice the number that measured decreases (13). This evidence points to an increase in the annual mean NO_2 during the first half of 2006. It is additionally likely that the photochemical incidents in July 2006 will also lead to a further increase in the annual mean concentrations of NO_2 for 2006.

Hourly Mean Objective

During 2005, the hourly mean Objective was exceeded at 9 London kerbside and roadside sites: Ealing 6 (Hanger Lane – 157 hours)), Greenwich 8 (Woolwich Flyover 43 hours), Hammersmith & Fulham 1 (Hammersmith Broadway – 29 hours), Hounslow 4 (Chiswick – 22 hours), Kens and Chelsea 3 (Knightsbridge – 288 hours), Kens and Chelsea 4 (Chelsea – 82 hours), Lambeth 4 (A23 Brixton – 3741 hours), Marylebone Rd (849 hours) and Sutton 4 (Wallington – 174 hours).

All of the sites that exceeded the Objective during 2005 continued to do so during the year ended June 2006. Additionally, the Camden 1 (Swiss Cottage) kerbside site and the Thurrock 2 roadside site in Essex also exceeded the hourly mean NO_2 Objective.

Each of the 10 sites that exceeded the hourly mean NO_2 Objective also exceeded the annual mean Objective by a large margin. The annual mean Objective therefore remains the tighter of the 2 Objectives for the management of NO_2 concentrations.

Comparing the breaches of the hourly mean NO_2 Objective during 2005 with those measured during the year ended June 2005, a great deal of variation was evident between monitoring sites. This is expected from an Objective based on peak concentrations. Large changes in this Objective can also occur during ratification.

Long term trends in this Objective cannot be determined within the scope of this report. However the situation in 2005 contrasts with that during 2002 when only one London site exceeded this Objective. The rise in the number of hours with mean NO_2 above 200 μgm^{-3}

may be linked to rises in direct emissions of primary NO_2 as discussed in Carslaw and Beevers (2004a, 2004b, 2005a and 2005b) and Carslaw 2005.

During the first 6 months of 2006, 6 sites exceeded the hourly mean AQS Objective for NO_2 for the year: Ealing 6, Kens and Chelsea 3, Kens and Chelsea 4, Lambeth 4, Marylebone Rd and Sutton 4.

Ozone

O_3 is a seasonal pollutant with the highest peak concentrations being measured during photochemical episodes during the summer months when O_3 is formed by reactions between sunlight and precursor atmospheric pollutants. O_3 is a regional pollutant, with episodes extending over many thousands of square kilometres and being caused by the combination of precursor emissions from the UK and EU countries. In addition to this behaviour at the regional scale, the highest daily mean concentrations are often during the spring (Monks 2000). The elevated daily mean concentrations at this time are likely due to global emissions of ozone precursors during the northern hemisphere winter. In terms of health affects O_3 is an important pollutant in it's own right, which is reflected in the AQS Objectives, however it also affects the formation of NO_2 and PM_{10}.

O_3 also exhibits local variation caused by the scavenging effect of NO close to NO_X emission sources; at the roadside for example. Health-based standards are rarely exceeded at roadside and kerbside sites and O_3 monitoring is not generally undertaken in these locations. However, roadside monitoring of O_3 can lead to a better understanding of the mechanisms that determine roadside NO_2 concentrations and direct emissions of NO_2. For this reason further O_3 monitoring at roadside sites in London is encouraged.

The AQS has an Objective of 100 μgm^{-3} for O_3, measured as a rolling 8 hour mean, which should not be exceeded on more than 10 days per year. The greatest concentrations of O_3 are generally measured at sites on the periphery of London and in the Home Counties.

There is ample evidence to show that the mean concentration of O_3 in London has risen substantially. The LAQN index for this pollutant shows a rise of over 30 % between 1996 and 2005 (Fuller, Johnson and Buchanan 2006).

During the 4 years 2000, 2001, 2002 and 2004, the majority of sites in outer London and the Home Counties exceeded the Objective, whilst many sites in inner and west London met the Objective. During these years outer London sites typically experienced around 20 to 30 days per year with peak concentrations above 100 μgm^{-3}, measured as a rolling 8 hour mean.

During 2003 a series of summertime photochemical pollution episodes lead to several sites measuring over 40 days above 100 μgm^{-3}, expressed as a rolling 8 hour mean; During 2003 the AQS Objective was exceeded at all O_3 measurement sites in London except the kerbside site Marylebone Road.

During 2005 the AQS Objective for O_3 was exceed at almost all background sites in London. The background sites achieving the Objective were, City of London 1, Ealing 1 and Westmister AURN. The number of days with rolling 8 hour mean O_3 greater than 100 μgm^{-3} was lower than recent years with most London sites measuring between 10 and 20 days and 23 days were measured in Sevenoaks.

During the year ended June 2006 all background sites exceeded the Objective with the exception of City of London 1. The majority of outer London sites measured over 20 days rolling 8 hour mean O_3 greater than 100 μgm^{-3}, and 28 days were measured at Sevenoaks 2.

The photochemical incidents during July 2006 were on-going at the time of writing this briefing but it looks likely that many suburban sites will measure around 10 to 15 days with rolling 8 hour mean O_3 greater than 100 μgm^{-3} during July 2006, exceeding the annual target on the basis of measurements during this month alone.

PM_{10} Particulate

PM_{10} can be considered to comprise primary particulates (mainly emitted from local sources), secondary particulates (mainly from distant sources), and coarse particulates whose origin can be local or further afield. There are two AQS Objectives for PM_{10}: 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}. These Objectives are in line with the EU Daughter Directive Stage 1 Limit Value.

Annual Mean

During 2005 the annual mean Objective was exceeded at the Bexley 4 and Brent 5 sites which are on residential streets near waste transfer sites. The Ealing 8 site measured a mean concentration above the Objective, however, the site did not operate for the full year and therefore has insufficient data capture for a valid comparison to be made. The annual mean Objective was also exceeded at 2 roadside sites; Brent 4 (North Circular) and Greenwich 8 (Woolwich Flyover). The annual mean Objective was also exceeded at Marylebone Road. Each of these sites measured PM_{10} by TEOM.

All of the sites that exceeded the Objective during 2005 continued to do so during the year ended June 2006. By the end of June 2006, the Ealing 8 site had been operating for sufficient time to achieve a valid annual mean concentration; 84 μgm^{-3} TEOM*1.3, more than twice the Objective.

Comparing the annual mean concentrations during 2005 with those measured during the year ended June 2005, the largest change was an increase of 5 μgm^{-3} TEOM*1.3 measured at the Bexley 8 roadside site. This is subject to road widening works and additionally local PM_{10} concentrations are also frequently affected by traffic on a nearby unpaved road. The annual mean PM_{10} concentration at the Kensington & Chelsea 2 roadside site also increased by 3 μgm^{-3} TEOM*1.3. Overall 28 sites measured increases in the annual mean concentration of PM_{10}. Only 2 sites, the roadside site Hammersmith & Fulham 1 and the Croydon 3 background site measured decreases in the annual mean when compared to 2005. In both cases the decrease was 1 μgm^{-3} TEOM*1.3.

Daily Mean

During 2005, the daily mean Objective (35 days per year) was also exceeded at those sites on residential streets near waste transfer sites; Bexley 4 (105 days), Brent 5 (180 days) and Ealing 8 (230 days). Several other roadside and kerbside TEOM sites exceeded the Objective: Brent 4 (N Circular), Camden 1 (Swiss Cottage), Greenwich 8 (Woolwich Flyover), Hammersmith & Fulham 1 (Hammersmith Broadway), Hounslow 5 (A4/M4), Kensington & Chelsea 2 (Cromwell Road) and Marylebone Road. Two BAM sites exceeded the daily mean Objective: Lambeth 4 (A23) and Lambeth 5 (Vauxhall Cross).

All of the sites that exceeded the Objective during 2005 continued to do so during the year ended June 2006. During this period, the daily mean Objective was also exceeded at Bexley 8 due to nearby road works.

Comparing the daily mean Objective during 2005 with that measured during the year ended June 2005, the largest change was an increase of 19 days at Bexley 8. The roadside site Kensington & Chelsea 2 (Cromwell Road) measured an increase of 11 days, Camden 1 (Swiss Cottage) measured an increase of 10 days and Marylebone Road measured an increase of 9 days. All of these sites measure PM_{10} by TEOM. Increases were measured at the majority of monitoring sites, in line with changes in the annual mean PM_{10} concentration. The largest decrease at any LAQN site was measured at the TEOM site Brent 5, and at the BAM roadside sites Enfield 2 and Redbridge (5 days)

The increases in the daily mean Objective at roadside sites reflects a gradual increase that has been occurring in the PM_{10} concentrations at many roadside sites throughout 2005 and 2006 (Fuller, Johnson and Buchanan 2006). Source apportionment of annual mean

concentrations of PM_{10} in London was carried out by Fuller and Green (2006). This analysis showed increases in the concentration of primary PM_{10} in London between 1999 and 2003 and it is highly likely that these increases are due to increases in road transport emissions. It is less clear however if these increases are due to increases in tail pipe or non-tail pipe emissions.

During the first 6 months of 2006, 9 LAQN sites exceeded the AQS Objective for PM_{10} for the year: the 3 sites near waste transfer facilities; Bexley 4 (56 days), Brent 5 (85 days) and Ealing 8 (133 days) and 6 kerbside and roadside sites; Brent 4 (N Circular – 51 days), Bexley 7 (Crayford – 36 days), Camden 1 (Swiss Cottage – 36 days), Greenwich 8 (Woolwich Flyover – 61 days), Lambeth 5 BAM (Vauxhall Cross – 90 days) and Marylebone Road (60 days).

The photochemical incidents during July 2006 are likely to bring about an increase in PM_{10} concentrations for the year.

Measurement methods

DEFRA recently published the results of the UK PM_{10} equivalence trials (Bureau Veritas 2006). These trails compared the PM_{10} concentration measurements obtained using automated instruments to those obtained from the EU reference method. It was found that the measurements obtained from the FDMS TEOM were within the equivalence criteria and measurements from 2 types of BAM instruments were within the criteria if measurements were first multiplied with a 'correction factor'. Importantly the practice of multiplying TEOM measurements by the DEFRA recommended 1.3 factor did not meet the criteria.

Our understanding of PM_{10} concentrations is determined by the measurements that we make. Each PM_{10} measurement method produces different results mainly as a consequence of their different sensitivity to semi-volatile PM_{10} and particle bound water. The likely future change of automated PM_{10} measurement method from TEOM to FDMS or BAM will therefore change our perception of the PM_{10} problems affecting London. FDMS and BAM measurements in London have been studied by KCL by Green (1999) and Green and Fuller (2004). Each of these methods is more sensitive to ammonium nitrate particulate, an important regional secondary component of the PM_{10} affecting London. It is therefore likely that analysis of FDMS and BAM measurements of PM_{10} will provide less concentration differences between roadside and background locations and will increase the relative importance and frequency of spring and summertime PM_{10} incidents.

It is important to remember that acceptance in equivalence trial does not mean that an instrument will provide identical results to the reference measurement instead it means that the instrument provided results that fall within an accepted uncertainty envelope within the environmental conditions of the test. For instance, it is interesting to note the difference in the 2005 measurements obtained from different particle measurement methodologies at Marylebone Road. The TEOM measured 119 days above 50 μgm^{-3} (TEOM*1.3). The FDMS and the Partisol gravimetric sampler, which both passed the DEFRA equivalence trails without the need for correction factors, measured 39 days and 84 days respectfully. The KFG gravimetric sampler, which is the EU transfer standard, measured 69 days. The reasons for these differences warrant greater examination; the data capture, FDMS operational characteristics and the type of filter media used in the gravimetric samplers may be important factors but these differences may raise questions about the applicability of the UK equivalence trials to the PM_{10} experienced at road and kerbside locations.

Sulphur Dioxide

The short-term AQS Objective for SO_2 is based on 35 breaches of a 15 minute mean of 266 μgm^{-3} (100 ppb).

During 2005 the AQS 15 minute mean Objective was not approached at any site in the network, although Havering 3, Lambeth 4 and Lambeth 5 measured 15 minute means above 266 μgm^{-3}.

The AQS 15 minute mean Objective was also met at all sites during the year ended June 2006, although Crystal Palace, Havering 3 and Tower Hamlets 1 measured 15 minute means above 266 μgm^{-3}.

The AQS hourly and daily mean Objectives were met at all sites during 2005 and the year ended June 2006.

Measurements during the photochemical episodes of July 2006 indicate a number of incidents where plumes from industrial sources in the East Thames area came to ground in London. These have not lead to a breach of the AQS Objectives at any site.

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