London-Wide Nitrogen Dioxide Diffusion Tube Survey

Annual Report 2001

Ref: CS/AQ/020260101/LL/1952
November 2002

Report

London-Wide Nitrogen Dioxide Diffusion Tube Survey Annual Report 2001

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Prepared for

London Borough of Barking & Dagenham
London Borough of Barnet
London Borough of Bexley
London Borough of Brent
London Borough of Camden
Corporation of London
London Borough of Croydon
London Borough of Ealing
London Borough of Greenwich
London Borough of Hammersmith
London Borough of Harrow
London Borough of Hillingdon
London Borough of Hounslow
Royal Borough of Kensington & Chelsea
London Borough of Newham
London Borough of Richmond-upon-Thames
City of Westminster

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Executive Summary

Casella Stanger has undertaken the London-Wide Environment Programme (LWEP) since 1986. The LWEP consists of the monitoring, analysis and reporting of key environmental indicators throughout the Greater London region.

Nitrogen dioxide has been regarded as a one of the main pollutants that need to be targeted due to the high road traffic emission levels that are found in London. London Boroughs have a statutory duty to regularly review and assess air quality within their remit. This process is coupled with the Greater London Authority's air quality management schemes that are outlined in the Mayor's strategy, and which takes an over-arching view on London-wide air quality issues. Subsequent air quality management schemes that are to be introduced indicate the necessity for monitored nitrogen dioxide data on a citywide scale in order to estimate the effect on a spatial and temporal basis. The LWEP is principally provided as a service for the London Boroughs.

The geographical spread shows higher concentrations in central parts of London and a reduction in concentration further away from the city centre.

Seventeen Boroughs reported annual average NO_2 concentrations at 326 individual sites. Annual average concentrations were equal to or above 40 $\mu g\ m^{-3}$ at 8 background and intermediate sites and 64 roadside sites.

Results from the year 2001 survey indicate a continued gradual decreasing trend in NO_2 concentrations at background, intermediate and roadside sites, although some Boroughs are beginning to see the rate of decline level off somewhat for some site classifications.

Linear trend analysis showed that mean intermediate and roadside concentrations within most participating Boroughs have shown a decreasing trend between 1993 and 2001. Mean background concentrations over the same period generally demonstrated no significant trend, with a slight decline exhibited by most Boroughs.

Contribution from road traffic to annual average NO_2 concentrations has shown a general decrease in many Boroughs, though eight Boroughs have displayed a general increase since 2000. These are London Borough of Camden, London Borough of Croyden, London Borough of Hammersmith and Fulham, London Borough of Hillingdon, London Borough of Hounslow, London Borough of Kensington and Chelsea, London Borough of Newham and London Borough of Westminster. However, some of these increases were not significant and may just reflect natural fluctuations rather than long-term trends.

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1 Introduction

The London-Wide Environment Programme (LWEP) has been managed by Casella Stanger (formerly Stanger Science and Environment (SSE)) since 1986, following on from its origin as the Greater London Council's Scientific Services Department.

The LWEP has been an on-going programme consisting of the monitoring, analysis and reporting of key environmental indicators throughout the Greater London region. One of the more important components are the monitoring of nitrogen dioxide (NO_2) by passive diffusion tubes as this is a cost effective method for assessing the spatial distribution of NO_2 and identifying hotspots in an urban environment.

In recent years it has proven to be a useful tool for local authorities in screening processes and baseline surveys and particularly with regards to the Review and Assessment process of local air quality management (Part IV of the Environment Act 1995). Additionally, the Greater London Authority (GLA) has been given an important role to play in the air quality management of the city by providing an additional London air quality strategy that must be taken into consideration by the local authorities when disposing of the above duties.

In year 2001 a total of 17 London Boroughs were part of the nitrogen dioxide London-Wide Environment Programme:

London Borough of Barking & Dagenham
London Borough of Barnet
London Borough of Bexley
London Borough of Brent
London Borough of Camden
Corporation of London
London Borough of Croydon
London Borough of Ealing
London Borough of Greenwich
London Borough of Hammersmith & Fulham
London Borough of Harrow
London Borough of Hillingdon
London Borough of Hounslow
Royal Borough of Kensington & Chelsea
London Borough of Newham
London Borough of Richmond-upon-Thames
City of Westminster

1.1 Objectives

The overall objective of this report is to provide subscribing local authorities with an overview of the NO_2 concentrations recorded as part of the LWEP NO_2 Diffusion Tube Survey in 2001 and to view these results in the broader context of regulatory requirements and previous monitoring data.

This overall objective will be met by:

- Outlining the reasons for undertaking the monitoring of ambient levels of NO_2;
- Outlining relevant existing and future legislative air quality requirements;
- Detailing the NO_2 sampling methods employed by Casella Stanger in undertaking the LWEP NO_2 Diffusion Tube Survey, including the quality assurance and quality control procedures used;
- Identifying areas within Greater London where receptors may be exposed to relatively high ambient levels of NO_2;
- Assessing the long term trend in NO_2 concentrations recorded as part of the LWEP NO_2 Diffusion Tube Survey since 1986;
- Reporting the annual average NO_2 concentrations at each site, for all participating boroughs in 2001 and to place the 2001 results in the context of other results gathered since 1993;
- Undertaking analysis of the results to assess trends in pollution at Background, Intermediate and Roadside classes for each participating borough; and
- Identifying the elevation in NO_2 concentrations at Roadside and Intermediate site classes when compared to Background levels in each participating borough.
- Validation of Casella Stanger nitrogen dioxide diffusion tubes. Analysis of results from co-located tubes at automatic analysers in London.
- Rigorous in-house QA/QC procedures through participation in the Workplace Analysis Scheme for Proficiency (WASP) and the NETCEN Field Inter-comparison Exercise.

2 Sources and Effects of NO_2

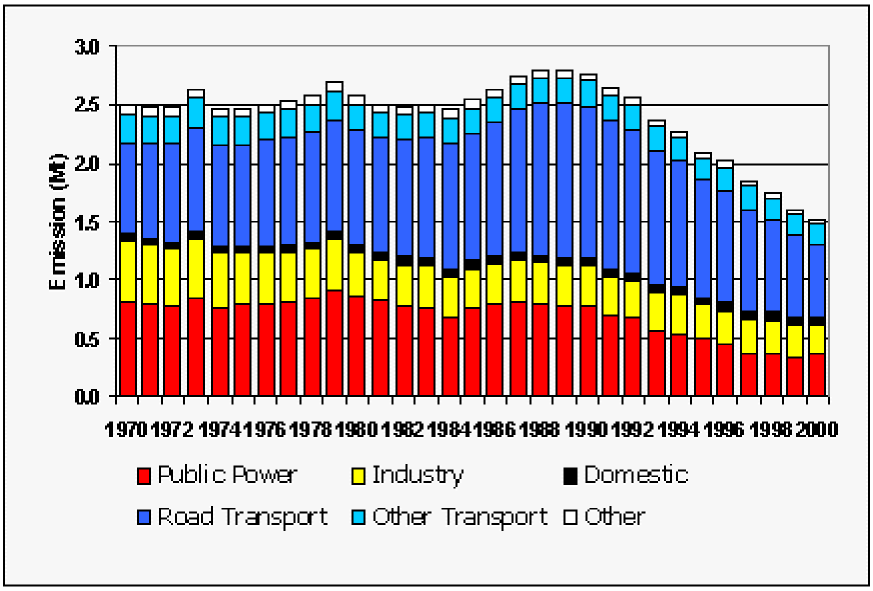
2.1 Emission sources

The greatest contributions to atmospheric oxides of nitrogen (NO_x), produced in the UK are from motor vehicles. Estimates indicate that 629,000 tonnes (42% of total emissions) were produced by road transport in 2000[1] (see Figure 1). Fossil fuelled power stations contributed around a quarter of the total NO_2 in the same year, whilst the remainder comes from a variety of sources including industry and domestic activity.

Overall there has been a reduction in NO_x emissions with 2000 levels being 39% below 1970 levels. Since 1989 the proportion of NO_x has declined by 46% as a result of a 53% decrease from road transport, mainly due to the introduction of catalytic converters and stricter regulations, and a 54% decrease in emissions from power stations.

Outdoor concentrations of NO_2 at ground level are influenced by the UK transport sector, which continues to be the major source of NO_x. Power stations and industrial plants are less important in this respect as they release pollutants into the atmosphere from tall stacks above the boundary layer.

Figure 1 Estimated UK Emissions of Nitrogen Oxides by Emission Source 1970 – 2000[2]



Oxides of nitrogen can also be produced biologically as part of the nitrogen cycle. The NO_2 produced by the combined effect of the soil, its bacteria, and vegetation may contribute to levels in some rural areas.

[1] Source: DEFRA (2002) Digest of Environmental Protection and Water Statistics. http://www.defra.gov.uk/environment/statistics/des/index.htm
[2] Source: National Atmospheric Emissions Inventory (2002) http://www.naei.org.uk/pollutantdetail.php

2.2 Formation of atmospheric nitrogen dioxide

NO_2 is the gaseous product of the reaction between nitrogen and oxygen. This reaction usually takes place in two stages, the first stage resulting in the formation of nitric oxide. The nitric oxide then undergoes a secondary reaction with oxygen atoms, usually derived from atmospheric ozone, to form nitrogen dioxide. NO_2 can in turn act as a future source of oxygen in the formation of ozone under photochemical conditions.

Due to the nature of the formation of nitrogen dioxide in the atmosphere, there is often an inverse relationship between concentrations of ozone and nitrogen dioxide.

Meteorological conditions have an influence on the production of NO_2. During the winter months anti-cyclonic weather systems often result in stable, cold weather conditions, which along with oxidation by atmospheric oxygen often produce pollution episodes. The product of such conditions is thought to be responsible for the extremely high nitrogen dioxide concentrations recorded over London in December 1991, when levels peaked at over 803.5 $\mu g\ m^{-3}$ (420 ppb) in the evening rush hour.

During the summer, increased temperatures and solar radiation serve to increase the rate of photochemical reactions in the atmosphere. The higher the concentration of NO_2 the more oxygen is available for the production of ozone.

2.3 Health Effects

Medical and epidemiological evidence suggests that nitrogen dioxide may have both acute and chronic effects on health.

Experimental evidence has shown that NO_2 probably exerts its biological damage by oxidation, with the primary toxic effect occurring in the respiratory system. Susceptible groups include young children, asthmatics and people with chronic respiratory diseases. It has also been shown that individuals sensitive to allergens will show a significant response to high concentrations of NO_2. Whilst there have been recorded responses in the susceptible groups listed, it has been demonstrated that individuals not suffering from respiratory disease will be, by-and-large, unaffected by air pollution episodes.

At present, there are still uncertainties concerning the effects of NO_2 exposure over a broader time scale, this is due to the wide range of modifying influences on the behaviour of a single pollutant. It is difficult statistically to separate the impacts on health of NO_2 from those of other pollutants. During the December 1991 episode particles were also recorded at high levels. It is probable that a synergistic combination of pollutants gives rise to detrimental health effects, as opposed to individual pollutants acting alone. Research conducted at St Bartholomew's Hospital in London showed that exposure of asthmatics to high SO_2 and NO_2 levels in combination can increase the subject's response to airborne allergens.

Many studies estimating the chronic effects of NO_2 use un-quantified and indirect measures of exposure, these do suggest that the effects of NO_2 exposure are significant.

3 Policy Framework

3.1 Standards and Objectives

Air quality standards relevant to nitrogen dioxide concentrations have undergone continuous change, both nationally and on a European level. For Europe, the First Air Quality Daughter Directive sets out limits for mean annual and hourly NO_2 concentrations and aims to achieve the objectives by 1st January 2010.

Air quality standards relevant to the UK are found in The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[3] (AQS). The document was published in January 2000, superseding the earlier National Air Quality Strategy[4] (NAQS) published in March 1997, and provides a revised framework for reducing air pollution at national and local levels from a wide range of emission sources. The AQS sets out two Air Quality Objectives (AQOs), one hourly and one annual (Table 1), and are in line with those set in the European Directive, although an earlier date for the objectives to be achieved is 31st December 2005 has been set.

The standards for the eight pollutants covered by the strategy have been provided by recommendations made by the Government's Expert Panel on Air Quality Standards (EPAQS). The objective levels have been based on medical and scientific evidence of how each pollutant affects human health. Factors such as economic efficiency, practicability, technical feasibility and timescale have also been taken into consideration by the government administration when setting the final objective values. Objectives for NO_2 are prescribed in the regulations for the purpose of Local Air Quality Management (LAQM) and thus have direct relevance to the diffusion tube network in London.

Table 1 Air Quality Objectives for nitrogen dioxide in AQS

	AQS Objectives		
	Concentration	**Measured as**	**Date to be Achieved by**
Hourly	200 µg m^{-3} (104.6 ppb) with a maximum of 18 exceedences*	1 hour mean	31 December 2005
Annual	40 µg m^{-3} (21 ppb)	Annual mean	31 December 2005

* Exceedence is defined as 'great than' for the AQS objectives.

3 DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working together for Clean Air"

4 DoE (1997) The United Kingdom National Air Quality Strategy

LAQM is at the heart of the AQS. Local authorities are charged with reviewing current air quality and assessing whether the relevant AQO will be achieved by 2005. Those authorities that conclude that one or more of the objectives are unlikely to be achieved, will be obliged to declare Air Quality Management Areas (AQMAs) and draw up action plans of how to reduce air pollution. Most London boroughs are declaring AQMAs on the prediction that the AQO for NO2 will not be met in 2005.

3.2 The Greater London Authority

The Greater London Authority (GLA), created under the Greater London Authority Act 1999 assumed its responsibilities on 3 July 2000. It was created to give London it's own decision making authority, which is in line with the Governments wider environmental, transport, economic and planning objectives.

As a result the Mayor has significant decision-making abilities being charged, amongst other things, with the responsibility for the London-wide environment and a duty to promote the health of Londoners. The Mayor has a duty to develop an air quality management strategy, in consultation with the London Boroughs, to deliver improvements to air quality in London and is required to include proposals and policies from the National AQS as well as any other proposals and policies that the Mayor considers appropriate. The Mayor's Air Quality Strategy was published in September 2002, and states that among others meeting targets for NO_2 is the primary concern of the strategy.

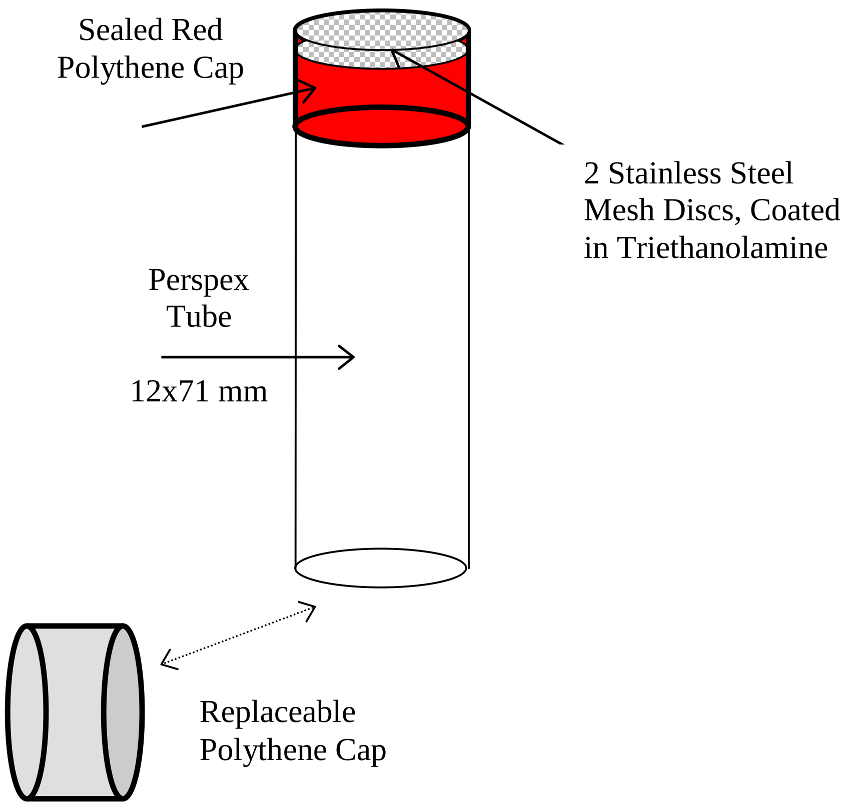
The strategy recognises that road traffic is the primary cause of air pollution in London and is consequently linked to other relevant strategies and measures taken by Transport for London (TfL), the Greater London Authority, and the London Development Agency (LDA). TfL in particular will be instrumental in tackling this problem with implementation of measures to reduce traffic, promote cleaner technology, reduce current emissions and by promoting and adopting alternative fuels. New schemes such as a congestion charging zone around London and the anticipated Low Emission Zone are likely to lead to environmental benefits. In addition to road traffic, commercial and domestic space heating is another large source of NO_2 though measures needed to reduce this emission source are yet uncertain. Long term monitoring of NO_2 by diffusion tube with it's geographical spread across London will aid in determining the effect of a number of these policies in the future.

4 NO_2 Sampling Methods

4.1 Diffusion Tubes

Diffusion tubes are passive monitoring devices. They are made up of a Perspex cylinder, with 2 stainless steel mesh discs, coated with triethanolamine held inside a polythene cap, which is sealed onto one end of the tube. The diffusion tube has an internal dimension of 12mm diameter x 71mm length (Figure 2).

Figure 2 NO_2 Diffusion Tube Components



Diffusion tubes sample NO_2 when ambient concentrations enter and pass up through the tube and are absorbed by the triethanolamine, which is present on the coated discs[5].

Prior to and after sampling, an opaque polythene cap is placed over the opposite end of the diffusion tube to prevent further adsorption onto the discs.

The diffusion tubes are labelled and kept refrigerated in plastic bags prior to and after exposure.

4.2 Sampling

As results from the LWEP are incorporated into the National Nitrogen Dioxide Diffusion Tube Survey, the tubes are exposed for a four - five week period, consistent with the national survey. The 2001 exposure dates are set out in Table 2.

Table 2 UK Nitrogen Dioxide Survey Monitoring Periods, 2001[6]

Month	Start Date	Duration (Weeks)
January	2 January	4 weeks
February	30 January	4 weeks
March	27 February	5 weeks
April	3 April	4 weeks
May	1 May	4 weeks
June	29 May	5 weeks
July	3 July	4 weeks
August	31 July	5 weeks
September	4 September	4 weeks
October	2 October	4 weeks
November	30 October	5 weeks
December	4 December	4 weeks

Adherence to the change over dates is important to enable as valid an inter-comparison as possible between boroughs.

Sites included in the LWEP NO_2 Diffusion Tube Survey are given a site classification based upon the location of the site. The definitions of the site classes used in the LWEP NO_2 survey are broadly based upon those used in the national survey and are set out in Table 3. In some cases the classification may differ from the range listed below as the distance to main road source is subject to individual site characteristics.

5 Source: Chemistry and Microbiology - 'Determination of Nitrogen Dioxide in Environmental Samples'; Stanger Science and Environment. 1991.

6 Source: NO_2 Diffusion Tube Calendar, at: http://www.aeat.co.uk/netcen/airqual/data/nonauto/no2caldr.html

Table 3 Site Selection Criteria for NO_2 Diffusion Tubes

Classification	Symbol	Distance From Source/Road
Roadside	R	0-20m
Intermediate	I	20-40m
Background	B	>40m

Since

December 2000 the UK NO_2 Diffusion Tube Network no longer included sites of the 'intermediate' classification, since it was found that these sites provided little information and they are not required for LAQM purposes specified in the Technical Guidance Note LAQM.TG1 (00). However, some Boroughs have continued to monitor at sites within this classification and therefore they have been included in this report. Further details of site classification and other technical guidance for the use of NO_2 tubes can be found in the UK NO_2 Diffusion Tube Network Instruction Manual at:
http://www.aeat.co.uk/netcen/airqual/reports/no2man/no2man.html.

4.3 Analysis

Analysis of the returned diffusion tubes is undertaken by UKAS accredited Gradko International Ltd. laboratory, based in Winchester, Hampshire on behalf of Casella Stanger.

4.4 Quality Assurance and Quality Control

In order to maintain the highest degree of confidence in our results, Casella Stanger has from June 1999 onwards taken part in the Health and Safety Laboratory WASP[7] NO_2 diffusion tube scheme. This is a recognised performance-testing programme for laboratories undertaking NO_2 diffusion tube analysis as part of the UK NO_2 monitoring network. The scheme is designed to help laboratories meet the European Standard EN482[8]. The laboratory performance for all months in 2001 was rated 'good' which signifies results a laboratory with excellent quality control can achieve.

7 Health and Safety Executive, Workplace Analysis Scheme for Proficiency

8 European Committee for Standardisation (CEN) Workplace Atmospheres, General requirements for the performance of procedures for the chemical measurement of chemical agents, EN482, Brussels, CEN 1994.

Table 4 2001 Nitrogen dioxide Survey – Workplace Analysis Scheme for Proficiency Results

Month	Analyte	Performance
January	QC Solution	Good
February	QC Solution	Good
March	QC Solution	Good
April	QC Solution	Good
May	QC Solution	Good
June	QC Solution	Good
July	QC Solution	Good
August	QC Solution	Good
September	QC Solution	Good
October	QC Solution	Good
November	QC Solution	Good
December	QC Solution	Good

Casella Stanger also participated in the '2001 Field Inter-comparison Exercise' which compliments the WASP scheme in assessing sampling and analytical performance of diffusion tubes under normal operating conditions. The Casella Stanger diffusion tubes exhibited a bias relative to the automatic analyser within the set target of $\pm$25%.

In addition Casella Stanger conducted an 'in-house' study to establish the bias of the NO_2 diffusion tube sampling method compared with continuous analysers which give more accurate concentrations. This study examines results from triplicate exposures of diffusion tubes that have been co-located with continuous analysers in London as part of the LWEP 2001 programme. The study shows that the mean bias is –26.7% (range = –19.8 to –37.5%) across the sites.

Gradko International Ltd. perform their own blank exposures and all results are blank subtracted before they are issued to their relevant Borough.

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5 Overview of Results

5.1 Data Capture Statistics

The number of tubes exposed at each site class is to the discretion of each local authority involved in the monitoring programme. As NO_2 concentrations in London are mainly attributed to road transport there is a strong bias towards roadside site locations as opposed to intermediate and background sites. Figure 3 shows the overall percentage of each site classification included in the study and Table 5 gives the percentage data capture for year 2001 for each borough.

Figure 3.Percentage of monitoring sites by classification

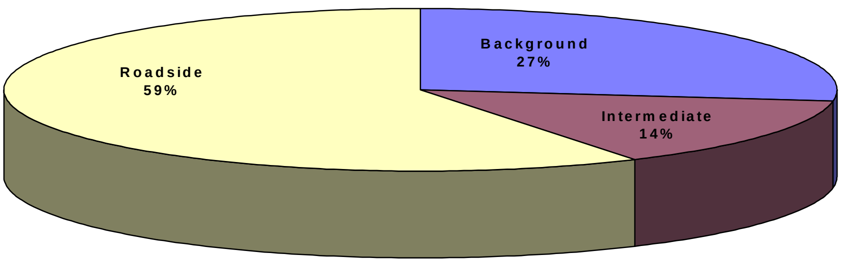


Table 5. Percentage data capture for each Borough in year 2001

London Borough	% Data Capture year 2001*
London Borough of Barking & Dagenham	100
London Borough of Barnet	90
London Borough of Bexley	86
London Borough of Brent	99
London Borough of Camden	94
Corporation of London	89
London Borough of Croydon	88
London Borough of Ealing**	70
London Borough of Greenwich	85
London Borough of Hammersmith & Fulham	98
London Borough of Harrow	94
London Borough of Hillingdon	83
London Borough of Hounslow	90
Royal Borough of Kensington & Chelsea	97
London Borough of Newham	88
London Borough of Richmond-upon-Thames	96
City of Westminster	82

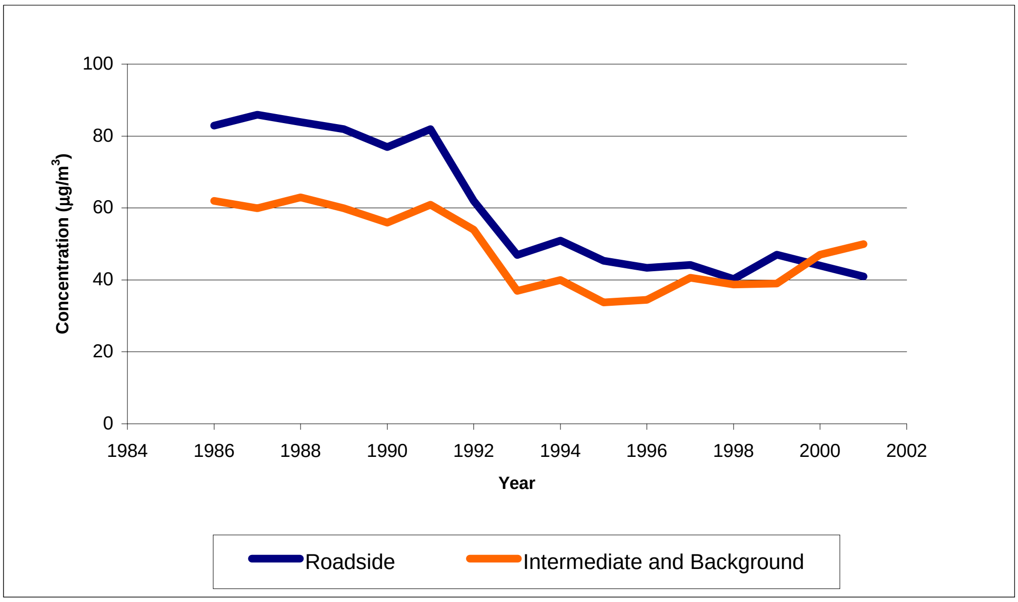
*The value refers to number of months data was captured.

** Sampling commenced in April 2001

5.2 Long Term Trends

The NO_2 Diffusion Tube Survey has since 1986 been recording NO_2 concentrations for 12 sites on a continuous basis. The introduction of the UK Nitrogen Dioxide Diffusion Tube Survey in 1993 and the resultant increase in exposure time from 2 to 4/5 weeks showed a distinct change in long-term concentrations.

Figure 4 Long-term mean concentrations at selection of LWEP sites



Site GW32 was taken out of use in 1999 and site TH31 was taken out of use in 2000. The results in the above figure do not therefore include results for these sites for the relevant years.

Table 6 Roadside, intermediate and background sites surveyed since 1986 as part of the London Wide NO_2 diffusion tube survey.

Roadside Sites	Background & Intermediate Sites
CL36	BR31
CL38	TH31
GW32	
GW33	
GW34	
GW35	
HM32	
TH32	
WM32	
WM36	

Either side of 1992 and 1993, mean concentrations at all site classes appear to have fallen at a relatively constant rate. The time series indicates a long-term decrease in NO_2 concentrations at all site classes since 1993 though intermediate and background sites show an increase in years 2000-2001 that rose above roadside concentrations. The increase is likely to be attributed to the limited available data for this year, as removal of sites has resulted in just one background and intermediate site (BR31) remaining in these years, compared with 9 roadside sites. Concentrations at BR31 site used are uncharacteristically high for that site classification.

5.3 Nitrogen dioxide concentrations – Geographical spread

In 2001, background and intermediate concentrations were generally found to be higher in Boroughs situated towards the centre of London.

Overall there were 326 sites reporting in 2001 from 17 Boroughs. A total of 72 of these sites recorded an annual mean of NO_2 concentrations greater than the 2005 AQO of 40 $\mu g/m^3$. Of these, 8 sites belong to the category of intermediate or background sites whilst 64 were classified as roadside sites.

Maps 1 and 2 show the geographical spread of the annual mean concentrations for the nitrogen dioxide diffusion tube survey across London. The maps do not include data from Boroughs other than the ones that are part of the London Wide Environment Programme for nitrogen dioxide.

The background and intermediate concentrations range between 18 – 51 $\mu g\ m^{-3}$ (mean = 29 $\mu g\ m^{-3}$). The higher NO_2 levels are concentrated around central parts of London while further away from the centre the levels tend to decrease.

The roadside sites range between 19 – 62 $\mu g\ m^{-3}$ (mean = 37 $\mu g\ m^{-3}$). Similar to the intermediate and background sites the geographical spread shows higher concentrations towards central London with lower concentrations further away from central parts of the city.

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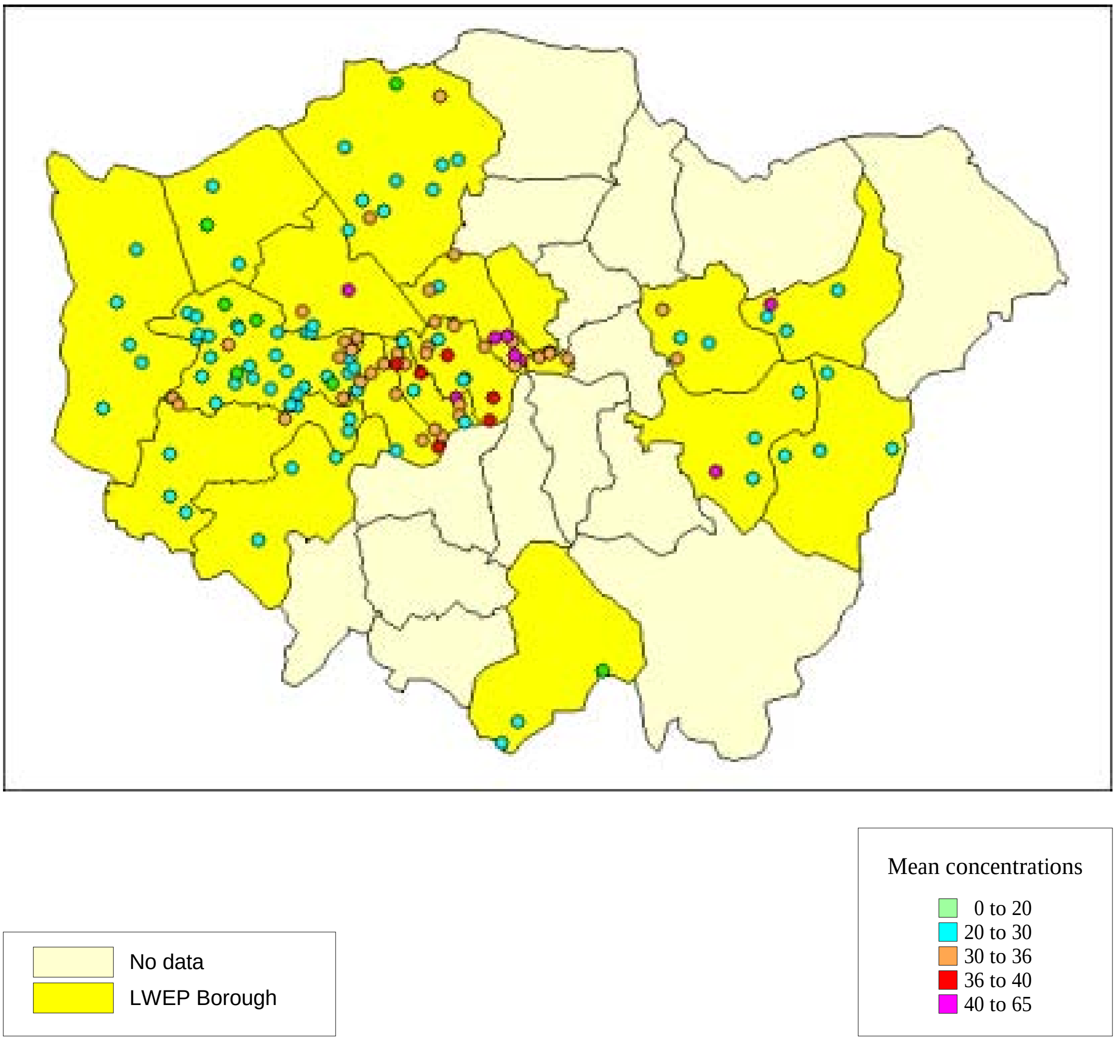
Map 1 2001 Mean Background and Intermediate NO_2 diffusion tube Concentrations by Site Location



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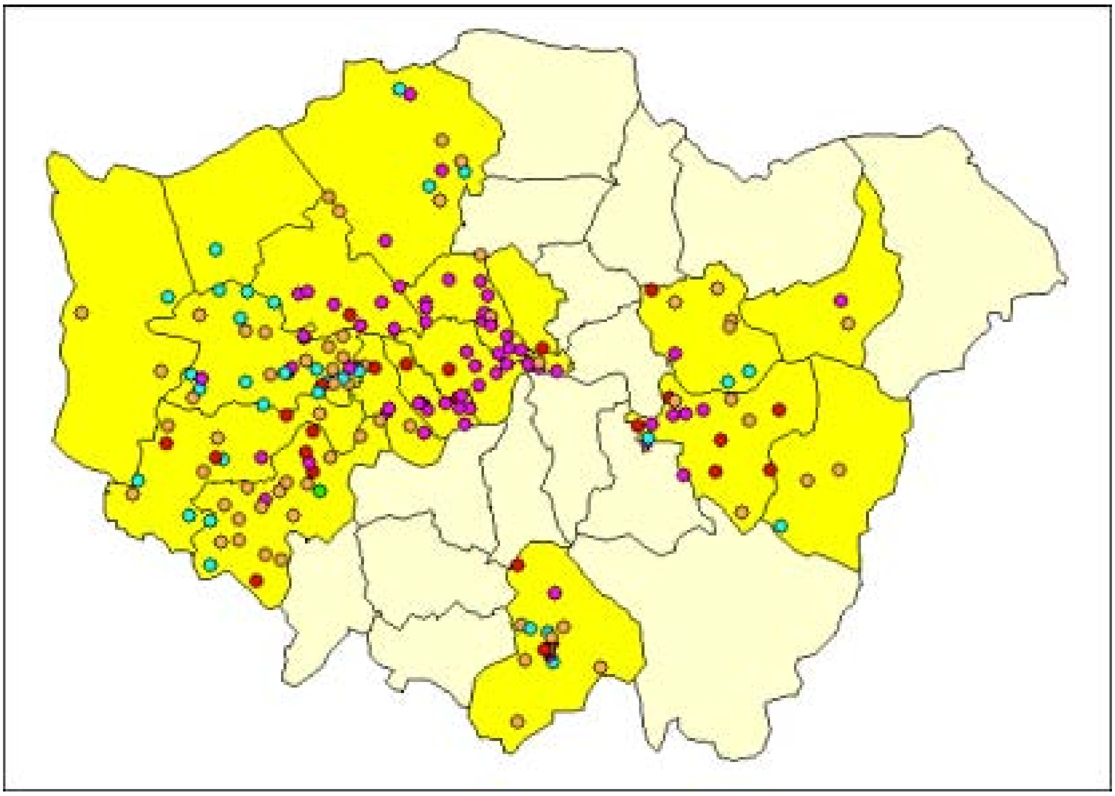
Map 2 2001 Annual Mean Roadside NO_2 diffusion tube Concentrations by Site Location



No data
LWEP Borough

Mean concentrations
0 to 20
20 to 30
30 to 36
36 to 40
40 to 65

6 Reporting - Participating Boroughs

6.1 Introduction

For the 2001 LWEP NO_2 Report, results and analysis can be viewed in two sections for each of the participating boroughs.

The first section reports the year 2001 results for individual sites and places them in context with other values for the same sites recorded over recent years since 1993.

The second section focuses on the analysis of the results of recent years. Trends are assessed for each site class, with the variation between site classes is also analysed to identify patterns in NO_2 concentrations.

All results have been recorded as the mean annual concentration in $\mu g\ m^{-3}$, in order to allow direct comparison of results with the AQS annual average Air Quality Objective of 40 $\mu g\ m^{-3}$ in 2005.

6.2 Reporting of Results

6.2.1 2001 Mean Values

Bar charts have been created showing the 2001 annual average NO_2 concentration recorded at each site included in the LWEP survey. Unless indicated, all mean annual values have been calculated from at least 6 months of validated monitoring data[9].

The sites have been classified by distance from the nearest major road into Background, Intermediate and Roadside (Table 3).

25% error bars have been included to represent the acceptable level of variability of NO_2 diffusion tube monitoring stated in the data quality objective as set out in the European Union Daughter Directive for NO_2[10].

6.2.2 Site Time Series

Time series plots have been created for sites with up to 8 years of continuous monitoring data. Each time series plot contains data for sites as grouped by their site class.

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[9] Source: Urban Air Quality in the United Kingdom. First Report of the Quality of Urban Air Review Group. DoE. January 1993.
[10] Source: Directive 96/62/EU.

6.3 Analysis of Results

6.3.1 Trend Analysis by Site Class

Monitoring sites with a minimum of 5 years continuous data were first identified. Individual concentrations were then grouped by site class to provide an arithmetic mean for each site class.

The mean annual class concentrations have been plotted and a simple linear trend model applied to assess whether concentrations have generally risen or fallen at background, intermediate and roadside locations within each Borough.

6.3.2 Intermediate & Roadside Elevation

Mean annual background concentrations were subtracted from mean annual intermediate and roadside concentrations to produce 3-dimensional elevation graphs.

The subtraction of the background component may provide an indication of the level of NO_2 being received at intermediate and roadside locations from road transport sources.

Sites were only included in the calculation of mean annual concentrations for each site class if consistent and valid data was available. Any sites with 1 or more years of absent or invalid data were not used.

7 Analysis of Results – Participating Boroughs

7.1 London Borough of Barking and Dagenham

2001 Mean Values

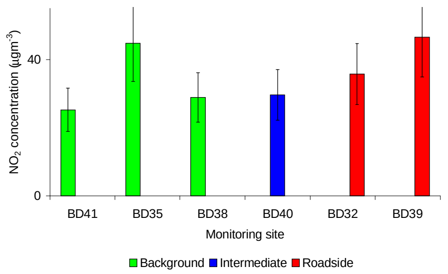

Figure 5 Barking & Dagenham annual Average NO_2 Concentrations, 2001

Annual average background concentrations ranged between 25 and 45 µg m^{-3}.

The intermediate site had an average of 30 µg m^{-3}. BD35 has exceeded the 2005 AQO of 40 µg m^{-3} this year. The remaining background and intermediate sites are well below the objective.

The annual average for roadside sites was 36 µg m^{-3} at BD32 and 47 µg m^{-3} at BD39. The latter exceeds the 2005 AQO whilst BD32 is approaching the exceedence level.

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Site Time Series

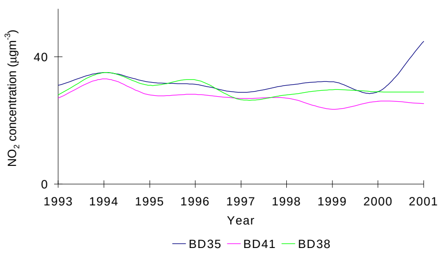

Figure 6 Barking & Dagenham Background Sites Time Series, 1993 – 2001

The background sites have shown a fairly static trend between 1993 and 2000. The annual averages at sites BD41 and BD38 have remained constant the past year, however BD41 has increased by 55% since 2000.

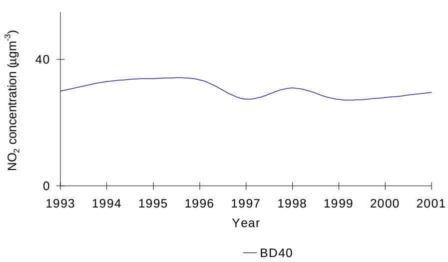

Figure 7 Barking & Dagenham Intermediate Sites Time Series, 1993 – 2001

The intermediate site has shown a degree of fluctuation in recent years, with the overall trend remaining fairly static. The annual average at BD40 increased slightly since 2000.

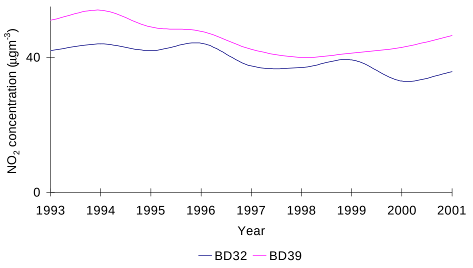

Figure 8 Barking & Dagenham Roadside Sites Time Series, 1993 – 2001

Roadside concentrations show a marked increase at BD32 and BD39. Generally the two sites have show fluctuating values with BD39 showing a slight downward trend.

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Trend Analysis by Site Class

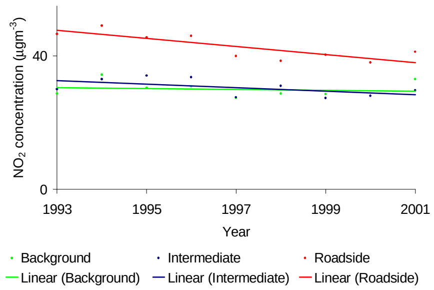

Figure 9 Barking & Dagenham Trend Analysis, 1993 – 2001

Linear trend analysis reveals a decreasing or static trend at all site classes between 1993 and 2001.

Background and intermediate concentrations remain below the 40 µg m^{-3} 2005 AQO. Intermediate concentrations have slowly declined whilst background concentrations have remained more or less the same. In contrast roadside sites have had a more dramatic decrease over the same period.

These decreasing trends indicate a reduction in NO_2 from road traffic sources.

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Intermediate & Roadside Elevation

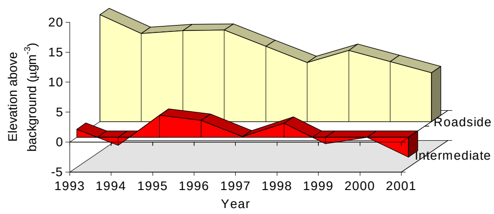

Figure 10 Barking & Dagenham Intermediate & Roadside Elevation 1993 – 2001

Figure 10 shows mean intermediate and roadside concentrations above mean background concentrations. This makes it possible to estimate the contribution of road traffic to NO_2 concentrations at these sites.

The level at the intermediate site has remained fairly close to background concentration, fluctuating between –3.3 and 3.7 µg m^{-3}, showing no evidence of a trend.

The levels at the roadside sites are higher than the intermediate site and appear to have a downward trend over the same time period.

The analysis confirms that generally the contribution from road traffic seems to be declining.

7.2 London Borough of Barnet

2001 Mean Values

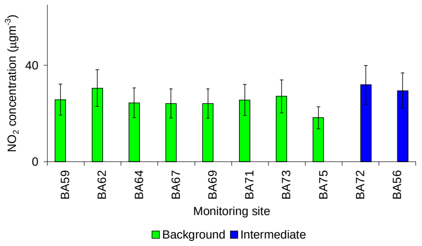

Figure 11 Barnet Background & Intermediate Annual Average NO_2 Concentrations, 2001

Background sites in Barnet recorded values of between 18 μg m^{-3} and 30.5 μg m^{-3} in 2001. All sites were below the 2005 AQO. The background site BA75 was introduced for the first time in 2001.

Intermediate sites recorded annual mean values 29 μg m^{-3} and 32 μg m^{-3}. Again none of the sites exceed the 2005 AQO level.

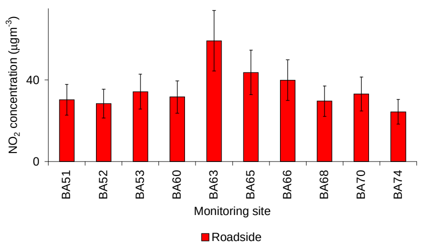

Figure 12 Barnet Roadside Annual Average NO_2 Concentrations, 2001

Roadside sites recorded values ranging from 24 μg m^{-3} at BA74 up to 59 μg m^{-3} at BA63. Two of the sites exceeded the 2005 AQO of 40 μg m^{-3}. The roadside site BA74 was introduced for the first time in 2001

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Site Time Series

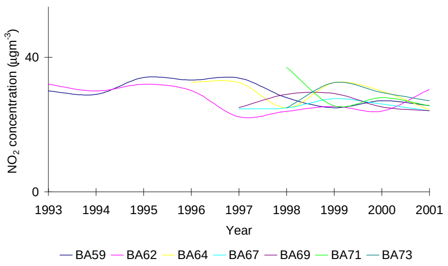

Figure 13 Barnet Background Sites Time Series, 1993-2001

Levels at BA62 have increased slightly since 2000 whilst all remaining sites have decreased. Overall, there is no clear pattern though variations between concentrations are less than in previous years.

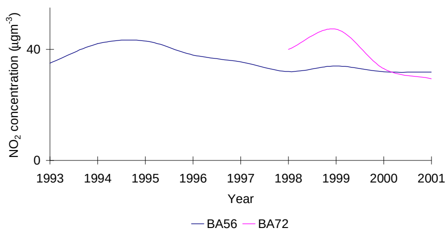

Figure 14 Barnet Intermediate Sites Time Series, 1993-2001

Intermediate site BA56 peaked in 1994, then declined steadily until levelling off and showed annual average level of 32 μg m^{-3} in 2000 and 2001. Site BA72 has declined significantly over the last two years, the concentration in 2001 was 29μg m^{-3}.

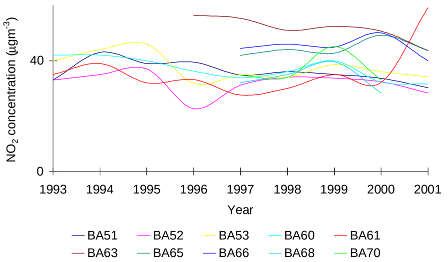

Figure 15 Barnet Roadside Sites Time Series, 1993-2001

All roadside sites showed decreased concentrations in 2001 with the exception of BA61, which showed a sharp increase from previous years. There is no general pattern as concentrations have fluctuated in previous years.

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Trend Analysis by Site Class

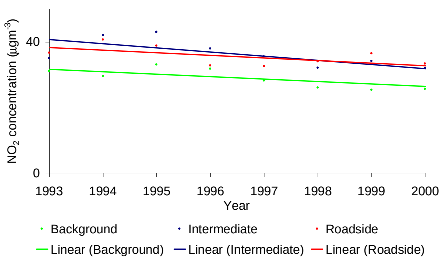

Figure 16 Barnet Trend Analysis, 1993-2001

Linear trend analysis of mean concentrations shows the decreasing trend for all classes continued in 2001.

The decline in background and intermediate site classes is greater than the roadside site class.

Annual mean concentrations for all classes were above the long-term trends.

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Intermediate & Roadside Elevation

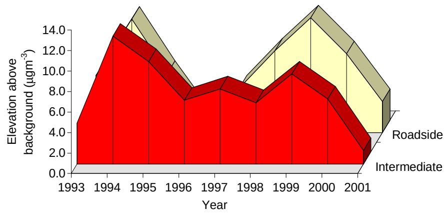

Figure 17. Barnet Intermediate & Roadside Elevation, 1993-2001

Generally, both intermediate and roadside sites have followed a similar pattern between 1993 and 2001. A significant increase was observed in 1994, followed by a steep decline at both site classes. The concentrations increased from 1996/97, peaking in 1999 and then falling again during years 2000 and 2001.

Both site classifications were at the lowest elevation to date in 2001, being 1.3 and 3 µg m^{-3} above background concentrations for intermediate and roadside sites respectively. This indicates that NO_2 concentrations from traffic sources have become less significant, particularly in the last year.

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7.3 London Borough of Bexley

2001 Mean Values

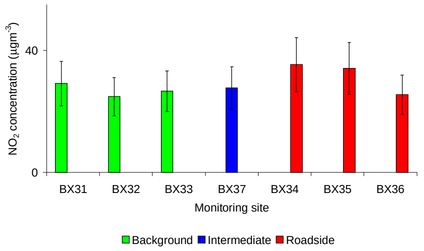

Figure 18 Bexley Annual Average NO_2 Concentrations, 2001

Background and intermediate sites showed values well below the 2005 annual average AQO of 40 µg m^{-3}in the year 2001. Roadside site averages were also safely below the AQO.

Annual average background values ranged from 25 µg m^{-3} to 29 µg m^{-3} at the monitored sites. The intermediate site had an annual average of 28 µg m^{-3}.

Roadside annual average values ranged from 25.5 µg m^{-3} at BX36 up to 35 µg m^{-3} at BX34.

- - -

Site Time Series

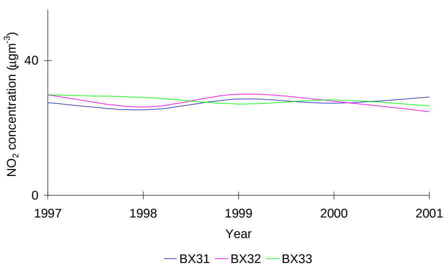

Figure 19 Bexley Background Sites Time Series, 1997-2001

The time series of annual average background concentrations from 1997 to 2000 shows that all sites have remained relatively constant at levels just below 30 µg m^{-3}.

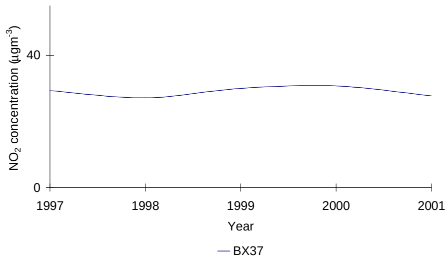

Figure 20 Bexley Intermediate Site Time Series, 1997-2001

Similarly, annual average concentrations recorded at the intermediate site BX37 have also remained fairly static during the same period.

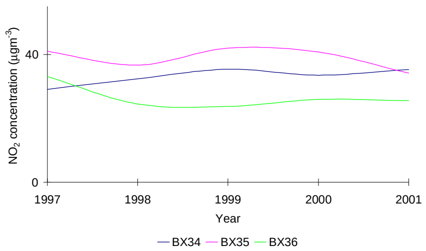

Figure 21 Bexley Roadside Sites Time Series, 1997-2001

Since 1999, annual average roadside concentrations at BX34 and BX36 have remained fairly constant and below the AQO whilst concentrations for BX35 have shown a gradual decline.

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Trend Analysis by Site Class

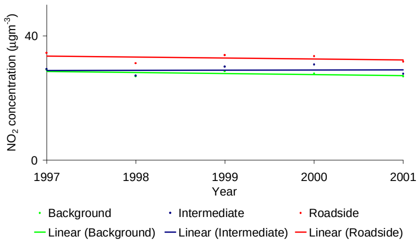

Figure 22 Bexley Trend Analyses, 1993 – 2001

Since 1998 the overall annual average concentrations at all site classifications have remained constant, and as yet there is no evidence of a trend occurring.

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Intermediate and Roadside Elevation

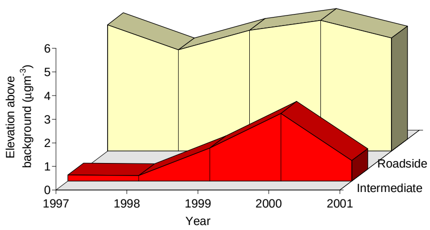

Figure 23 Bexley Intermediate & Roadside Elevation, 1997-2001

The intermediate site in Bexley has recorded a concentration close to the mean background concentration in both 1997 and 1998. However, concentrations increased above background levels between 1999 and 2000. The elevation dropped back to the 1999 level of 1µg m^{-3} in 2001.

The mean concentration at roadside sites dipped slightly from 1997 to 1998. The elevation above background increased in 1999 and 2000. In 2001 the elevation dipped once more, although not as much as the decline seen at the intermediate site, and overall the elevation has been quite consistent, fluctuating been between 4-6 µg m^{-3} since 1997.

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7.4 London Borough of Brent

2001 Mean Values

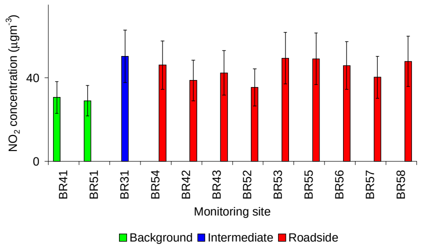

Figure 24 Brent Annual Average NO_2 Concentrations, 2001

In 2000 annual average concentrations recorded at background sites in Brent showed results of 29 µg m^{-3} and 31 µg m^{-3}.

The intermediate site BR31, has risen in NO_2 concentrations for the second consecutive year and is currently exceeds the 2005 AQO with an annual average of 50 µg m^{-3}.

Concentrations recorded at roadside sites varied between 35 µg m^{-3} at BR52 and 49 µg m^{-3} at both BR53 and BR55. In all, 7 out of the 9 roadside sites equalled or exceeded the 2005 AQO.

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Site Time Series

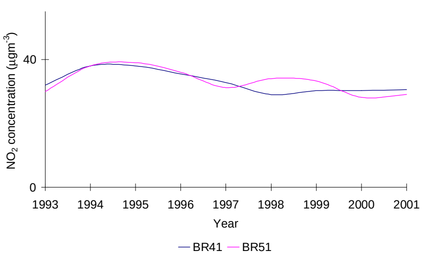

Figure 25 Brent Background Sites Time Series, 1993-2001

Concentrations at both background sites followed a similar trend and fell steadily to 1997, after peaking in 1995. Site BR41 continued to follow a downward trend to 1999 and levelled off, whilst BR51 has fluctuated somewhat before levelling off in 2000.

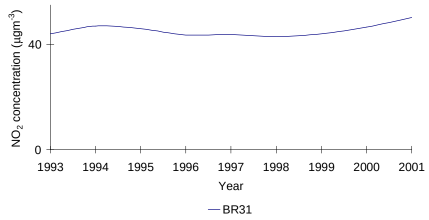

Figure 26 Brent Intermediate Sites Time Series, 1993-2001

Concentrations at the intermediate site have been fairly stable through the monitored period, although year 2001 has shown a continued slow rise in concentration, and it is now the highest level to date.

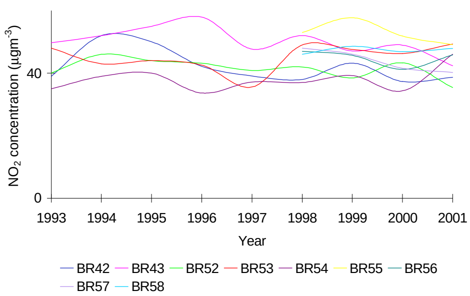

Figure 27 Brent Roadside Sites Time Series, 1993-2001

Roadside concentrations at BR42 and BR54 seem to follow a similar trend and have both increased in 2001 whilst BR43 and BR52 have decreased, this is the opposite pattern to the previous year. BR55 has also decreased in 2001, and BR56 has increased. Most sites have fluctuated on a yearly basis with no clear trend, although BR53 and BR58, and to a lesser extent, BR57 have levelled off.

Trend Analysis by Site Class

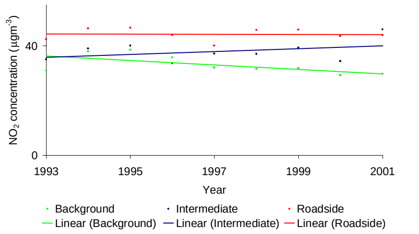

Figure 28 Brent Trend Analyses, 1993-2001

Linear trend analysis shows that the background site class displays a decreasing linear trend, and the roadside class displays no clear trend. The intermediate site class shows a steadily increasing trend.

Overall concentrations show high levels for the roadside class followed by the intermediate class, and background class respectively.

The increase in concentration at site BR31 has resulted in this intermediate site approaching the roadside site levels.

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Intermediate & Roadside Elevation

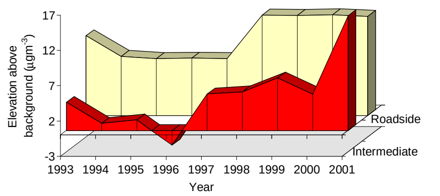

Figure 29 Brent Intermediate & Roadside Elevation, 1993-2001

Figure 29 shows elevated intermediate and roadside concentrations above background levels.

The elevation at intermediate locations increased sharply in 2001 from the 2000 level of 4 µg m^{-3} above background concentrations to 16 µg m^{-3}. Since 1996 the elevation has increased above 1993 levels with only a slight decrease between 1999 and 2000.

Between 1993 and 1996, the elevation at roadside locations remained stable. In 1996 the elevation showed a stepwise increase, after which the elevation has remained stable at 14 µg m^{-3} each year.

Generally, the pattern emerging from the Figure 28 suggests that local changes in traffic flow may have affected the traffic contribution to total NO_2 concentrations at site BR31 during monitoring period, as there appears to be an increasingly important source nearby. Traffic continues to be a major contributor to elevated NO_2 levels at roadside sites.

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7.5 London Borough of Camden

2001 Mean Values

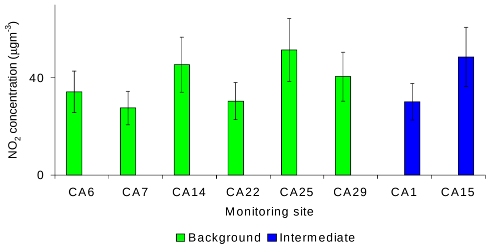

Figure 30 Camden Background & Intermediate Annual Average NO_2 Concentrations, 2001

2001 saw the introduction of two new background sites, CA25 and CA29. NO_2 concentrations at three background sites and one intermediate site equalled or exceeded the 2005 AQO in 2001, including the two new sites.

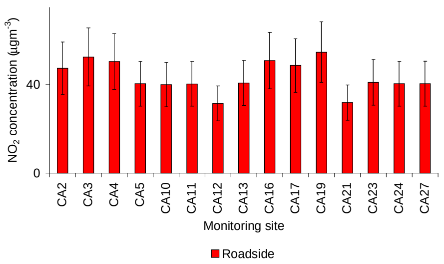

Figure 31 Camden Roadside Annual Average NO_2 Concentrations, 2001

Only two of the 15 roadside sites showed annual average NO_2 concentrations that fell below the 2005 AQO. Roadside concentrations ranged between 32 µg m^{-3} at sites CA12 and CA21 to 55 µg m^{-3} at site CA19.

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Site Time Series

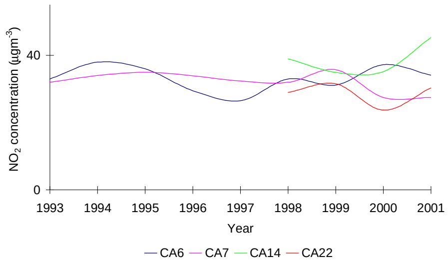

Figure 32 Camden Background Sites Time Series, 1993-2001

Background concentrations at CA7 have shown only minor fluctuations since 1993 with a decrease between 1999 and year 2000. 2001 saw concentrations stay at the 2000 level. Site CA6 has shown a greater degree of fluctuation. The 2001 concentration is slightly lower than the previous year. Concentrations at sites CA14 and CA22 dipped in 2000, but in 2001 they increased to 45 and 30 µg m^{-3} respectively.

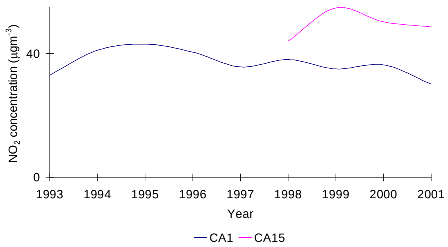

Figure 33 Camden Intermediate Sites Time Series, 1993-2001

The concentrations measured at the intermediate site CA1 exceeded the AQO between 1994 and 1996. The level has however decreased and shows a downward trend, falling to 30 µg m^{-3} in year 2001. Site CA15 exceeds the 2005 AQO in all years from 1998.

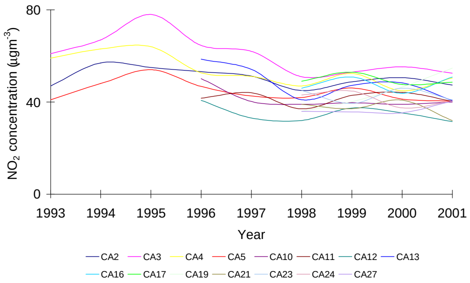

Figure 34 Camden Roadside Sites Time Series, 1993-2001

Concentrations at roadside sites had a peak in 1995 after which there was a decreasing trend to 1998. 1999 showed a rise in concentrations. More recently fluctuations have been less marked. In 2001 the biggest increases were seen at CA4, CA16, CA19, CA24 and CA27. Concentrations at CA10 and CA17 remained fairly constant from the previous year, whilst decreases were observed for CA2, CA3, CA5, CA11, CA12, CA13, CA21 and CA23.

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Trend Analysis by Site Class

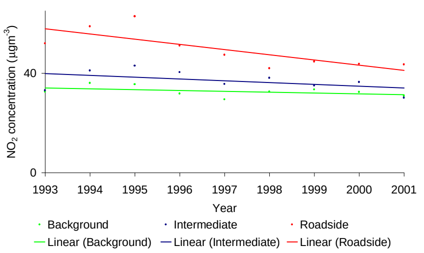

Figure 35 Camden Trend Analysis, 1993-2001

Linear trend analysis reveals a decreasing trend in all site classes with annual average values for year 2001 close to the respective trendlines for background and roadside sites.

Background and intermediate sites display a similar degree of reduction in concentration over the monitored period.

The roadside sites show a comparatively steep decline in concentration over time, though it remains above the 2005 AQO of 40 $\mu g\ m^{-3}$ even in year 2001.

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Intermediate & Roadside Elevation

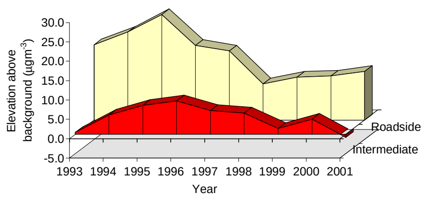

Figure 36 Camden Intermediate & Roadside Elevation, 1993-2001

The concentration elevation at intermediate and roadside site classes is shown above in Figure 36.

The intermediate class was close to background levels in 1993. After a peak in 1996 the concentrations dropped to 1999, increased slightly in 2000, and in 2001 dropped again to 0.8$\mu g\ m^{-3}$ below background concentrations.

Throughout the same period, the roadside class showed a greater elevation above background values than the intermediate sites. Roadside elevation values rose between 1993 and 1995 after which they fell below 1993 levels in 1998. The concentrations have risen since then but remain below 1993 levels which suggests a general reduction in the contribution from road traffic sources within the Borough over the monitoring period, although in 2001 it had increased slightly above the 2000 level.

7.6 Corporation of London

2001 Mean Values

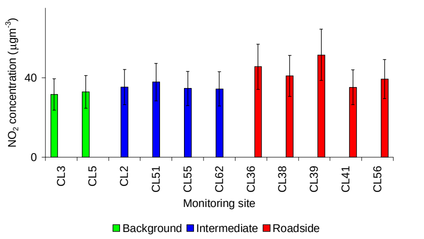

Figure 37 Corporation of London Annual Average NO_2 Concentrations, 2001

Monitored concentrations at background sites were measured at an annual average of 32 µg m^{-3} and 33 µg m^{-3} in 2001, which is below the 2005 AQO level of 40 µg m^{-3}.

Intermediate sites recorded values between 34 µg m^{-3} and 38µgm^{-3}.

Roadside values ranged between 35 µg m^{-3} and 51.5 µg m^{-3}. Three out of five roadside sites exceeded the 2005 AQO, one site was close to exceeding, with a concentration of 39 µg m^{-3}.

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Site Time Series

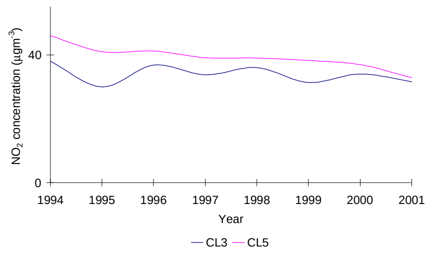

Figure 38 Corporation of London Background Sites Time Series, 1994-2001

Background site CL5 has shown a gradual decrease in concentration since 1993. CL3 has had a similar trend but with fluctuating concentrations and a less apparent decrease in concentration.

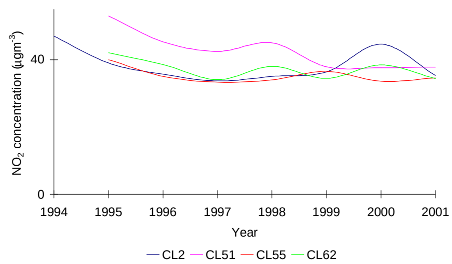

Figure 39 Corporation of London Intermediate Sites Time Series, 1994-2001

All intermediate sites have decreased over time with CL2 and CL62 having a peak in 2000. In 2001 none of the intermediate sites exceeded the 2005 AQO, although CL51 was close at 38 µg m^{-3}.

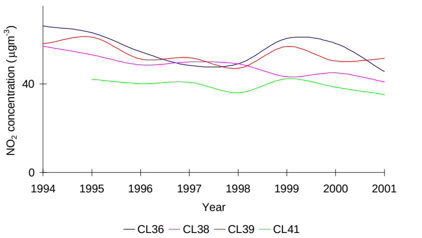

Figure 40 Corporation of London Roadside Sites Time Series, 1994-2001

All roadside sites show a general decrease in NO_2 concentration throughout their monitoring period with fluctuating concentrations. 1999 showed an increase, but concentrations have reverted back to previous levels since. All site concentrations decreased in 2001 with the exception of CL39. All concentrations are lower in 2001 than they were at the beginning of the monitoring period.

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Trend Analysis by Site Class

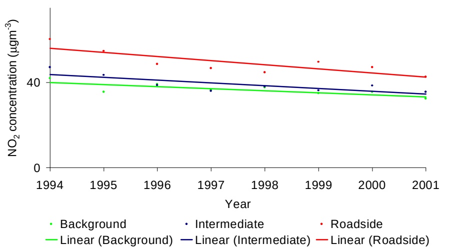

Figure 41 Corporation of London Trend Analysis, 1994-2001

Linear trend analysis indicates a clear declining trend at all site classes. The decline has been most significant at the roadside and intermediate sites.

The background sites have shown a less significant decline keeping just below the 2005 AQO.

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Intermediate & Roadside Elevation

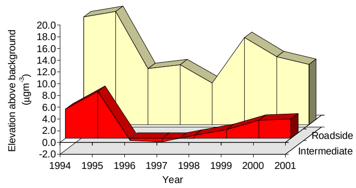

Figure 42 Corporation of London Intermediate & Roadside Elevation, 1994-2001

Figure 42 shows elevation above background concentrations for intermediate and roadside class concentrations to assess the contribution of road traffic to NO_2.

The intermediate site showed a small degree of elevation, which went below background levels in 1996 and 1997. Since then there has been a steady rise in concentration but is still at a relatively low level. The roadside class shows a higher concentration with a decrease between 1996 and 1998. After a steep rise in 1999 the levels have dropped in the last two years.

The figure shows that during the period between 1994 and 2001 the contribution from road traffic sources has become less significant.

7.7 London Borough of Croydon

2001 Mean Values

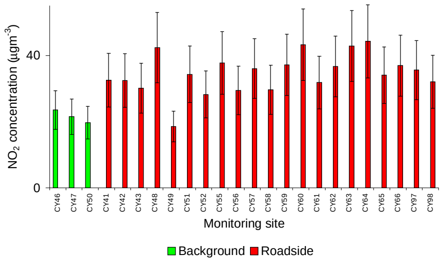

Figure 43 Croydon Annual Average NO_2 Concentrations, 2001

In 2001 roadside sites CY55-66 were introduced for the first time and the intermediate site CY45 was removed. In 2001 the concentrations exceeded the 2005 AQO at roadside sites CY48A, CY60, CY63 and CY64.

Background values ranged from 20 µg m^{-3} to 23.5 µg m^{-3}.

Roadside sites recorded values ranged between 18.5 µg m^{-3} at site CY49 to 44 µg m^{-3} at site CY64.

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Site Time Series

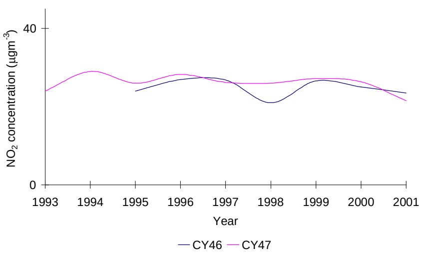

Figure 44 Croydon Background Sites Time Series, 1993-2001

Long-term background trends have shown little variation in concentration since 1993. Between 1999 and 2001 there has been a slow reduction in concentration at all background sites.

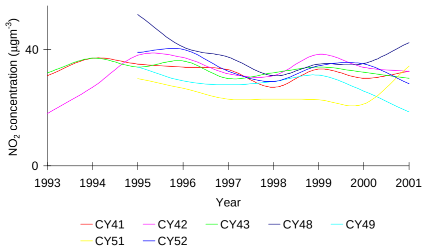

Figure 45 Croydon Roadside Sites Time Series, 1993-2001

The Roadside sites have fluctuated in a similar pattern since 1993. A decreasing trend was seen between 1995 and 1998, with a sudden rise in concentration in 1999. In 2000 concentrations at most sites decreased. However in 2001 three sites (CY41, CY48 and CY51) saw a rise in concentration, whilst three sites (CY43, CY49 and CY52) saw a decrease, and one site (CY42) remained unchanged on 2000 results.

Trend Analysis by Site Class

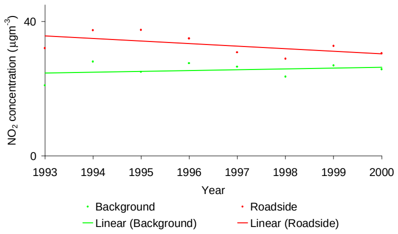

Figure 46 Croydon Trend Analyses, 1993-2001

Linear trend analysis shows a slight upward trend at background sites within

Croydon and a slowly decreasing trend at roadside sites.

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Roadside Elevation

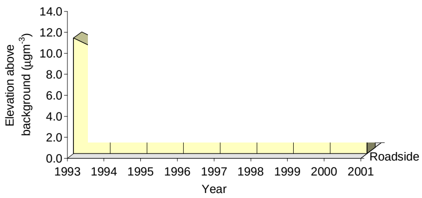

Figure 47 Croydon Intermediate & Roadside Elevation, 1993-2001

The removal of background concentrations from roadside concentrations provides an indication of NO_2 from road traffic sources.

The intermediate site is no longer in place and therefore these results have not been presented in 2001. However, the previous intermediate and roadside classes followed a similar pattern of concentration between 1993 and 2000 with coinciding troughs and peaks.

Roadside elevation[11] levels rose to a peak between 1993 and 1995. From 1995 to 1997 roadside elevations fell to their lowest levels and again rose to a peak in 1999 with a decrease in 2000. In 2001 the trend took a steep upward move from 5 to 9µg m^{-3}.

Overall, the pattern shows that the proportion of total NO_2 from road traffic sources has decreased since 1993, although in 2001 it is apparent that traffic may be more important at certain sites in Croydon than previously thought.

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[11] This analysis did not include the new sites for 2001, and therefore is not attributed to changes to the number of site locations.

7.7 London Borough of Ealing

2001 Mean Values

The London Borough of Ealing has been included in the LWEP network for the first time in 2001. The results from the diffusion tubes that were sited from April 2001 are included here. There are no long-term data, therefore the only averages for each site are reported, although the elevation of the mean annual average concentrations at the intermediate and roadside sites above that of the background sites for 2001 is reported.

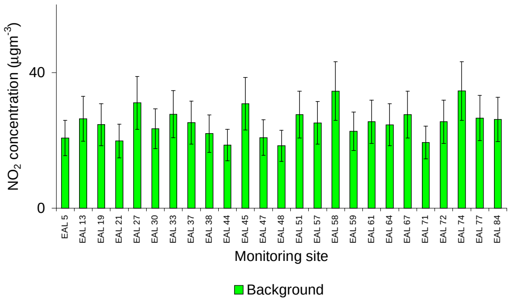

Figure 48 Ealing Background Site Annual Average NO_2 Concentrations, 2001

Average concentrations at the 25 background sites in the Borough ranged from 18 µg m^{-3} at EAL48 to 35 µg m^{-3} at EAL58 and EAL74. There were no exceedences of the 2005 AQO at any of these sites.

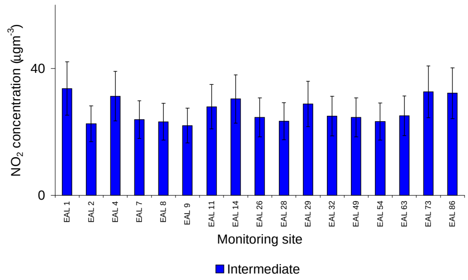

Figure 49 Ealing Intermediate Site Annual Average NO_2 Concentrations, 2001

In 2001 the annual average concentrations at the 17 intermediate sites ranged from 22 µg m^{-3} at site EAL9 to 34 µg m^{-3} at EAL1. Again, there were no exceedences of the 2005 AQO at any of these sites.

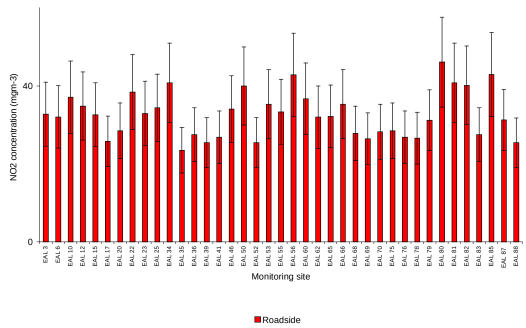

Figure 50 Ealing Roadside Site Annual Average NO_2 Concentrations, 2001

The 39 roadside sites showed concentrations between 24 µgm^{-3} at site EAL35 to 46 µg m^{-3} at EAL80. Overall there were seven sites where the annual average concentrations exceeded the 2005 AQO.

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Roadside Elevation

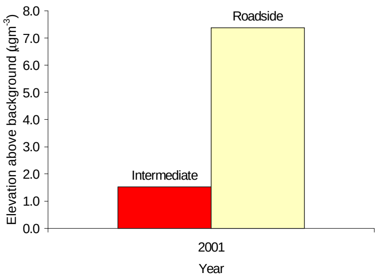

Figure 51 Ealing Intermediate & Roadside Elevation, 2001

Subtraction of the mean of the background levels from the mean of the annual average concentration at the other site classes reveals the influence of local traffic sources at both intermediate and roadside sites.

In 2001 the elevation above background levels at intermediate sites was less than 2 µg m^{-3}, whereas at roadside sites the elevation was 7 µg m^{-3}.

The contribution from local traffic sources is therefore more distinct at roadside sites in the Borough.

CASELLA STANGER

7.8 London Borough of Greenwich

2001 Mean Values

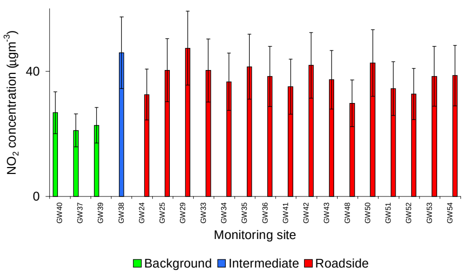

Figure 52 Greenwich Annual Average NO_2 Concentrations, 2001

In 2001 six new roadside sites, GW50-55, were introduced in Greenwich. In addition site GW39 changed from being an intermediate site to a background site.

In 2001, all background sites fell well below the 2005 AQO of 40 µg m^{-3}. Annual average background levels ranged from 21 µg m^{-3} at GW37 to 27 µg m^{-3} at GW40.

The intermediate site GW38 is 46 µg m^{-3} and therefore exceeds the 2005 AQO.

Concentrations at roadside sites ranged between 30 µg m^{-3} at GW49 and 47 µg m^{-3} at GW29. Six of the ten roadside sites were equal to, or greater than, the 2005 AQO.

- - -

Site Time Series

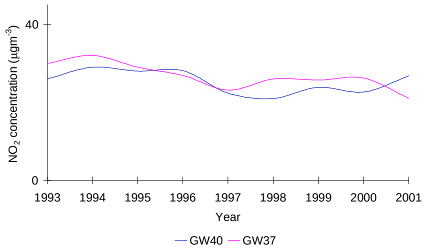

Figure 53 Greenwich Background Sites Time Series, 1993-2001

Both background sites recorded a downward trend in 1997 followed by a slight increase before levelling off to 2000. In 2001 GW40 increased whilst site GW37 decreased, both by similar amounts.

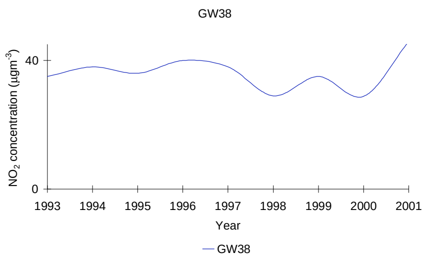

Figure 54 Greenwich Intermediate Site Time Series, 1993-2001

Concentrations at intermediate site GW38 have fluctuated between 1993 and 2000 but have remained below the 2005 AQO at all but one year which was equal to the AQO. However, in 2001 the annual average concentration increased significantly to 46 µg m^{-3}, thus exceeding the AQO.

CASELLA STANGER

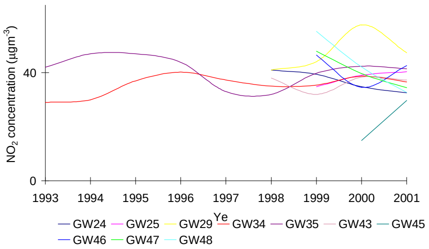

Figure 55 Greenwich Roadside Sites Time Series, 1993-2001

Roadside sites measured since 1993 have shown a fluctuating trend. GW35 peaked in 1995 and had a sharp fall in 1997. GW34 has fluctuated much less over the same period of time. Between 1998 and 2000 concentrations rose at these sites, but they decreased slightly in 2001. Sites GW33 and GW36 have shown similar trends, decreasing between 1996-1998, rising in 1999, and decreasing in 2000 and 2001 to similar concentrations that are marginal exceedences of the 2005 AQO.

Between 1998 and 2000 ten roadside sites were introduced to the network. In 2001 concentrations at these sites have generally decreased or remained at similar concentrations to 2000 levels, although sites GW45 and GW46 displayed quite significant increases in the same year.

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Trend Analysis by Site Class

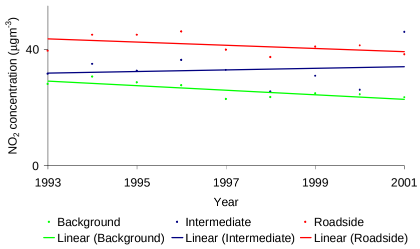

Figure 56 Greenwich Trend Analyses, 1993-2001

Linear trend analysis reveals a decreasing trend at background and roadside site classes in Greenwich between 1993 and 2000. The rate of decline is similar for both site classes.

The Intermediate site class displays an upward trend, which is mostly due to the exclusion of site GW39 in 2001, leaving GW38 as the sole intermediate site for Greenwich, which has typically seen greater concentrations than GW39. In 2001, since the value at this site had increased significantly the trendline was influenced accordingly.

The annual mean concentration was slightly higher than the trendline for roadside and background classes and lower for the intermediate class in year 2000.

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Intermediate & Roadside Elevation

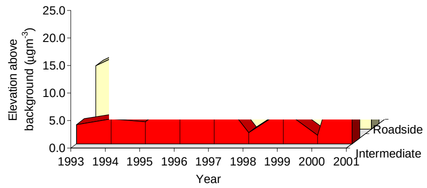

Figure 57 Greenwich Intermediate & Roadside Elevation, 1993-2001

Analysis of the elevation at intermediate and roadside site class concentrations above that of background site concentrations gives an indication of pollution from road traffic sources.

The elevation level of the roadside class is, as expected, higher than the intermediate site class. Both sites have had an increase in concentration in 1996 and 1997 with a marked decrease in 1998. In 1999 the concentration rose at both site classes, and in 2000 remained stable for roadside sites with a decrease at intermediate sites.

As discussed in the previous section, the removal of GW39 and the sudden increase in concentration at site GW38 has resulted in a profile change for the intermediate classification in Greenwich in 2001. This is reflected in the sharp increase in elevation observed for the 2001 value in Figure 53 for intermediate sites.

The roadside annual average concentration in 2001 is below that of the intermediate sites due to the range of sites included, the elevation is lower for this site classification for the first time, and has decreased from that of the previous year.

The pattern emerging from the figure suggests that NO_2 pollution, attributable to road traffic sources is relatively high showing only small signs of decrease at roadside sites.

CASELLA STANGER

7.9 London Borough of Hammersmith & Fulham

2001 Mean Values

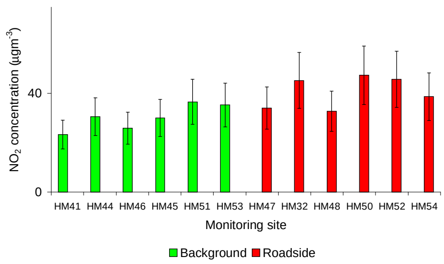

Figure 58 Hammersmith & Fulham Annual Average NO_2 Concentrations, 2001

Annual average background concentrations for year 2001 ranged from 23 μg m^{-3} at HM41 to 37 μg m^{-3} at HM51. All background sites fell below the 2005 AQO of 40 μg m^{-3}.

Roadside site concentrations ranged between 33 μg m^{-3} at HM48 and 47 μg m^{-3} at HM50. Three of the six roadside sites exceeded the 2005 AQO.

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Site Time Series

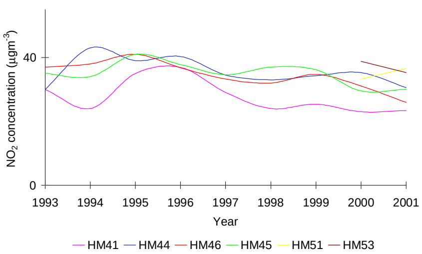

Figure 59 Hammersmith & Fulham Background Sites Time Series, 1993-2001

Time series analysis of background sites shows fluctuations in concentrations for all the sites with a decreasing trend since monitoring started in 1993. The levels fluctuated above the 2005 AQO between 1994 and 1996 after which they stayed below the objectives.

Concentrations have fallen at all sites between 2000 and 2001 apart from HM41 and HM45, which stayed the same in this time period, and HM51 which showed a small increase.

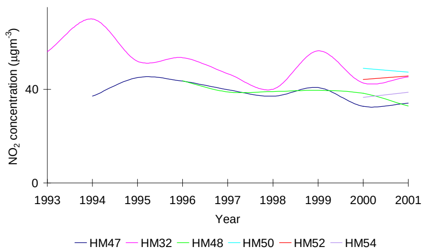

Figure 60 Hammersmith & Fulham Roadside Sites Time Series, 1993-2001

Concentrations at roadside sites differ between the sites. HM32 has shown a fluctuating trend staying above the 2005 AQO for all monitored years. The annual average concentration was greater at this site in 2001 than it was in 2000. Sites HM47 and HM48 have lower (and more stable) average concentrations that have been equal to, or below, the 2005 AQO since 1996. Site HM47 showed a small increase in 2001, whilst HM48 decreased after being relatively stable since 1997. Overall there were no big increases or decreases in 2001. Relatively new sites HM50 and HM52 exceed the 2005 AQO in 2000 and 2001, whilst HM54 is just below for the same two years.

Trend Analysis by Site Class

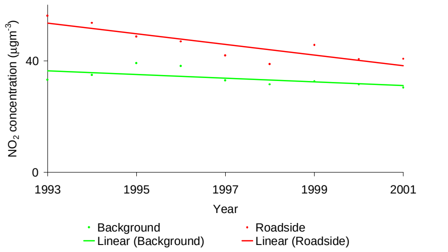

Figure 61 Hammersmith & Fulham Trend Analysis, 1993-2001

Linear trend analysis undertaken on long-term background and roadside concentrations can be seen above in Figure 57.

The background class trend line shows a slow decrease over time. However, the roadside class trend line, displays a steeper decreasing trend between 1993 and 2001.

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Roadside Elevation

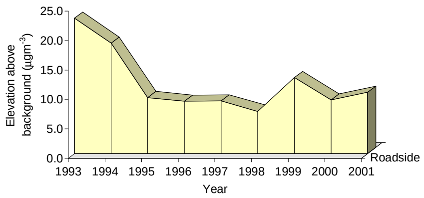

Figure 62 Hammersmith & Fulham Roadside Elevation, 1993-2001

The elevation in NO_2 concentration at the roadside class is indicative of the contribution from road traffic sources.

The elevation had a sharp fall between 1993 and 1995. The level remained stable until 1999 where there was a sharp rise followed by a small fall in 2000. In 2001 the elevation increased again but only by the small amount of 1.3 $\mu g\ m^{-3}$.

The elevation pattern indicates that during the period between 1993 and 2001 there has been an overall decrease in pollution from road traffic, although there has been no significant change since 1995.

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7.10 London Borough of Harrow

2001 Mean Values

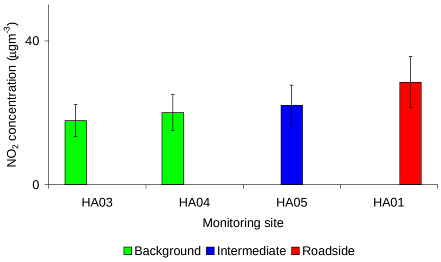

Figure 63 Harrow Annual Average NO_2 Concentrations, 2001

Annual average concentrations for all sites classes within Harrow fell below the 2005 annual average AQO for NO_2 in 2001.

Background sites recorded 18 µg m^{-3} at HA03 and 20 µg m^{-3} at HA04.

Concentrations at the intermediate site HA05 recorded an average of 22 µg m^{-3} and the roadside site at HA01 had an annual average concentration of 28.5 µg m^{-3}.

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Site Time Series

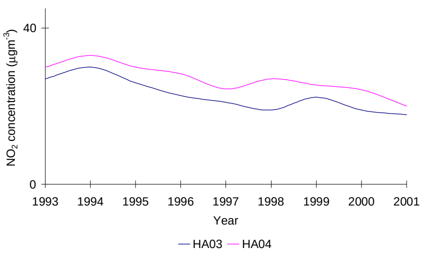

Figure 64 Harrow Background Sites Time Series, 1993-2001

Concentrations at background sites between 1993 and 2001 show a rise occurred 1994 with a subsequent decrease below levels measured in 1993.

Concentrations at HA04 decreased by 4 µg m^{-3} from 2000 to 2001 whilst HA03 decrease by 1 µg m^{-3} over the same period.

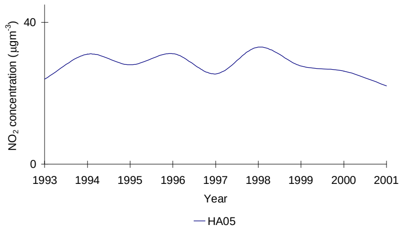

Figure 65 Harrow Intermediate Sites Time Series, 1993-2001

The intermediate site has shown fluctuations in levels between 1993 and 1998, but has shown a steady decrease in concentration since then. In 2001 the annual average concentration was just below that seen when monitoring began in 1993.

Average concentrations in 2001 at HA05 saw a decrease of 4 µg m^{-3} from 2000.

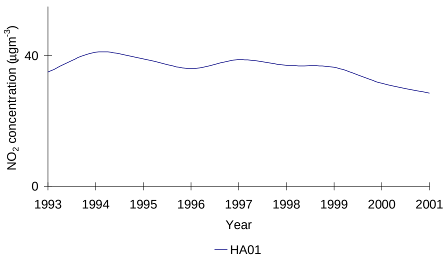

Figure 66 Harrow Roadside Sites Time Series, 1993-2001

Concentrations at the roadside site rose above the 2005 AQO in 1994 after which they decreased to a stable downwards trend below the AQO. Between 2000 and 2001 the level dropped for the forth consecutive year and is the lowest average among the monitored years.

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Trend Analysis by Site Class

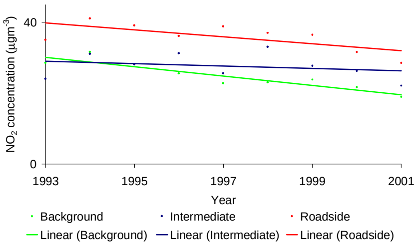

Figure 67 Harrow Trend Analyses, 1993-2001

Linear trend analysis shows a steady declining trend between 1993 and 2001 for the background and roadside site classifications. The annual average concentrations in 2001 were below the long-term trend for both site classes.

As a contrast the intermediate site trend shows little overall change in concentration has occurred throughout the same period, although the annual average for 2001 falls below the trendline.

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Intermediate & Roadside Elevation

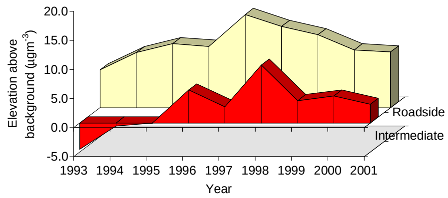

Figure 68 Harrow Intermediate & Roadside Elevation, 1993-2001

The elevation at the intermediate class was below background levels between 1993 and 1995. However, the concentrations have risen since then with fluctuating levels and for 2001 were 3 µg m^{-3} above background levels.

In contrast, the elevation at the roadside site is well above background levels. Between 1993 and 1996 the elevation rose slightly to 11 µg m^{-3}. There was then a sharp rise to a peak of 16 µg m^{-3} in 1997 after which the level has declined steadily, and in 2001 was 9.5 µg m^{-3} above background levels, though this only slightly lower than the 2000 elevation.

The elevation patterns indicates that road traffic contributes to a great proportion to total NO_2 concentrations which has declined somewhat since 1997.

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7.11 London Borough of Hillingdon

2001 Mean Values

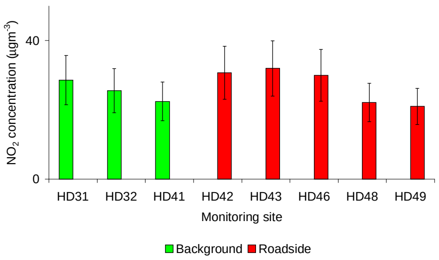

Figure 69 Hillingdon Annual Average NO_2 Concentrations, 2001

The annual average concentrations recorded at background sites in 2001 varied from 22 µg m^{-3} to 29 µg m^{-3}.

The intermediate site was closed in 2001 and so is no longer reported. Roadside sites varied from 21 µg m^{-3} to 32 µg m^{-3}. All sites fell safely below the 2005 AQO.

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Site Time Series

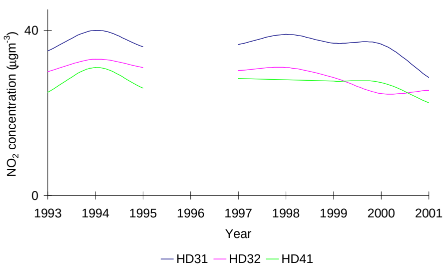

Figure 70 Hillingdon Background Sites Time Series, 1993-2001

Concentrations at background sites have been quite constant with time after an initial rise in 1994. In 2001 annual average concentrations fell at HD31 and HD41, and stayed more or less the same at HD32.

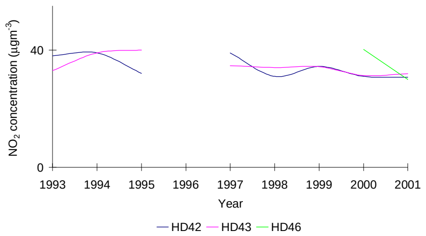

Figure 71 Hillingdon Roadside Sites Time Series, 1993-2001

Concentrations at HD42 declined between 1993 and 1995. Values measured in 1997 showed a peak of 39 µg m^{-3}, followed a steep declined in 1998. HD43 had an increase in concentration the first two years after 1993. Levels then dropped in 1997 and concentrations at both sites remained stable from 1998. Both sites had very similar concentrations since 1999. Site HD46, introduced in 2000, was initially greater than the other two sites, but the 2001 concentration was around the same concentration.

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Trend Analysis by Site Class

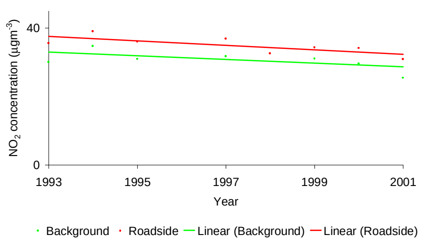

Figure 72 Hillingdon Trend Analyses, 1993-2001

Trend analysis for both site classes shows an almost static relationship of concentration with time, though a slow decline can be seen.

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Roadside Elevation

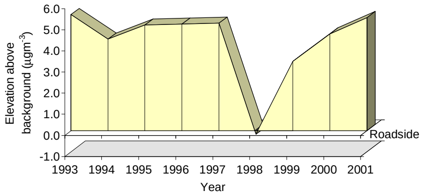

Figure 73 Hillingdon Roadside Elevation, 1993-2001[12].

Identifying the elevation at roadside and intermediate site classes gives an indication of the level of pollution derived from road traffic sources.

Roadside elevations remained stable until a sharp fall in 1998 took the level just below that of the background. Levels rose again in 1999, and in 2001, have returned to the levels seen before 1998, and have increased for three consecutive years.

The pattern would suggest that the contribution from local road sources can vary, but on the whole are not especially high. With the maximum elevation over the monitoring period being 5.5 $\mu g\ m^{-3}$.

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[12] Values for 1996 have been interpolated for graphical representation of the data.

7.12 London Borough of Hounslow

2001 Mean Values

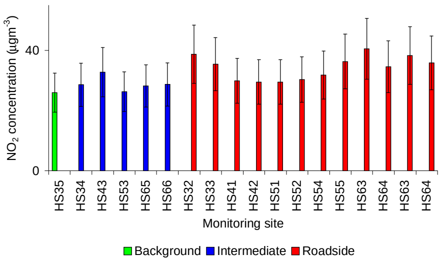

Figure 74 Hounslow Annual Average NO_2 Concentrations, 2001

The annual average concentration at the background site was 26 µg m^{-3} in 2001. Values at intermediate sites ranged between 26 µg m^{-3} and 33 µg m^{-3}, all well below the 2005 AQO.

The roadside sites ranged between 29.5 µg m^{-3} and 41 µg m^{-3}. Just one of the sites exceeded the 2005 AQO.
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Site Time Series

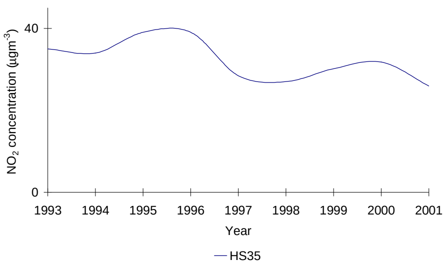

Figure 75 Hounslow Background Sites Time Series, 1993-2001

The background site HS35 has shown fluctuating concentrations levels over the monitored period. A rise was seen in 1995/1996 with a subsequent fall in 1997. Concentrations rose again to 2000, but have fallen again in 2001 and overall there has been a decline since 1993.

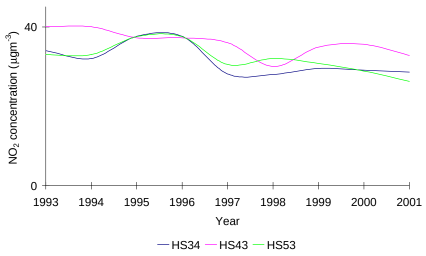

Figure 76 Hounslow Intermediate Sites Time Series, 1993-2001

All intermediate sites have declined overall between 1993 and 2001. Levels of NO_2 at HS34 and HS53 followed a similar pattern of elevated levels in 1995/96 and a drop in 1997 after which level have remained stable. HS43 has had slightly more elevated levels but with a gradual decline, concentrations remaining higher than those at the other two intermediate sites since 1999.

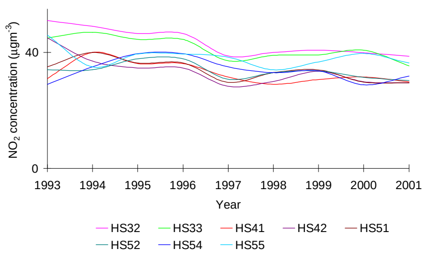

Figure 77 Hounslow Roadside Sites Time Series, 1993-2001

Concentrations at roadside sites have generally fallen between 1993 and 2001. Concentration s remained high until 1996 after which there was a general fall in 1997. After 1997 levels subsequently remain fairly stable,

although HS42, HS54 and HS55 fluctuated slightly.
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Trend Analysis by Site Class

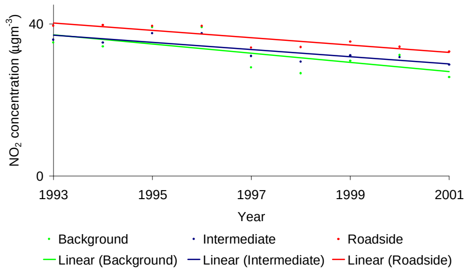

Figure 78 Hounslow Trend Analyses, 1993-2001

Linear trend analysis shows a decreasing trend for all 3 site classes between 1993 and 2001.

The annual average concentration for year 2001 was close to the long-term trend for the roadside and intermediate sites and below the trendline for the background site.

All site classes have a similar rate of decline. The intermediate and background site class trendlines are within the same range whereas the roadside class levels are higher.

The trend analysis would suggest that NO_2 concentrations have fallen significantly between 1993 and 2001, and annual average concentrations for all site classes are now below the 2005 AQO.
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Intermediate & Roadside Elevation

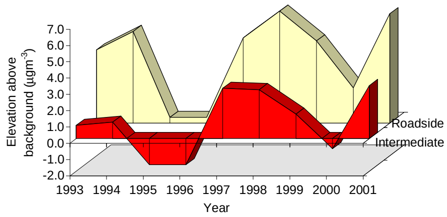

Figure 79 Hounslow Intermediate & Roadside Elevation, 1993-2001

Elevated levels of NO_2 at intermediate and roadside classes above mean background concentrations show similar variation in concentrations of NO_2 between 1993 and 2001, although roadside elevations are higher than those seen at intermediate sites.

Elevated NO_2 levels at both site classes rose between 1993 and 1994. Intermediate site elevations dropped to below background levels in 1995 and 1996, whilst roadside sites dropped to be very close to background levels. However a sharp rise occurred in 1997 and 1998 with a subsequent fall until 2000. In 2001 the elevation levels were once more similar to levels seen in 1998, continuing the fluctuating pattern seen in previous years.

The elevation pattern at intermediate and roadside sites reflect the changes seen at the background site since 1993 and implies that the contribution of NO_2 from road traffic sources fell in 1995 and 1996, increased in 1997 and fell again into a second trough in year 2000.

7.13 Royal Borough of Kensington & Chelsea

2001 Mean Values

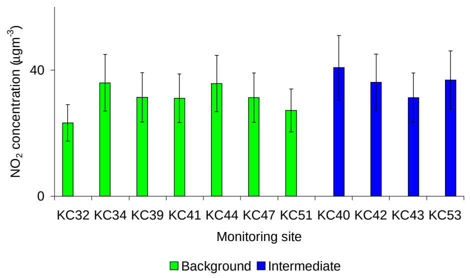

Figure 80 Kensington & Chelsea Background & Intermediate Annual Average NO_2 Concentrations, 2001

2001 background values ranged between 23 µg m^{-3} at KC32 to 36 µg m^{-3} at KC34 and KC44. None of the sites exceeded the 2005 AQO.

Intermediate sites varied from 31 µg m^{-3} at KC43 to 41 µg m^{-3} at KC40, the latter being the only one to exceed the 2005 AQO.

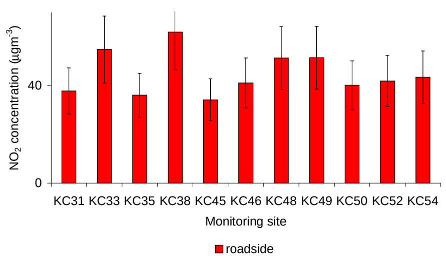

Figure 81 Kensington & Chelsea Roadside Annual Average NO_2 Concentrations, 2001

Roadside sites ranged between 34 µg m^{-3} at KC45 and 62 µg m^{-3} at KC33. Only three roadside sites in the Borough did not exceed the 2005 AQO.

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Site Time Series

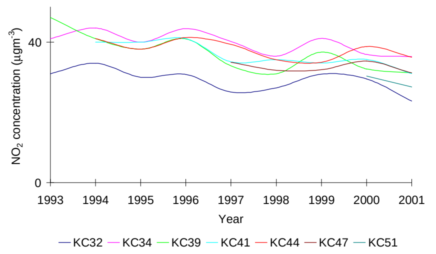

Figure 82 Kensington & Chelsea Background Sites Time Series, 1993-2001

Generally, the background sites show similar fluctuation levels between 1993 and 2001. The peaks and troughs coincide with each other, suggesting a good correlation in background levels. An overall decline in concentration is shown by all sites, with no increases in 2001. Since 1998 there has been just one exceedence of the 2005 AQO. Prior to this exceedences were commonplace at all sites except KC32.

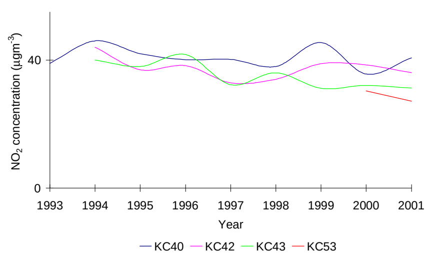

Figure 83 Kensington & Chelsea Intermediate Sites Time Series, 1993-2001

The intermediate sites have similarly fluctuated during the monitoring period and generally show a slow decline between 1993 and 2001. KC40 and KC43 have had overall decreasing levels of NO_2. However KC40 shows no sign of decreasing, with an increase of 5 µg m^{-3} in 2001 taking it over the 2005 AQO.

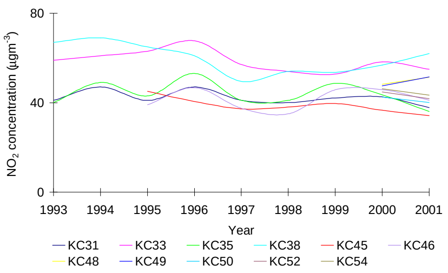

Figure 84 Kensington & Chelsea Roadside Sites Time Series, 1993-2001[13].

The levels of NO_2 between the roadside sites vary considerably for each monitored year. All sites show a net decrease between 1993 and 1998 after which there is a subsequent rise in 1999. After this point concentrations at all sites have remained high but on the whole fairly level.

KC31 and KC45 have had fluctuations but remained fairly static since 1997. KC35 and KC46 have had peaks in 1996 and 1999 and are now showing a static or downward sloping trend. KC48 and KC49, introduced in 2000, have increased in 2001, whilst other recent sites (KC50, KC52 and KC54) have decreased.

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Trend Analysis by Site Class

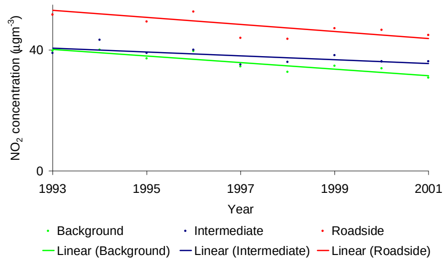

Figure 85 Kensington & Chelsea Trend Analysis, 1993-2001

Linear trend analysis shows a decreasing trend at background and intermediate site classes. The roadside site class shows a more significant decline and also at a higher level which is characteristic of roadside classes.

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Intermediate & Roadside Elevation

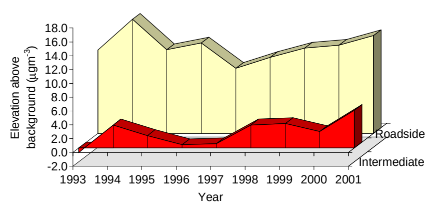

Figure 86 Kensington & Chelsea Intermediate & Roadside Elevation, 1993-2001

Elevation above background concentrations for intermediate and roadside sites are estimated by subtraction of background values. This reveals the contribution of road traffic to NO_2 concentrations for each year.

The intermediate site shows two peaks between 1993 and 2000. The peaks in 1994 and 1998 rose

[13] 1995 values for KC38 have been interpolated for graphing

to around 3 μg m^{-3} above background level while the troughs were less than 1 μg m^{-3} above background. However, in 2001 the elevation at this site class rose to the highest elevation to date, and was 5 μg m^{-3} above background levels.

The roadside class elevation had a peak of 17 μg m^{-3} in 1994 followed by a drop down to 9 μg m^{-3} in 1997. The elevation level has since risen a small amount each year and was 14 μg m^{-3} in year 2001.

The variations in elevation levels show that the general level of NO_2 from road traffic sources has fluctuated between 1993 and 2000.

Both site classes show a similar pattern of increases and decreases in concentration though the roadside site seems to show more variation. This does however indicate that roadside sites are influenced quite strongly by local traffic pollution, and a gradual upward trend has been observed since 1998 at both site classes.

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7.14 London Borough of Newham

2001 Mean Values

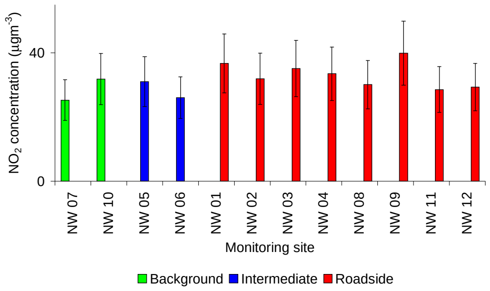

Figure 87 Newham Annual Average NO_2 Concentrations, 2001

Background values in 2001 were both below the 2005 AQO with a mean concentration of 25 µg m^{-3} for NW07 and 32 µg m^{-3} for NW10.

Intermediate sites recorded similar concentrations of 31 µg m^{-3} at NW05 and 26 µg m^{-3} at NW06.

Concentrations at roadside sites were between 29 µg m^{-3} for NW11 and 40 µg m^{-3} for NW09. With the exception of the latter, all roadside sites were below the 2005 AQO.

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Site Time Series

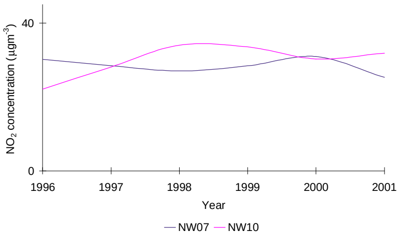

Figure 88 Newham Background Sites Time Series, 1996-2001[14].

Between 1996 and 2001 site NW07 has shown small fluctuations, varying between 25 and 31 µg m^{-3}, the minimum value occurring in 2001. In contrast site NW10 showed a steady increase between 1996 and 1998 and a subsequent decrease in concentration to 2000. Concentrations at this site have risen slightly in 2001, and there has been a net increase in concentration since 1996.

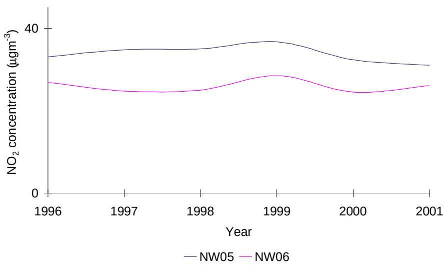

Figure 89 Newham Intermediate Sites Time Series, 1996-2001[15]

Site NW05 and NW06 have not varied significantly in concentration at either site over

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[14] 1997 values for NW10 have been interpolated for graphing

[15] The 2000 LWEP NO_2 Survey Annual Report incorrectly reported the value for site NW06 as 40 µg m^{-3}. The correct annual average concentration in 2000 was 25 µg m^{-3}.

recent years. Since 1996 the annual average concentrations for NW06 have fluctuated between 24.5 and 28.5 µg m^{-3}, whilst the annual average concentrations for NW05 have fluctuated between 31 and 36 µg m^{-3}. The small fluctuations at these two sites are closely matched, suggesting good inter-site correlation. Concentrations at NW05 have always exceeded NW06.

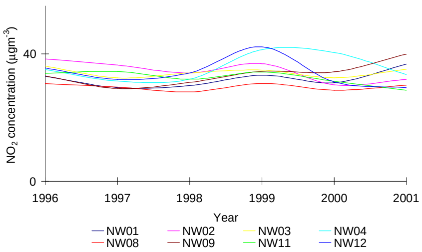

Figure 90 Newham Roadside Sites Time Series, 1996-2001

Levels of NO_2 at all roadside sites followed a stable downward trend between 1996 and 1998. In 1999 all sites increased, and sites NW04 and NW12 exceeded the objective level. In 2000 all sites decreased in concentration, but NW04 remained at the 2005 AQO. Site NW04 decreased in 2001, together with minor decreases at NW11 and NW12. All other sites have increased in the reporting year.

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Trend Analysis by Site Class

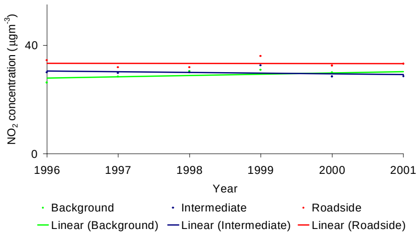

Figure 91 Newham Trend Analyses, 1996-2001

Linear trend analysis shows that the concentrations have not changed by very much at any of the three site classifications sites since monitoring began in 1996.

Background and intermediate sites have been very closely related to each other since 1998, whereas the roadside site levels are higher, which is typical for this site classification.

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Intermediate & Roadside Elevation

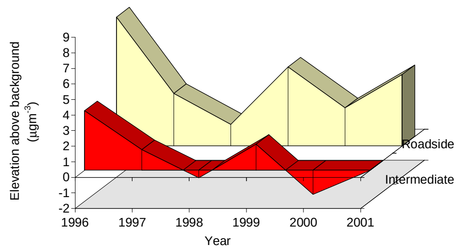

Figure 89 Newham Intermediate & Roadside Elevation, 1996-2001

Elevation levels have been estimated by subtraction of background values from intermediate and roadside values.

Both site classes show similar variations in elevation levels with closely matching peaks and troughs, although the roadside elevations are higher, as would be expected.

After an initial elevation level of 4 µg m^{-3} in 1996, elevations at intermediate sites have varied from background means by no more than ±2 µg m^{-3}. In 2001 the annual mean concentration at intermediate and background sites were equal, therefore the elevation was zero for this site class.

Roadside elevations were also relatively high in 1996, but since then they have ranged from a minimum of 1.4 µg m^{-3} in 1998 to a maximum of 5 µg m^{-3} in 1999. Elevations above background levels in 2001 were 4.5 µg m^{-3} at roadside sites.

The contribution from road traffic to NO_2 concentrations shows a year-to-year variability that is likely to reflect traffic flow variability within the vicinity of the sites.

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7.15 London Borough of Richmond-upon-Thames

2001 Mean Values

The London Borough of Richmond-Upon-Thames network was extended in 2000 with the inclusion of 30 new roadside sites, most of which have been included here for the first time. Sites RUT 01, 03 and 04 were established in 1993.

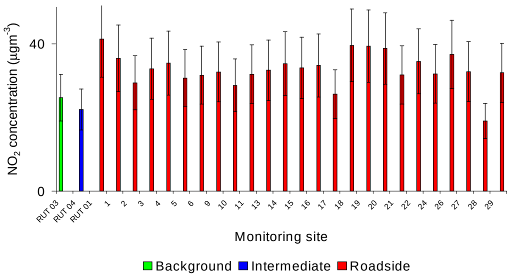

Figure 92 Richmond-upon-Thames Annual Average NO_2 Concentrations, 2001

Mean value of NO_2 measured at background site RUT03 was 25 µg m^{-3}. Intermediate site RUT04 recorded a mean concentration of 22 µg m^{-3}. The roadside site RUT01 had an annual mean concentration of 41 µg m^{-3}.

New roadside sites ranged from 19 µg m^{-3} at Site 28 to 40 µg m^{-3} at Site 18. Two marginal exceedences were therefore observed at roadside sites only.

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Site Time Series

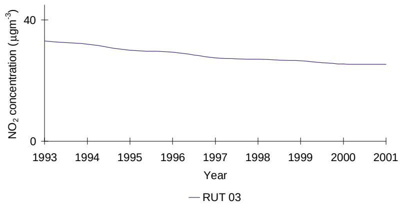

Figure 93 Richmond-upon-Thames Background Sites Time Series, 1993-2001

The background site RUT03 shows a relatively uniform rate of decrease in concentration. There was a net fall of 8 µg m^{-3} between 1993 and 2000, with no change in annual mean concentration between 2000 and 2001.

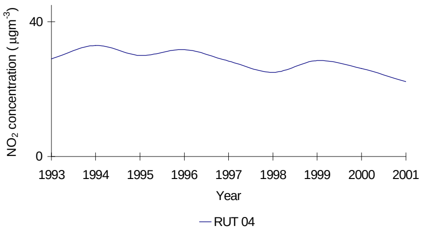

Figure 94 Richmond-upon-Thames Intermediate Sites Time Series, 1993-2001

Intermediate site RUT04 has shown a slightly fluctuating trend since 1993. There was an increase in 1999 with minor peaks in 1994 and 1996. Overall there has been a net decrease of 7 µg m^{-3} between 1993 and 2001.

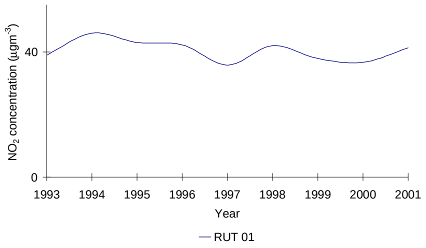

Figure 95 Richmond-upon-Thames Roadside Sites Time Series, 1993-2001

The roadside site RUT01 increased between 1993 and 1994 which was followed with small fluctuations in concentration, with a reduction in 1997. However, there has not been any overall trend with time, as concentrations fall within ±6 µg m^{-3} of the 2005AQO.

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Trend Analysis by Site Class

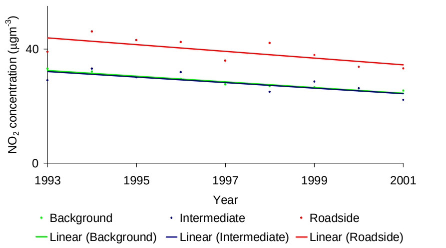

Figure 96 Richmond-upon-Thames Trend Analysis, 1993-2001[16]

The linear trend analysis shows a downward sloping trend for all site classes between 1993 and 2001.

The background site and intermediate site class trendlines lie in exactly the same place, with the annual average concentration for 2001 being just above the trendline for the background classification and just below for the intermediate site.

The roadside class trendline is approximately parallel with the other two site classes; all are therefore decreasing at a very similar rate. The roadside trend decreased below the 2005 AQO of 40 µg m^{-3} in 1998.

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Intermediate & Roadside Elevation

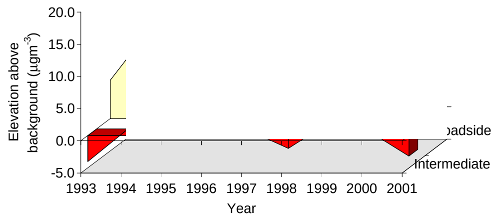

Figure 97 Richmond-upon-Thames Intermediate & Roadside Elevation, 1993-2001[17]

The subtraction of background class concentration from intermediate and roadside site classes gives an indication of the contribution of road traffic to NO_2 concentrations.

The intermediate class has a low elevation level. Fluctuations occur regularly between years that are 4 µg m^{-3} below to 2 µg m^{-3} above the mean background concentration, with no apparent trend emerging. Elevations in 2001 were 3 µg m^{-3} below the background concentration. This indicates that local road traffic is not a major source of NO_2 at this site.

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[16] The analysis includes the results from the new sites in 2000 and 2001

[17] The analysis includes the results from the new sites in 2000 and 2001

In contrast the roadside site had a sharp increase in 1994 after which there was a decline to an elevation value of 8 μg m^{-3} in 1997. The levels rose again to a peak in 1998, but have since dropped to 8 μg m^{-3} above the background levels in 2001. The relatively high elevation levels indicate that the roadside sites are strongly influenced by variations in local traffic conditions.

7.16 City of Westminster

2001 Mean Values

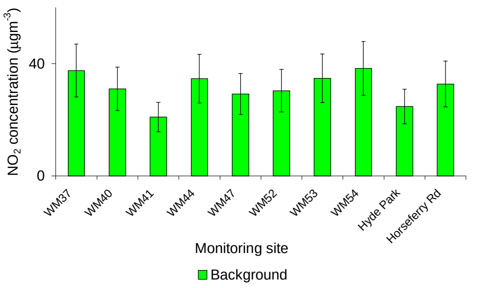

Figure 98 City of Westminster Background Annual Average NO_2 Concentrations, 2001

Background concentrations range between 21µg m^{-3} at WM41 and 38µg m^{-3} at WM54. None of these sites exceeded the 2005 AQO.

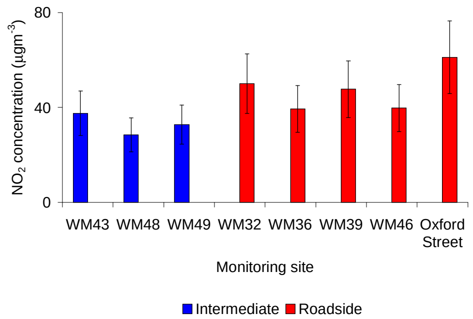

Figure 99 City of Westminster Intermediate & Roadside Annual Average NO_2 Concentrations, 2001

Intermediate site concentrations ranged between 28 µg m^{-3} and 38 µg m^{-3} and there were no exceedences the 2005 AQO. Roadside sites ranged between 39 µg m^{-3} and 61 µg m^{-3} with only WM36 remaining just below the 2005 AQO exceedence value.

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Site Time Series

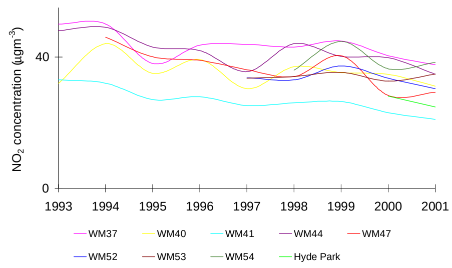

Figure 100 City of Westminster Background Sites Time Series, 1993-2001

Most of the background sites show a fluctuating pattern of concentration on a yearly basis between 1993 and 2001. Site WM41 has kept a relatively low and steadily declining level over the monitored period. By contrast, WM40 and WM44 show an almost cyclical pattern with alternate years of peaks and troughs. Generally the levels are lower in 2001 comparative to 1993. Most sites decreased between 2000 and 2001, although there were increases at sites WM47, WM53 and WM54.

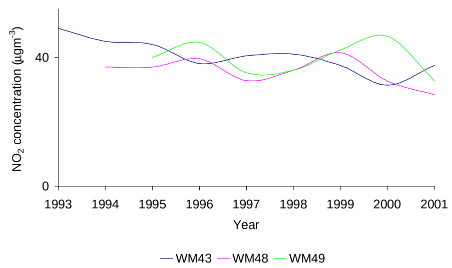

Figure 101 City of Westminster Intermediate Sites Time Series, 1993-2001

The intermediate sites have shown some variation over the monitoring period. WM43 has shown a steady decline between 1993 and 2000, although the concentration rose from 31 µg m^{-3} to 38 µg m^{-3} between 2000 and 2001. WM48 and WM49 show greater fluctuations and follow a similar trend until 2000 where the latter exceeds the 2005 AQO. Both sites saw declines in the annual average concentrations in 2001 and were below the 2005 AQO.

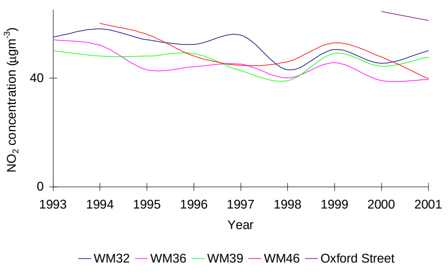

Figure 102 City of Westminster Roadside Sites Time Series, 1993-2001

The Oxford Street site is included on the time series analysis for the first time in this report. In the two years of monitoring it has shown levels that are very elevated and distinctly higher than the other roadside sites in the Borough. A time trend cannot be established yet, due to the infancy of the data set. However, the concentration remained greater than 60 µg m^{-3} in 2000 and 2001, with a small drop in the most recent year.

The other roadside sites show fluctuations in levels throughout the monitored period. All the sites follow the same trend of a fall in 1998, followed by a peak in 1999 and another drop in 2000. In 2001 WM46 showed further reductions in concentration, whereas other sites increased. All sites are exceedences or borderline exceedences of the 2005 AQO.

Although all roadside sites have generally been above the 2005 AQO, the levels seem to be declining with time and there is less variation between the sites.

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Trend Analysis by Site Class

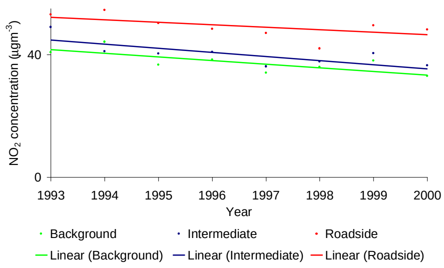

Figure 103 City of Westminster Trend Analyses, 1993-2001

Linear trend analysis shows a decreasing trend of NO_2 concentrations at all site classes between 1993 and 2001.

The intermediate and the background class show an equally strong decline in levels, whilst the roadside class has a slower rate of decrease at a higher level.

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Intermediate & Roadside Elevation

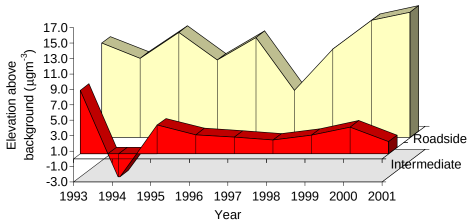

Figure 104 City of Westminster Intermediate & Roadside Elevation, 1993-2001

Subtraction of the mean of the background levels from the mean of the annual average concentration at the other site classes reveals the influence of local traffic sources at both intermediate and roadside sites.

The intermediate site classification shows a sharp fall in concentration in 1994 and a rise in 1995 followed by a slow decline until 1998 and a subsequent rise to 2000. In 2001 the elevation declined once more and was 1.6 µg m^{-3} above the mean background concentration. Currently the levels look quite stable at intermediate sites.

The general pattern displayed between 1993 and 2000 for the intermediate site can also be seen for the roadside site classification, though with much higher concentration values and increased level of variation between yearly concentrations. In 2001 the elevation rises to 16 µg m^{-3}, which is the maximum seen since monitoring began. This could be partly due to the annual average concentrations including the Oxford Street site from 2000. It is noteworthy that although there has been a general decline in the mean annual average concentrations for each site classification since 1993, the contribution from road traffic at roadside sites has peaked in 2001.

The elevation level has fluctuated considerably and it is difficult to determine any clear pattern. It is however certain that local road traffic is influencing NO_2 levels in the City of Westminster.

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8 Overall NO_2 Diffusion Tube Concentrations

8.1 Regression Analysis

Results for 2001 have been plotted against distance to road on a logarithmic scale to identify relationships between site classification and concentration.

This has been explored by correlating roadside levels to distance and intermediate and background sites to distance separately incorporating best-fit trendlines and related R^2-values.

Figure 105 Regression analysis – Roadside sites

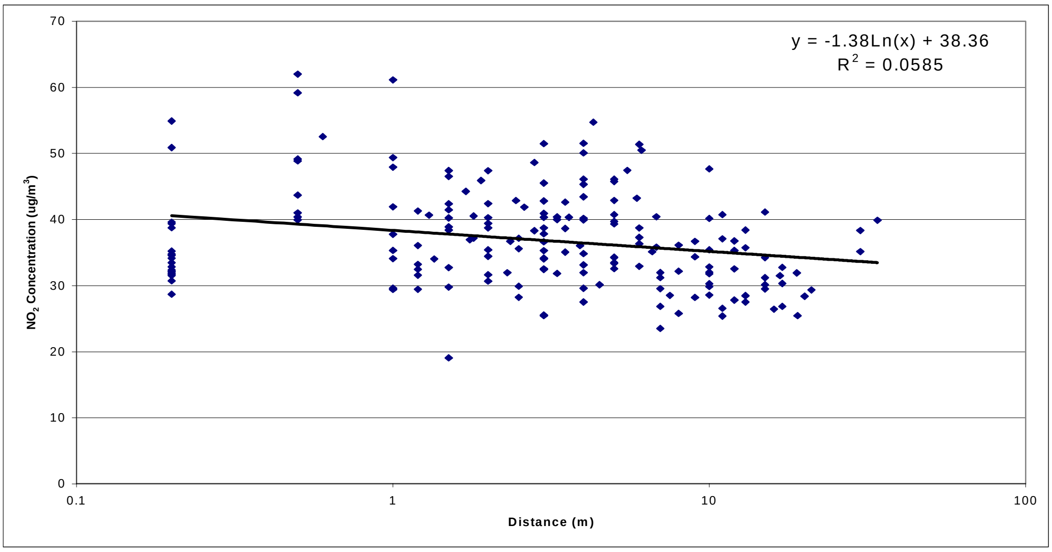
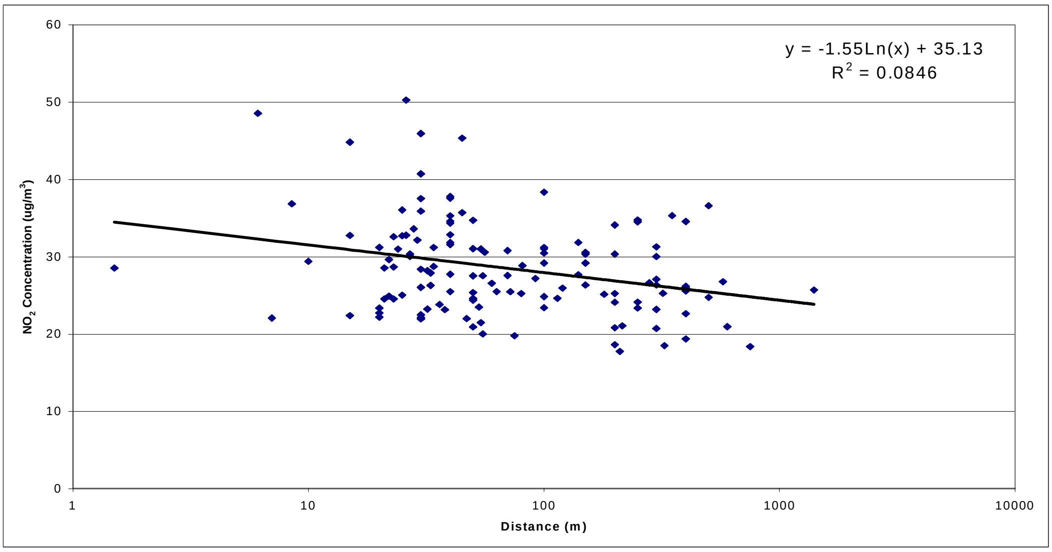


Figure 106 Regression Analysis – Intermediate and Background sites



The regression analysis shows a wide spread in NO_2 levels with distance to road for the roadside sites (Fig. 105). The R-value is at a best fit of 0.24, only showing a small degree of correlation between sites. The background and intermediate sites (Fig. 106) show a slightly better correlation between concentration and distance to road with an R-value of 0.29.

The difference in correlation, albeit at a small level, suggests that in areas of high NO_2 exposure level the decline in levels of NO_2 with increasing distance from the road is much more variable than those measured at intermediate/background sites. This is perhaps to be expected in an urban environment where local topography can strongly influence the dispersion of NO_2. Levels of NO_2 for intermediate and background sites are likely to be more stable than levels that are found for roadside sites. However it should be noted that the level of traffic can vary significantly even within each site class, and the classification of a roadside site as opposed to an intermediate site is not strictly based on distance to nearest busy road but is to the discretion of the local site operators. The results from the correlation exercise should therefore be regarded with caution. It is also noteworthy that some results at the intermediate sites show levels similar to roadside sites. This indicates that classification may require reviewing in these instances.

9 Diffusion tube collocation study

9.1 Introduction

The NO_2 diffusion tube sampling technique is a low cost monitoring option allowing large spatial coverage, which other sampling techniques may not be able to provide at the same cost. Though being widely used across the UK, particularly with regards to the review and assessment process and baseline surveys, its accuracy is however limited. There is therefore a need to establish the bias to more accurate sampling methods such as continuous analysers.

This chapter examines results from triplicate exposures of diffusion tubes that have been co-located with continuous analysers in London as part of the LWEP 2001 for nitrogen dioxide. Preparation and analysis of the diffusion tubes are undertaken by the UKAS accredited laboratory Gradko International Ltd. They participate in the Workplace Analysis Scheme for Proficiency (WASP) operated by the Health and Safety Executive, and the field intercomparison exercise operated by NETCEN (see Section 4.4). The diffusion tubes are prepared using 50% v/v TEA in Acetone similar to the preparation technique used by Casella Stanger in previous years of the LWEP survey.

9.2 Data Quality Objectives

The EU Daughter Directive sets data quality objectives for nitrogen dioxide along with other pollutants. Under the Directive, annual average NO_2 concentration data derived from diffusion tube measurements must demonstrate an accuracy of ± 25 % to enable comparison with the Directive air quality standards for NO_2. The NETCEN field intercomparison exercise recognises laboratories that are within $\pm 25\%$ of the reference concentration (i.e. that obtained from the automatic monitor) as performing satisfactorily[18].

9.3 Methodology

The diffusion tubes have been dispatched on a monthly basis to the local site operators for exposure on the dates determined by the UK NO_2 diffusion tube network and were consistent with the changeover dates shown in Table 2. Triplicate tubes have been exposed for 4-5 week periods within 0.5m distances from continuous analysers that are part of the Automatic Urban and Rural Network (AURN) or London Air Quality Network (LAQN). These sites are operated on behalf of DEFRA by Central Management and Coordination Units (CMCU) which are either Kings ERG (responsible for LAQN) or Casella Stanger (responsible for AURN). The sites are summarised in Table 7. Recognised QA/QC procedures for calibration and data ratification of the continuous monitoring data are performed by NETCEN.

[18] NETCEN UK NO_2 Network: 1999 Field Intercomparison Exercise

Table 7 Location, network and CMCU of five continuous monitors included in the diffusion tube collocation study

Site Location	Network	CMCU*	Site classification
Hillingdon	AURN	Casella Stanger	Suburban
Kensington and Chelsea	LAQN	Kings ERG	Urban Background
Brent	AURN	Casella Stanger	Urban Background
Camden Roadside	LAQN	Kings ERG	Roadside
Bloomsbury	AURN	Casella Stanger	Urban Centre

*CMCU = Central Management and Co-ordination

The triplicate tube results were averaged and compared to the period equivalent concentrations measured by continuous analyser. Period averages containing under 95% data capture by continuous analysers over the tube exposure periods have been omitted to ensure a comparative and robust data set.

9.4 Results

Details of calculations used to produce the % bias and adjustment factor can be found in the consultation draft of LAQM.TG(02)[19]

The study shows that the level of bias varies between –19.8 and –37.5% giving an average bias relative to the continuous monitor of –26.6% across the sites (Table 8).

A recent study undertaken by Air Quality Consultants Ltd.[20] has shown that tubes prepared by Gradko International using the preparation method of 50% v/v TEA in Acetone produces a range of negative bias similar to the one found in this study. A bias adjustment factor of 1.37 can therefore be applied to the monthly diffusion tube concentrations for 2001 to account for this bias.

[19] Source: DEFRA (2002) Draft Local Air Quality Management Review and Assessment: Technical Guidance, LAQM.TG(02)

[20] Source: Air Quality Consultants Ltd. (2002) Compilation of diffusion tube collocation studies carried out by Local Authorities. Report prepared on behalf of DEFRA and the Devolved Administrations

Table 8 Casella Stanger collocation data at 5 London AURN sites

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average Conc.	Mean site precision	% Bias, based on continuous monitor	Correction factor
Hillingdon																
Average diffusion tube	43.3	30.6	39.2	28.6	21.2	29.9	31.3	28.1	22.5	21.6	22.3	28.6	28.9			
Site precision	5.4	5.0	13.7	3.6	5.2	4.7	14.0	17.5	2.0	3.4	9.0	5.5		8.8		
Average - Continuous Analyser	48.8	56.2	55.3	41.2	38.1	52.4	42.4	46.1	36.2	52.2	45.3	41.1	46.3			
% Bias, based on continuous	-11.4	-45.6	-29.1	-30.7	-44.3	-43.0	-26.1	-39.1	-37.7	-58.6	-50.7	-30.6			-37.5	1.60
Kensington and Chelsea																
Average diffusion tube	42.3	34.7	29.9	27.6	34.3		32.6	23.2	21.5	38.0	35.1	26.8	31.5			
Site precision	5.2	2.4	5.2	2.7			3.1	4.0	7.3	5.8	1.6	4.7		4.5		
Average - Continuous Analyser	50.7	52.0	45.0	32.2	33.2		42.8	35.5	44.0	44.8	53.1	48.3	43.8			
% Bias, based on continuous	-16.6	-33.3	-33.5	-14.2	3.4		-23.7	-34.8	-51.2	-15.3	-33.9	-44.5			-28.2	1.39
Brent																
Average diffusion tube	28.9		26.8		30.7	23.1	19.4	25.5	24.8	39.6	35.3	35.8	29.0			
Site precision	2.9		1.8			3.1	4.4	5.6	3.3	3.0	15.7	3.7		6.0		
Average - Continuous Analyser	47.5		38.9		27.6	28.1	28.5	35.4	32.5	41.7	45.7	43.5	36.9			
% Bias, based on continuous	-39.1		-30.9		11.5	-17.8	-32.1	-27.8	-23.8	-5.1	-22.7	-17.8			-21.5	1.27
Camden roadside																
Average diffusion tube	48.3	54.4	48.3	62.8	34.3	39.6	43.3		49.1	56.4	43.9	56.0	48.8			
Site precision	4.7	2.8	4.7	5.4	15.3	11.5	12.9		8.9	3.9	17.2	6.9		9.8		
Average - Continuous Analyser	61.5	70.6	70.1	65.2	59.6	64.9	67.6		65.6	61.8	71.4	65.5	65.8			
% Bias, based on continuous	-21.4	-22.9	-31.1	-3.6	-42.5	-38.9	-35.9		-25.2	-8.8	-38.5	-14.4			-25.9	1.35
Bloomsbury																
Average diffusion tube	49.6	50.0	48.6	42.5	40.5	25.2	40.0	23.3	40.0	44.3	33.3	51.9	40.8			
Site precision	3.0	2.1	2.1	17.6	11.6	3.9	13.7	1.9	2.9	16.1	15.6	1.2		10.1		
Average - Continuous Analyser	57.4	56.6	54.6	47.0	47.0	44.5	45.5	41.9	47.2	54.0	57.6	56.3	50.8			
% Bias, based on continuous	-13.6	-11.7	-11.1	-9.6	-14.0	-43.3	-12.2	-44.3	-15.4	-17.9	-42.1	-7.8			-19.8	1.25
														Mean site precision:	8.2	
														Overall % Bias:	-26.6	
														Mean correction Factor:	1.37	

All NO_2 concentrations in $\mu g\ m^{-3}$

Notes on calculations:

Mean site precision = √(mean site variance)

% Bias = $((C_{diffusion\ tube} - C_{continuous\ monitor}) / C_{continuous\ monitor}) * 100$

Correction factor = $C_{diffusion\ tube} / C_{continuous\ monitor}$

where C is the annual average NO_2 concentration

The correction factors ranged from 1.25 at the Bloomsbury site to 1.60 at the Hillingdon site, with the overall mean of 1.37. The differences between the selected sites for this survey should be noted. For example, there are fundamental differences between the Bloomsbury site, which is situated in an 'urban centre' location, and Hillingdon, which is 'suburban' in location and will be influenced by the M4, approximately 30 meters away. The influence of specific site characteristics upon the NO_2 diffusion tube efficiency is unknown and un-quantifiable, but may account for some of the inter-site variation and almost certainly reflect the individual NO_x/NO_2 ratios. Although applying a correction factor of 1.60 would give a conservative indication of bias corrected NO_2 concentrations, applying a correction factor of 1.37 (Table 8) is more likely to be fully representative of London sites, taking all inter-site differences into account.

10 Conclusions

Since 1986, Casella Stanger has operated the NO_2 Diffusion Tube Survey for London Boroughs. This is a cost-effective method for determining ambient NO_2 concentrations on a wider scale through which intercomparison can be made and levels of NO_2 assessed over time.

A triplicate study carried out by collocation with automatic analysers at five sites in London showed that the diffusion tubes used in the current work under-read by 26.6%. This slightly outside the criteria of $\pm$25% set by the NETCEN inter-comparison exercise. Other field inter-comparison analysis, conducted as part of the WASP QA/QC programme, show that bias relative to automatic analysers is within the target $\pm$25%. However, WASP is less rigorous than the LWEP collocation study as the former uses results from two months of sampling, whereas the latter uses a year's worth of monitoring results. Other laboratory performance testing conducted as part of the scheme rated Gradko International Ltd. as 'good', signifying results were from a laboratory with excellent quality control.

The reported results are actual values not accounting for bias found in triplicate study to allow for long-term trend analysis.

Between 1986 and 2001, NO_2 concentrations have fallen for all site classes.

The AQS recommends a provisional annual average AQO of 40 $\mu g\ m^{-3}$ for NO_2 for 2005. A total of 72 sites of the total 326 reporting sites exceeded this value in 2001 of which 64 were classed as roadside sites (Table 9). Most of the exceedences are concentrated in central parts of London whilst lower concentrations are recorded towards suburban areas and outskirts.

However, if the correction factor of 1.37 is applied, anything above 30 $\mu g\ m^{-3}$ is equivalent to an exceedence of the 2005 AQO. Table 10 lists all the sites where NO_2 concentrations were annual mean 30 $\mu g\ m^{-3}$ or above, which should be considered as potential exceedences in addition to those listed in Table 9. Therefore, realistically, the number of exceedences include a further 101 roadside sites and 46 background and intermediate sites. This essentially results in the majority of the roadside sites included in the LWEP network showing annual average concentrations that exceed the 2005 AQO in 2001.

Table 9 Monitoring Sites Exceeding 40 µg m^{-3} in 2001

Borough	Site Class		
	Background	**Intermediate**	**Roadside**
London Borough of Barking & Dagenham	BD35	-	BD39
London Borough of Barnet	-	-	BA63 BA65 BA66
London Borough of Brent	-	BR31	BR43 BR53 BR54 BR55 BR56 BR57 BR58
London Borough of Camden	CA14 CA25 CA29	CA15	CA2 CA3 CA4 CA5 CA10 CA11 CA13 CA16 CA17 CA19 CA23 CA24 CA27 CA28
Corporation of London	-	-	CL36 CL38 CL39
London Borough of Ealing			EAL34 EAL50 EAL56 EAL80 EAL81 EAL82 EAL85
London Borough of Greenwich	-	GW38	GW25 GW29 GW33 GW35 GW42 GW50
London Borough of Hammersmith & Fulham	-	-	HM32 HM50 HM52
London Borough of Hounslow	-	-	HS61

Table 9 cont…

Royal Borough of Kensington & Chelsea	-	KC40	KC33 KC38 KC46 KC48 KC49 KC50 KC52 KC54
London Borough of Newham	-	-	NW09
London Borough of Richmond	-	-	RUT01 RD18
City of Westminster	-	-	WM32 WM39 WM46 Oxford Street

Table 10 Monitoring Sites between 30-40 µg m^{-3} in 2001[21]

Borough	Site Class		
	Background	Intermediate	Roadside
London Borough of Barking & Dagenham		BD40	BD32
London Borough of Barnet	BA62	BA72	BA51 BA53 BA60 BA68 BA70
London Borough of Bexley			BX34 BX35
London Borough of Brent	BR41		BR42 BR52
London Borough of Camden	CA06 CA22	CA01	CA12 CA21
Corporation of London	CL03 CL05	CL02 CL51 CL55 CL62	CL41 CL56

[21] Applying a bias correction factor of 1.37 to the reported values would result in an NO_2 concentration of 30 µg m^{-3} becoming 41 µg m^{-3}. Therefore annual average NO_2 concentrations that are greater than 30 µg m^{-3} should be regarded as potential exceedences of the 2005 AQO.

Table 10 cont…

London Borough of Croydon			CY41 CY42 CY43 CY51 CY55 CY57 CY58 CY59 CY61 CY62 CY65 CY66 CY97 CY98
London Borough of Ealing	EAL27 EAL45 EAL58 EAL74	EAL01 EAL04 EAL14 EAL73 EAL86	EAL03 EAL06 EAL10 EAL12 EAL15 EAL22 EAL23 EAL 25 EAL46 EAL53 EAL55 EAL60 EAL62 EAL65 EAL66 EAL79 EAL87
London Borough of Greenwich			GW33 GW34 GW36 GW41 GW43 GW48 GW51 GW52 GW53 GW54 GW55
London Borough of Hammersmith & Fulham	HM44 HM45 HM51 HM53		HM47 HM48 HM54
London Borough of Hillingdon			HD42 HD43 HD46

Table 10 cont…

London Borough of Hounslow		HS43	HS32 HS33 HS41 HS42 HS51 HS52 HS54 HS55 HS62 HS63 HS64
Royal Borough of Kensington & Chelsea	KC34 KC39 KC41 KC44 KC47	KC42 KC43 KC53	KC31 KC35 KC45
London Borough of Newham	NEW10	NEW05	NEW01 NEW02 NEW03 NEW04 NEW08
London Borough of Richmond			RD01 RD03 RD04 RD05 RD06 RD09 RD11 RD13 RD14 RD15 RD16 RD19 RD20 RD21 RD22 RD24 RD26 RD27 RD29
City of Westminster	WM37 WM40 WM44 WM52 WM53 WM54 Horseferry Road	WM43 WM49	WM36

Detailed trend analysis for each borough has shown a decrease in concentrations of NO_2 over time for many of the classes. At background locations this trend appears to be slower whilst the steepest decline is found at roadside sites.

Analysis of the intermediate and roadside elevation provides an indication of the contribution of road traffic to total NO_2 concentrations. The patterns shown by the intermediate and roadside elevations are often related. The elevation at intermediate sites is mostly lower than that of roadside sites, thus confirming a decrease in NO_2 levels with distance from major roads.

Contribution from road traffic to annual average NO_2 concentrations has shown a general decrease in many Boroughs, though eight Boroughs have displayed a general increase since 2000. These are:

- London Borough of Camden
- London Borough of Croyden
- London Borough of Hammersmith and Fulham
- London Borough of Hillingdon
- London Borough of Hounslow
- London Borough of Kensington and Chelsea
- London Borough of Newham
- London Borough of Westminster.

However, some of these increases were not significant and may just reflect natural fluctuations rather than long-term trends.

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11 Disclaimer

Casella Stanger completed this report on the basis of a defined programme of works and within the terms and conditions agreed with the Client. This report was compiled with all reasonable skill and care, bearing in mind the project objectives, the agreed scope of works, prevailing site conditions and degree of manpower and resources allocated to the project as agreed.

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