CASELLA STANGER

London-Wide Nitrogen Dioxide Diffusion Tube Survey

Annual Report 2002

Ref: CS/AQ/022150102/GE/2114
January 2004

Great Guildford House, 30 Great Guildford Street, London, SE1 0ES
T +44 (0)20 7902 6100 F +44 (0)20 7902 6149 E info@casella.co.uk

CASELLA STANGER

Report

London-Wide Nitrogen Dioxide Diffusion Tube Survey

Annual Report 2001

Prepared By

Gloria Esposito MSc, BSc
Consultant

Approved By

Richard Maggs PhD, BSc, DIC, CBiol, MIBiol
Principal Consultant

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 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

January 2004

Ref: CS/AQ/022150102/GE/2114

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. This report encompasses one of these indicators – nitrogen dioxide (NO_2).

Nitrogen dioxide has been regarded as a one of the main pollutants that needs to be targeted due to the high road traffic emission levels 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 City-wide 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.

Sixteen Boroughs reported annual average NO_2 concentrations at 320 individual sites in 2002. Annual average concentrations were equal to, or above, 40 $\mu g/m^3$ at 8 background and 49 roadside sites.

Results from the year 2002 survey indicate a continued gradual decreasing trend in NO_2 concentrations at background and roadside sites.

The geographical spread shows higher concentrations in central parts of London and a reduction in concentration further away from the city centre. A few hot spots are identified in boroughs on the outskirts of the city.

Linear trend analysis showed that mean background and roadside concentrations within the majority of participating Boroughs have shown a decreasing trend between 1993 and 2002.

Contribution from road traffic to annual average NO_2 concentrations shows a general decrease in many Boroughs, though seven Boroughs display a general increase since 2001. These are London Borough of Barnet, London Borough of Bexley, London Borough of Brent, London Borough of Greenwich, London Borough of Hillingdon, London Borough of Hounslow and London Borough of Newham. However, some of these increases were not significant and may just reflect natural fluctuations rather than long-term trends.

The monthly variation in NO_2 concentration at background and roadside sites averaged out for all participating boroughs in 2002 indicates a seasonal pattern. The highest NO_2 concentrations where recorded in the winter months of January and November. The lowest concentrations occur in the summer month of June.

Table of Contents

List of Tables

List of Figures

List of Maps

CASELLA STANGER

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 is the monitoring of nitrogen dioxide (NO_2) by passive diffusion tubes. This is a cost-effective method for assessing the spatial and temporal distribution of NO_2 as well as 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, 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 2002 a total of 16 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 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 2002 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 the geographic spread of annual mean NO_2 concentration of participating boroughs at Background and Roadside sites within Greater London;
- 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 mean NO_2 concentrations at each site, for all participating boroughs in 2002 and to place these results in the context of other results gathered since 1993;
- Undertaking analysis of the results to assess trends in pollution at Background and Roadside classes for each participating borough;
- Identifying the elevation in NO_2 concentrations at Roadside site classes when compared to Background levels in each participating borough;
- Identifying the overall monthly variation NO_2 concentration at Background and Roadside Sites for all participating boroughs;
- Validation of nitrogen dioxide diffusion tubes through the analysis of results from co-located tubes at automatic analysers in London.

2 Formation, Sources and Effects of NO_2

2.1 Formation of atmospheric nitrogen dioxide

NO_2 is generated naturally and by man made activities. NO_2 can be emitted directly known as primary NO_2 or can form during a series of chemical reactions in the atmosphere involving NO_x (NO + NO_2) and ozone, referred to as secondary NO_2. 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 NO_2 in the atmosphere, there is often an inverse relationship between concentrations of ozone and NO_2.

Combustion processes are the main anthropogenic source of NO_x emissions. These include road transport, power generation, and various high-temperature industrial processes.

The concentration of NO_2 in the atmosphere at any given location is influenced by a number of factors. These including the magnitude and proximity of NO_x emissions sources, the proportion of NO_x directly emitted as NO_2, the chemistry leading in the generation and destruction of NO_2, and meteorological conditions that affect the dispersion and accumulation 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 NO_2 concentrations recorded over London in December 1991, when levels peaked at over 803.5 $\mu g\ m^{-3}$ 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 leading to a general decrease in occurrence of NO_2 when compared to the winter months.

2.2 Emission sources

Emissions inventories are an important means of quantifying emissions of NO_x from different sources at different times, as can be seen in Figure 1. The greatest contributors of nitrogen oxides (NO_x) in the UK are motor vehicles. Estimates indicate that 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_x in the same year, whilst the remainder comes from a variety of sources including industry and domestic activity. The contribution of road transport to NO_x emissions in urban areas is generally higher than the national average. In London 68% of NO_x emissions come from road transport.

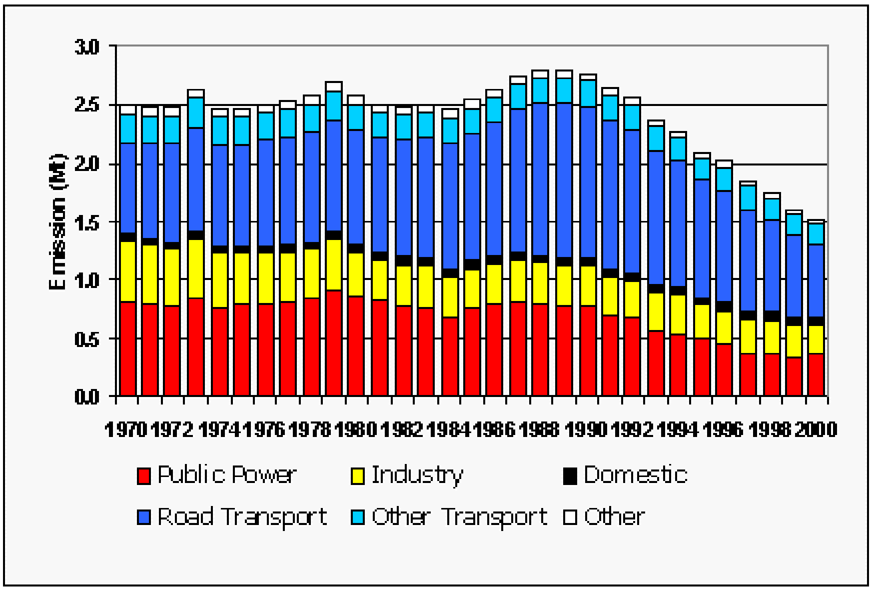
Ground level NO_2 concentrations are greatly influenced by road transport, which continues to be the major source of NO_x. There is evidence for significant amounts of NO_2 emitted directly from the tail pipe of diesel vehicles, with levels possibly as high as 25% of total NO_X emissions.[2] Primary emissions of NO_2 will be particularly significant

[1] Source: DEFRA (2002) Digest of Environmental Protection and Water Statistics. http://www.defra.gov.uk/environment/statistics/des/index.htm

[2] Source: AQEG (2002) Nitrogen Dioxide in the United Kingdom (Draft for Consultation)

for slow-moving buses and large HGVs, as well as possibly diesel vans and taxis in the centre of town and cities. The increasing sales of diesel cars in the UK should also be considered when assessing future NO_2 concentrations in urban areas.

Figure 1 Estimated UK Emissions of Nitrogen Oxides by Emission Source 1970-2000[3]



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.

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

[3] Source: National Atmospheric Emissions Inventory (2002) http://www.naei.org.uk/pollutantdetail.php

subject's response to airborne allergens. Many studies estimating the chronic effects of NO_2 use unquantified 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 NO_2 concentrations have undergone continuous change, both nationally and on a European level. For Europe, the First Air Quality Daughter Directive sets out limits for annual mean and hourly mean 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[4] (AQS). The document was published in January 2000, superseding the earlier National Air Quality Strategy[5] (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 time-scale 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 $\mu g\ m^{3}$ with a maximum of 18 exceedences*	1 hour mean	31 December 2005
Annual	40 $\mu g\ m^{3}$	Annual mean	31 December 2005

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

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,

[4] DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working together for Clean Air"
[5] DoE (1997) The United Kingdom National Air Quality Strategy

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 NO_2 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. It 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.

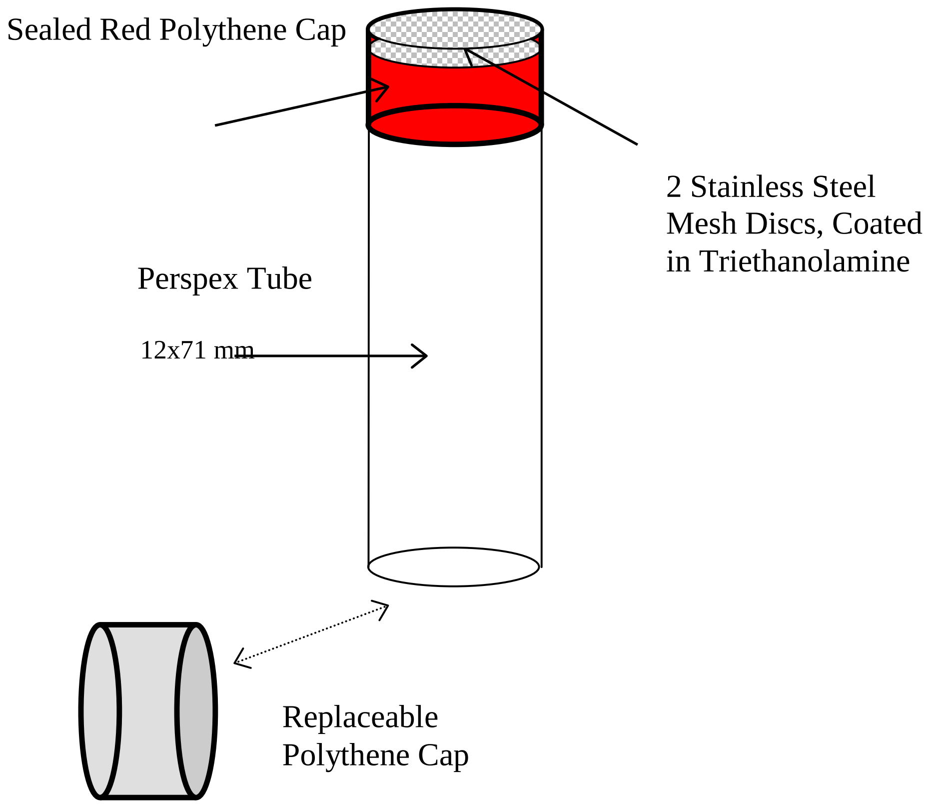
The strategy recognises that road traffic is the primary cause of air pollution in London and is consequently linked to other relevant strategies and measures taken by Transport for London (TfL), the Greater London Authority, and the London Development Agency (LDA). TfL in particular will be instrumental in tackling this problem with implementation of measures to reduce traffic, promote cleaner technology, and 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 its geographical spread across London will aid in determining the effect of a number of these policies in the future.

4 NO_2 Sampling and Analysis 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 through the tube and are absorbed by the triethanolamine (TEA), which is present on the coated discs[6]. There are three main preparation methods for diffusion tubes involving triethanolamine. The diffusion tubes employed in the LWEP programme are prepared by UKAS accredited Gradko International Ltd. using the 50% v/v triethanolamine with acetone method.

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 UK Nitrogen Dioxide Diffusion Tube Survey, the tubes are exposed for a four - five week period, consistent with the national survey. The 2002 exposure dates are set out in Table 2.

Table 2 UK Nitrogen Dioxide Tube Survey Monitoring Periods, 2002[7]

Month	Start Date	Duration
January	1 January	4 weeks
February	29 January	4 weeks
March	26 February	5 weeks
April	2 April	4 weeks
May	30 April	4 weeks
June	4 June	5 weeks
July	2 July	4 weeks
August	30 July	5 weeks
September	3 Sept	4 weeks
October	1 October	4 weeks
November	29 October	5 weeks
December	3 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.

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

7 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
Background	B	>20m

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.TG (03). All monitoring sites in 2002 have been classified as either the roadside or background depending on the distance from the road. Further details of the UK NO_2 Diffusion Tune Network are available at: http://www.aeat.co.uk/netcen/airqual/reports/no2man/no2man.html.

4.3 Analysis

Gradko International Ltd additionally undertakes the analysis of exposed diffusion tubes, on behalf of Casella Stanger, by ultra violet spectrophotometry.

4.4 Quality Assurance and Quality Control

In order to ensure that NO_2 concentrations reported are of a high caliber, a strict performance criteria needs to be meet through the execution of quality assurance and control procedures. A number of factors have been identified as influencing the performance of diffusion tubes including the laboratory preparing and analysing the tubes and the tube preparation method. [8] Quality assurance and control procedures are therefore an integral feature of any monitoring programme, ensuring that uncertainties in the data are minimised and allowing the best estimate of true concentrations to be determined.

Gradko International Ltd conducts rigorous quality control and assurance procedures in order to maintain the highest degree of confidence in their laboratory measurements. These are discussed in more detail bellow.

Gradko International Ltd participates in the Health and Safety Laboratory WASP[9] NO_2 diffusion tube scheme on a monthly basis. 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[10]. The laboratory performance for all months in 2002 was rated 'good' which signifies a high level of accuracy of laboratory measurements.

---

[8] Compilation of diffusion tube collation studies carried out by local authorities, prepared by Professor Duncan Laxen and Penny Wilson, 2002

[9] Health and Safety Executive, Workplace Analysis Scheme for Proficiency

[10] 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 2002 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

Gradko International Ltd also take part in the Network Field Inter-comparison Exercise, operated by NETCEN, which compliments the WASP scheme in assessing sampling and analytical performance of diffusion tubes under normal operating conditions. NETCEN have established performance criteria for participating laboratories. Of particular interest is the bias relative to the chemiluminescent analyser that gives an indication of accuracy. In conjunction with this is the uncertainty of a triplet of co-located tube measurements, referred to as precision. The performance targets can be seen in Table 5.

The Field Inter-comparison Exercise has historically generated the bias and precision results for each laboratory on an annual basis. This has recently been changed to the results being reported on a monthly basis. The 6-month summary for the latter half of 2002 for Gradko International Ltd is shown below. The results indicate that Gradko International Ltd diffusion tubes are well within the performance targets set by NETCEN.

Table 5 6-month Summary of NO_2 Network Field Inter-comparison Results, 2002

Bias % Performance Target	Gradko International Result %	Precision % Performance Target	Gradko International Result %
$\pm$25	12	$\pm$%10	6.9

Gradko International Ltd perform their own blank exposures that serve as a quality control check on the tube preparation procedure**.** All results are blank subtracted before they are issued to their relevant Borough.

Casella Stanger conduct 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 2002 programme. The study shows that the mean bias is -26% (range = -15 to -34%) across the sites.

5 Overview of Results

5.1 Data Capture Statistics

The number of tubes exposed at each site class is at 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 background sites. Figure 3 shows the overall percentage of each site classification included in the study and Table 6 gives the percentage data capture for year 2002 for each borough.

Figure 3. Percentage of monitoring sites by classification

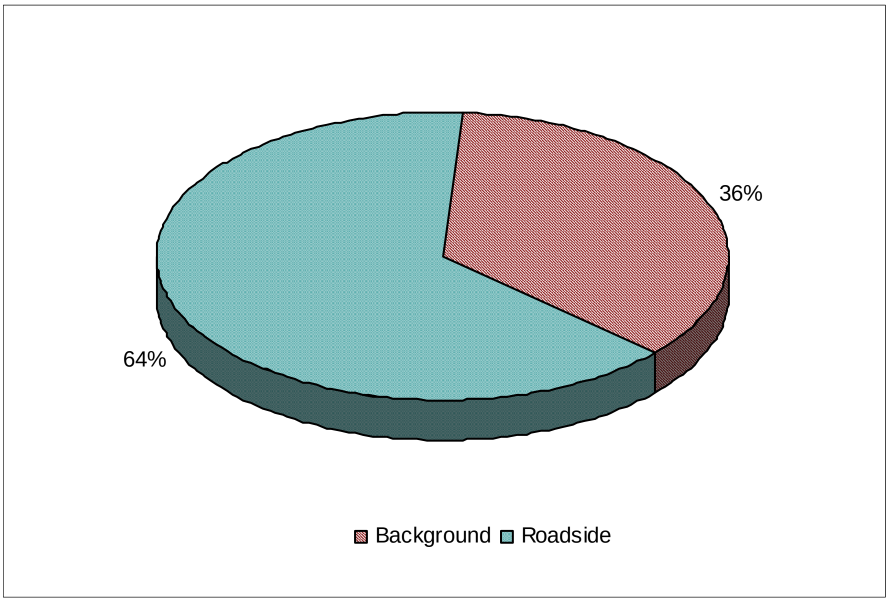


Table 6 Percentage data capture for each Borough in year 2002

London Borough	% Data Capture year 2002*
London Borough of Barking & Dagenham	93
London Borough of Barnet	71
London Borough of Bexley	85
London Borough of Brent	93
London Borough of Camden	77
Corporation of London	90
London Borough of Croydon	79
London Borough of Greenwich	90
London Borough of Hammersmith & Fulham	98
London Borough of Harrow	70
London Borough of Hillingdon	70
London Borough of Hounslow	99
Royal Borough of Kensington & Chelsea	97
London Borough of Newham	76
London Borough of Richmond-upon-Thames	98
City of Westminster	78

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

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.

Several sites have been eliminated, GW32 in 1999, TH31 2000 and TH32 in April 2002. The results in the above figure below do not therefore include results for these sites for the relevant years.

Table 7 Roadside, intermediate and background sites surveyed since 1986 as part of the London Wide NO_2 diffusion tube survey.

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

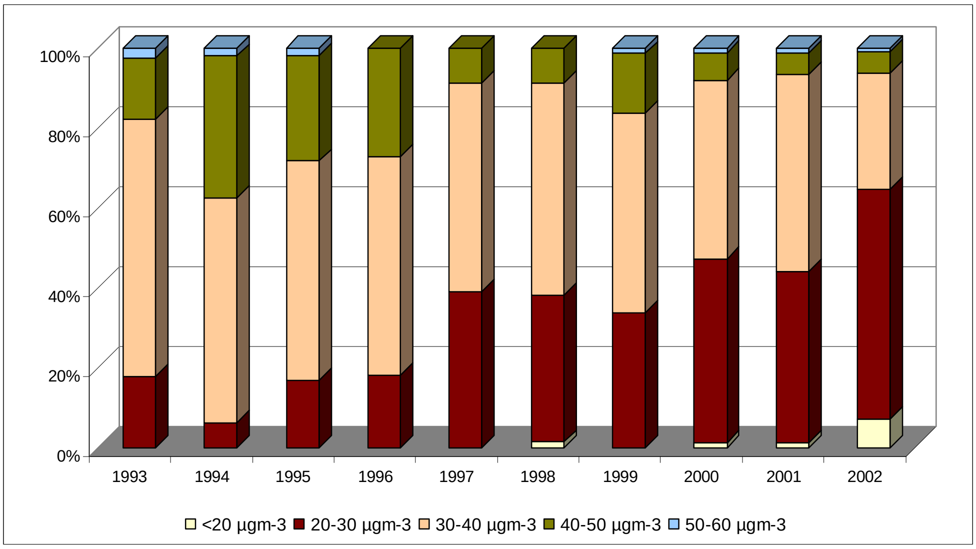
Figure 4 Long-term mean concentrations at selection of LWEP sites

The time series indicates a long-term decrease in NO_2 concentrations at all site classes since 1993 though 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 (BR31) remaining in these years, compared with 9 roadside sites. Concentrations at BR31 site used are uncharacteristically high for that site classification. The NO_2 concentration however decreases in 2002 at the background site. Between 1986 and 2002 annual mean NO_2 background concentrations has reduced by 50%, whereas roadside sites have experienced are more significant decrease of 63%.

5.3 Frequency Distribution of Long Term Annual Mean NO_2 Concentrations

Long term data from the 16 London boroughs included in this report, dating back to 1993, has been examined to reveal how annual mean NO_2 concentrations have varied over time at roadside and background sites.

Figure 5 Frequency Distribution of Annual Mean Background NO_2 Concentrations, 1993-2002

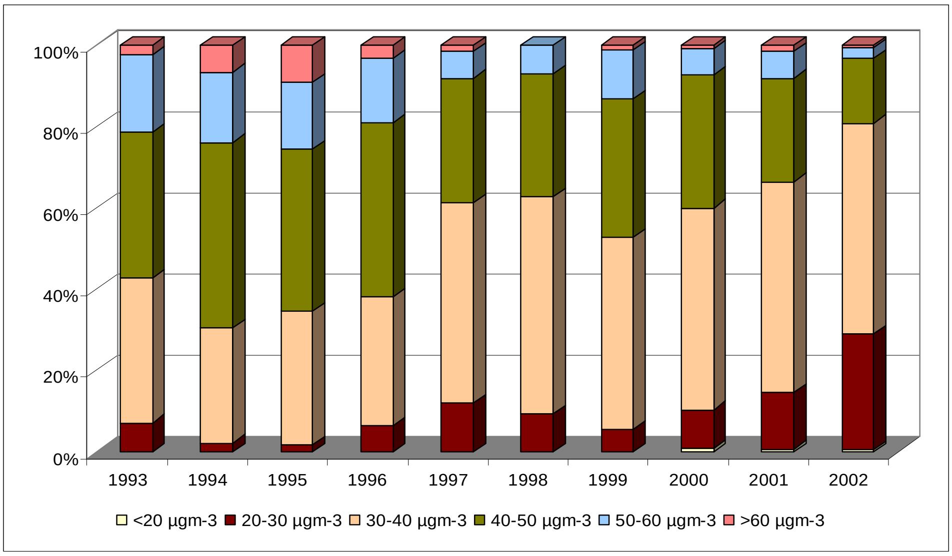


In the early part of the programme the largest percentage of annual mean NO_2 concentrations where present in the 30-40 $\mu g/m^3$ banding. Approximately 5% of sites recorded concentration in the 50-60 $\mu g/m^3$ banding.

From 1997 to 2002 there is a clear variation in the frequency of each banding. Annual mean NO_2 concentrations in the 50-60 $\mu g/m^3$ and 40-50 $\mu g/m^3$ banding reduce by approximately 50%. Annual mean NO_2 concentrations recorded in the 20-30 $\mu g/m^3$ range gradually increase over this period. In 1998 annual mean NO_2 concentrations drop for the first time to below 20 $\mu g/m^3$, and continue to be recorded in this banding over the next four years.

In 2002 annual mean NO_2 concentrations illustrate a distinct changed in the proportion of each concentration banding. The 20-30 µg/m^3 banding are the most frequently recorded concentrations at London sites, with those >20 µg/m^3 revealing their highest frequency as yet.

Figure 6 Frequency Distribution of Annual Mean Roadside NO_2 Concentrations, 1993-2002



Between 1993 and 1996 the highest percentage annual mean NO_2 concentrations accounted for at roadside were present in the 40-50 µg/m^3 concentration banding. Approximately 10% of sites recorded concentrations over 60 µg/m^3 and a very low number showed concentration in the 20-30 µg/m^3 banding.

A reduction in the frequency of annual mean roadside NO_2 concentrations in the >60µg/m^3, 50-60 µg/m^3 and 40-50 µg/m^3 bands are apparent from 1997 onwards. An elevation in sites recording concentrations in the 30-40 µg/m^3 band occurs in 1997 remaining at this frequency over the next 5 years. Between 2000 and 2002 sites begin to record concentrations >20 µg/m^3.

In 2002 roadside sites recording in the banding of 20 to 30 µg/m^3 show a sharp increase, whereas sites recording the higher bandings decline. The annual mean NO_2 concentration at roadside sites is mainly in the 30-40 µg/m^3 banding.

Overall a reduction in annual mean NO_2 concentration has taken place between 1993 and 2002 at both background and roadside sites.

5.4 Nitrogen dioxide concentrations – Geographical spread

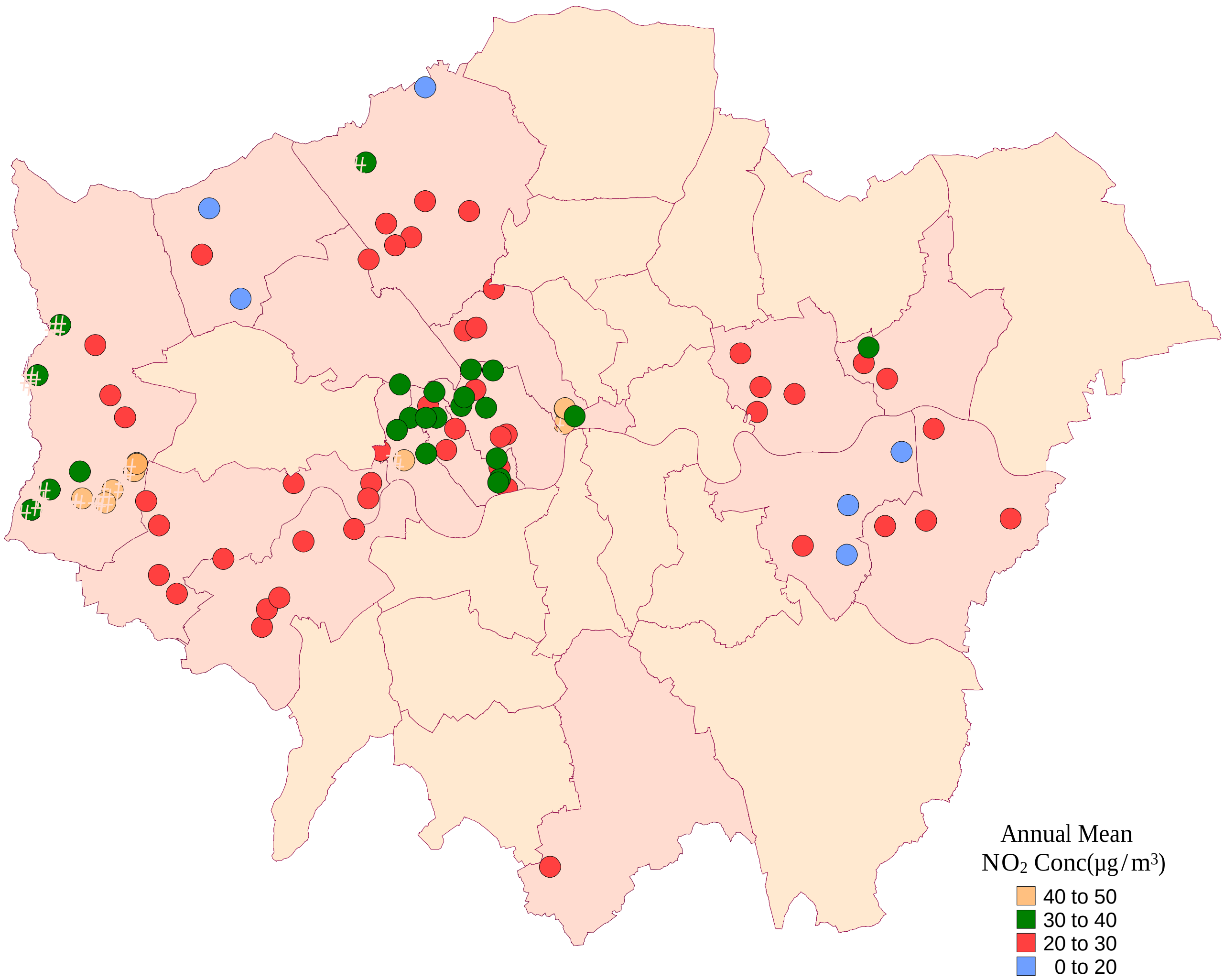
Maps 1 and 2 show the geographical spread of the annual mean concentrations[11] for the nitrogen dioxide diffusion tube survey across London. The maps do not include data from Boroughs other than the ones that are part of the London Wide Environment Programme for nitrogen dioxide.

The background concentrations range between 13 and 50 µg/m^3 (mean = 29.5 µg/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 NO_2 concentration at background sites is predominantly recorded in the 20-30 µg/m^3 range uniformly spread throughout the London. The highest background concentrations are clustered within the central London locations.

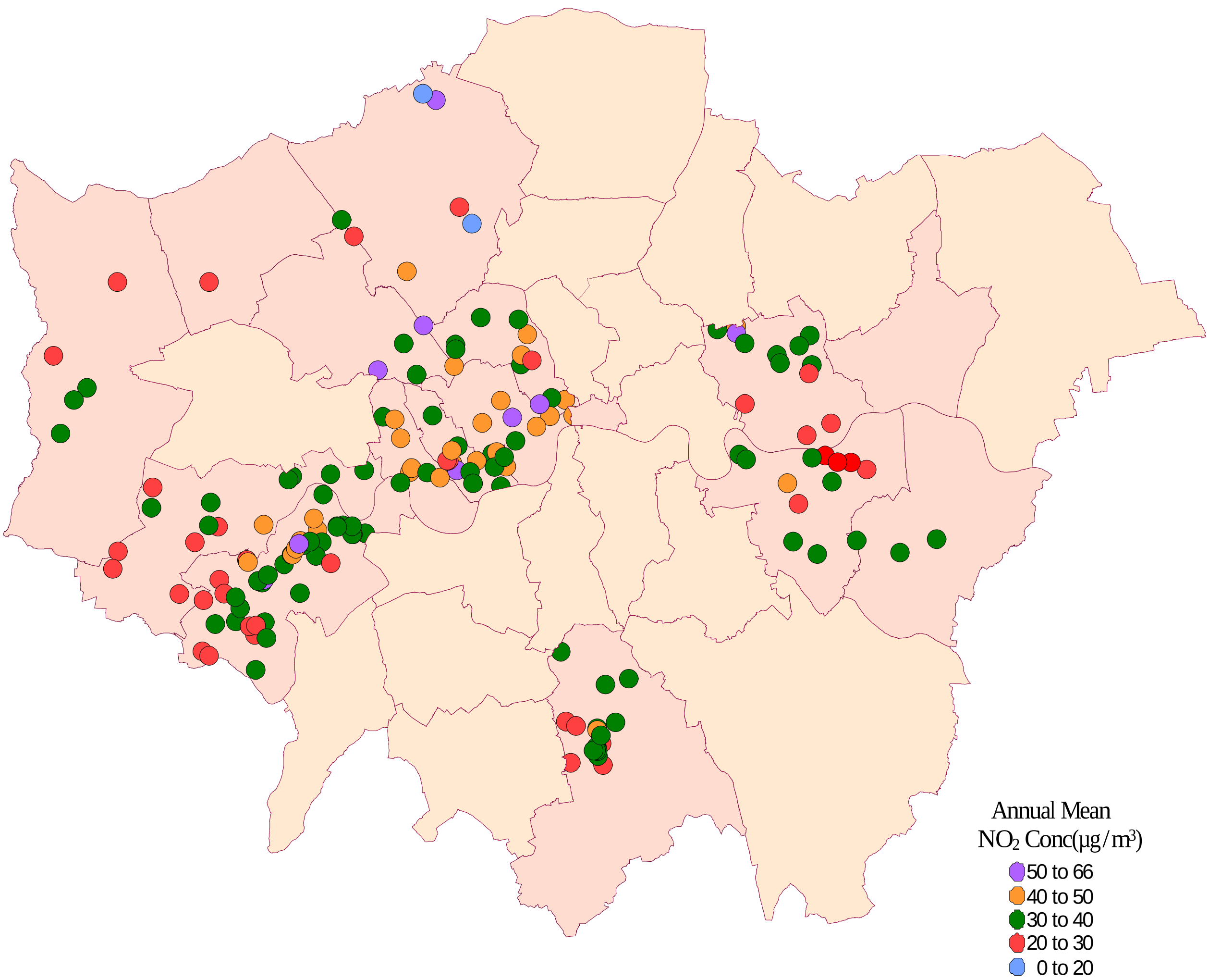
The roadside sites range between 18 and 66 µg/m^3 (mean = 35.4 µg/m^3). The geographical spread of NO_2 concentrations at roadside sites is predominantly recorded in the 30-40 µg/m^3 concentration range. The centre of London maintains the highest levels of NO_2 however a few boroughs situation away from the city experienced annual mean concentration in the 50-60 µg/m^3 banding. These may indicate local pollution hot spots.

[11] Annual mean NO_2 concentration has only been calculated for sites with over 6 months monitoring data.

Map 1 Annual Mean Background NO_2 Concentrations by Site Class, 2002



Map 2 Annual Mean Roadside NO_2 Concentrations by Site Class, 2002



6 Reporting - Participating Boroughs

6.1 Introduction

For the 2002 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 2002 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 Mean Air Quality Objective of 40 $\mu g/m^3$ in 2005.

6.2 Reporting of Results

6.2.1 2002 Mean Values

Bar charts have been created showing the 2002 annual mean 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[12]. Appendix 1 lists the NO_2 concentration for all the roadside and background sites in each borough. Sites that have exceeded the 40 $\mu g/m^3$ 2005 air quality objective have been highlighted.

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

6.2.2 Site Time Series

Time series plots have been created for sites with up to 6 years of continuous monitoring data. Each time series plot contains data for sites as grouped by their site class.

6.3 Analysis of Results

6.3.1 Trend Analysis by Site Class

Monitoring sites with a minimum of 8 years continuous data were first identified. Individual concentrations are grouped by site class to provide an arithmetic mean for each site class.

The mean annual class concentrations has 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.

[12] Source: Urban Air Quality in the United Kingdom. First Report of the Quality of Urban Air Review Group. DoE. January 1993.

6.3.2 Roadside Elevation

Mean annual background concentrations were subtracted from mean annual roadside concentrations to calculate the elevation above background NO_2 concentration. This may provide an indication of the level of NO_2 being received at 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.

6.3.3 Monthly variation in background and roadside NO_2 concentrations for all roadside and background sites, 2002

An average of monthly background and roadside NO_2 concentrations for all boroughs participating in the LWEP Programme has been represented in the line graph. This may provide an insight into the seasonal variation in NO_2 concentrations.

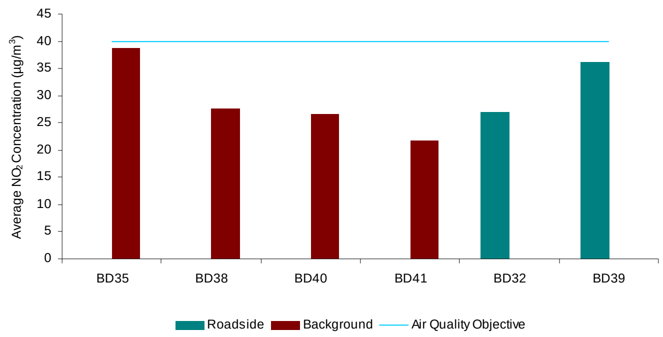
CASELLA STANGER

7 Analysis of Results – Participating Boroughs

7.1 London Borough of Barking and Dagenham

2002 Mean Values

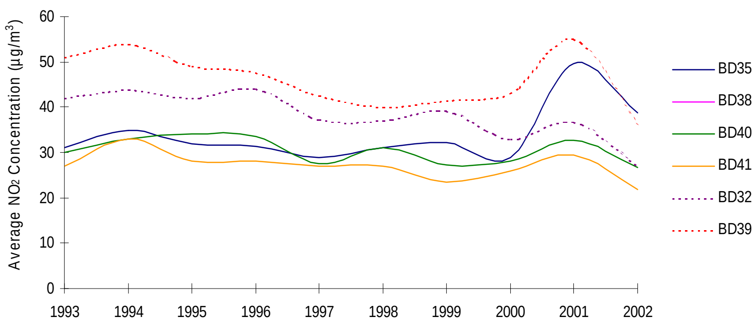
Figure 7 Barking and Dagenham Background and Roadside Annual Mean NO_2 Concentrations, 2002



Barking and Dagenham did not introduce any new monitoring sites in 2002. Background concentrations recorded between 22 and 39 µg/m³. Roadside concentrations vary between 27 and 36 µg/m³. The 2005 air quality objective was not exceeded at any monitoring site although the annual mean for BD35 approaches 40 µg/m³.

Site Time Series

Figure 8 Barking and Dagenham Background and Roadside Time Series, 1993-2002

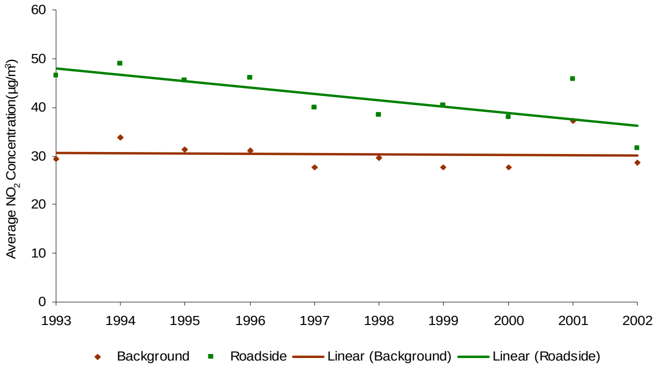


The roadside sites BD32 and BD39 and the background site BD35 follow a very similar trend from 1993 to 2002. Background sites BD40 and BD41 additionally display a comparable trend. In 2001 BD35 and BD39 show a marked increase in annual mean NO_2 concentration. All sites show a sharp decrease in concentration in 2002. The local authority may wish to consider reclassifying this site as a roadside site, as the distance from the road of 15m does not fit with that of a background location.

CASELLA STANGER

Trend Analysis

Figure 9 Barking and Dagenham Background and Roadside Trend Analysis, 1993-2002



Background concentrations display a relatively consistent trend around 30 µg/m^3 from 1993 to 2002. The roadside sites show a clear declining trend from 1993 to 2002 of approximately 47%. Between 2001 and 2002 roadside NO_2 concentrations shows the greatest reduction in concentrations, with 2002 recording the lowest annual mean roadside concentration since the start of the programme in 1993.

Roadside Elevation

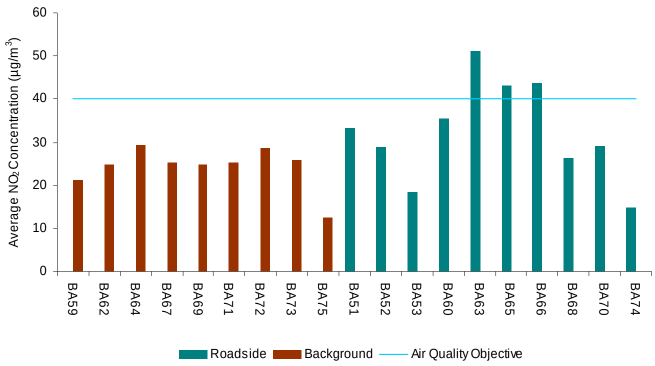
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m^3)	17.2	15.3	14.2	15.0	12.2	8.8	12.6	10.3	8.7	2.9

Roadside elevation in NO_2 concentration fluctuates over time but overall indicates a decreasing trend. A sharp decrease in roadside elevation from 2001 to 2002 is apparent. This may suggest that local traffic sources are becoming more influential at background sites. This is evident by the background site BD35 having the highest annual NO_2 mean concentration.

7.2 London Borough of Barnet

2002 Mean Values

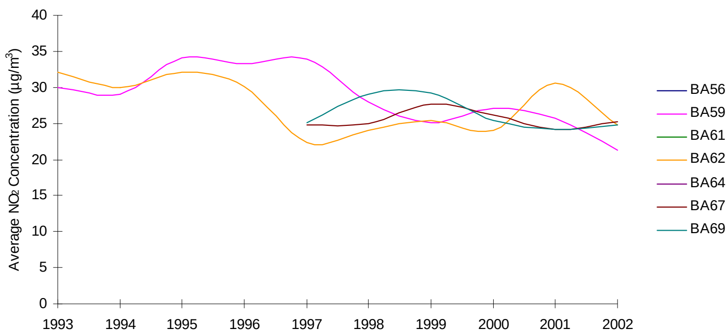
Figure 10 Barnet Background and Roadside Annual Mean NO_2 Concentrations, 2002



Barnet did not introduce any new monitoring sites in 2002. Background concentrations range between 13 and 29 µg/m^3. Roadside concentrations vary between 18 and 51 µg/m^3. The 2005 air quality objective was exceeded at BA63, 65 and BA66.

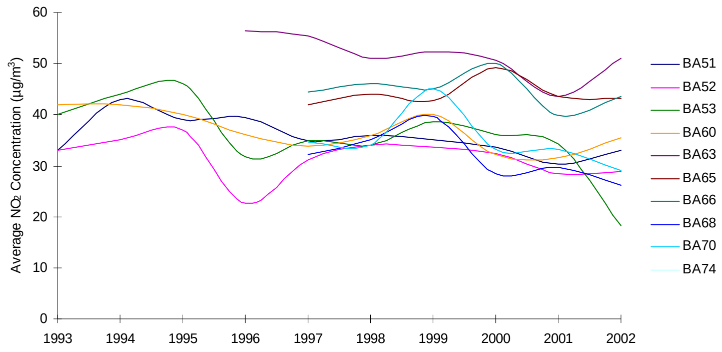
Site Time Series

Figure 11 Barnet Background Time Series, 1993-2002



Background concentrations do not appear to follow a trend. From 1999 onwards BA67 and BA69 vary in concentration concurrently showing a slight increase in 2002. BA59 and BA62 continue to show a decrease in mean NO_2 concentration from 2001 to 2002.

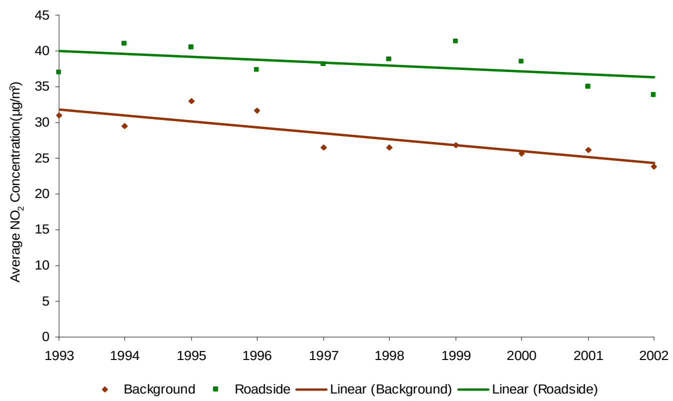
Figure 12 Barnet Roadside Time Series, 1993-2002



NO_2 concentrations fluctuate at all the sites with no obvious trend. Sites BA65, BA66 and BA63 display the highest concentrations. The annual mean NO_2 concentration at sites BA70, BA68, BA65 and BA53 reveal a decrease since 2001, with BA53 showing a reduction of almost 50%. Conversely the remaining roadsides show an increase in concentration since 2001.

Trend Analysis

Figure 13 Barnet Trend Analysis, 1993-2002



Background concentrations show a distinct downward trend from 1993 to 2002 where NO_2 concentrations have reduced by 30%. Roadside concentrations additionally display a decreasing trend but in a more subtle fashion.

Roadside Elevation

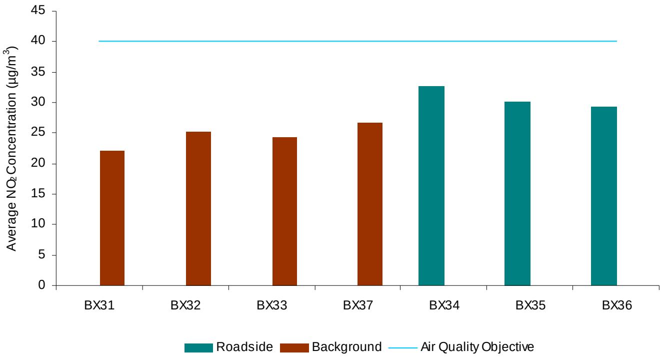
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above ba	6.0	11.5	7.5	5.6	11.6	12.4	14.5	12.8	8.8	9.9

The roadside elevation in NO_2 concentration fluctuates over time, showing a gradual increase from 1996 to 1999 and then a decline over the next two years. In 2002 the roadside elevation rises by 1 $\mu g/m^3$ on the previous 2001 result.

7.3 London Borough of Bexley

2002 Mean Values

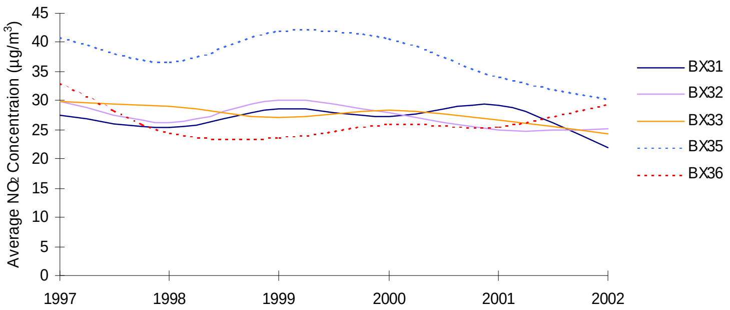
Figure 14 Bexley Background and Roadside Annual Mean NO_2 Concentrations, 2002



Bexley did not introduce any new monitoring sites in 2002. Background concentrations vary between 22 and 27 µg/m³. Roadside concentrations range between 29 and 33 µg/m³. The 2005 air quality objective was not exceeded at any monitoring site.

Time Series

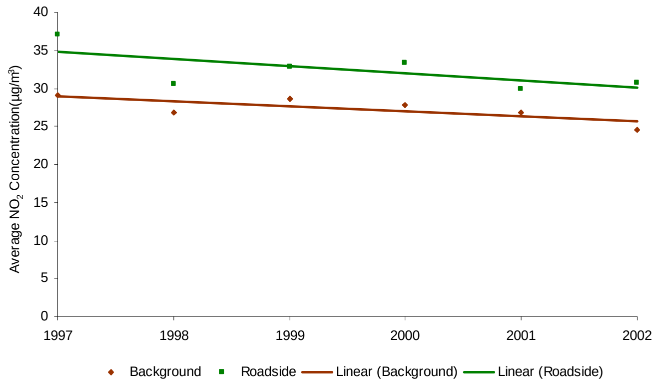
Figure 15 Bexley Background and Roadside Time Series, 1993-2002



Long-term data for Bexley begins in 1997 and displays a smooth undulating pattern for all monitoring sites. BX35 consistently records the highest concentrations over the past six years. Between 2001 and 2002 BX31, BX33 and BX35 experience a slight decrease in concentration whereas the remaining sites show a minor increase in annual mean NO_2 levels.

Trend Analysis

Figure 16 Bexley Trend Analysis, 1993-2002



Both background and roadside concentrations show a faint decreasing trend over time.

Roadside Elevation

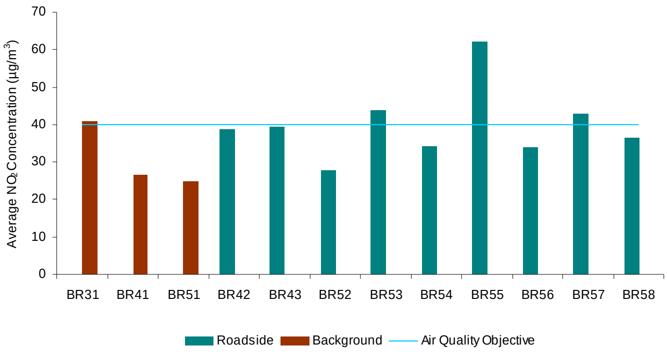
	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	8.0	3.7	4.3	5.5	3.0	6.2

The roadside elevation in NO_2 concentration drops by almost 50% between 1997 and 1998, then gradually increases by approximately 1 µg/m^3 over the next 3 yrs. After a minor reduction in 2001, the elevation above background concentration doubles in 2002. This may be a sign of increased local traffic.

7.4 London Borough of Brent

2002 Mean Values

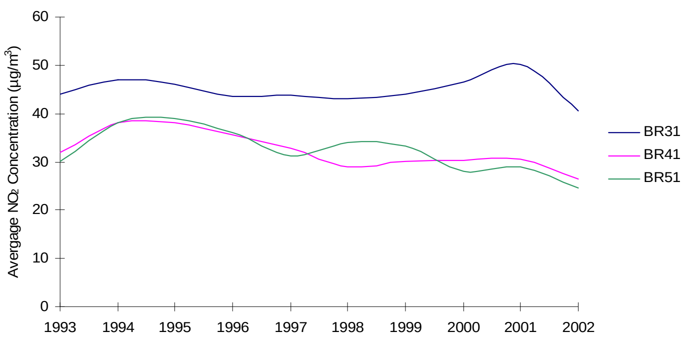
Figure 17 Brent Background and Roadside Annual Mean NO_2 Concentrations, 2002



Brent did not introduce any new monitoring sites in 2002. Background concentrations vary between 25 and 41 µg/m^3. Roadside concentrations range between 28 and 62 µg/m^3. The 2005 air quality objective was exceeded at BR31, BR53, BR55 and BR57 and closely approached at BR42 and BR43.

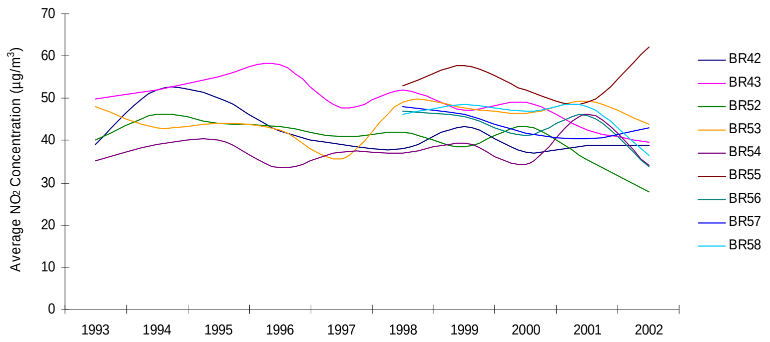
Site Time Series

Figure 18 Brent Background Time Series, 1993-2002



BR31 shows the highest background concentration throughout the ten-year monitoring period. Following a rise in annual mean NO_2 levels between 2000 and 2001, the three background sites show a drop in concentration between 2001 and 2002.

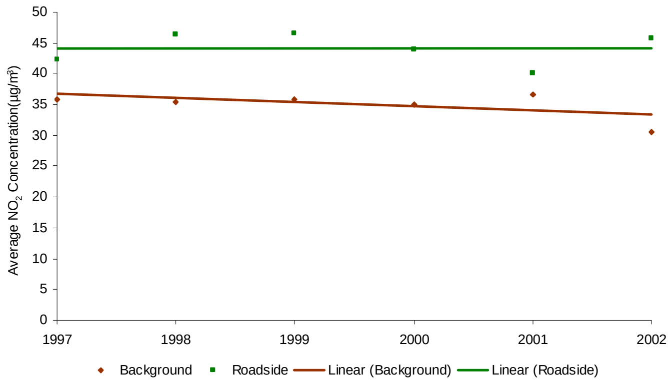
Figure 19 Brent Roadside Time Series, 1993-2002



Concentrations at roadside locations fluctuate between 1993 and 2002 with no obvious trends. Mean NO_2 concentrations at BR55 and BR57 increase between 2001 and 2002, whereas the remaining roadside sites show a decrease. The highest annual mean NO_2 concentration is recorded at BR55 since 1998.

Trend Analysis by Site Class

Figure 20 Brent Trend Analysis, 1993-2002



Trend analysis indicates that long-term roadside levels of NO_2 have remained fairly constant between 1997 and 2002. Background NO_2 concentrations reveal a distinct downward trend in long-term NO_2 concentrations.

Roadside Elevation

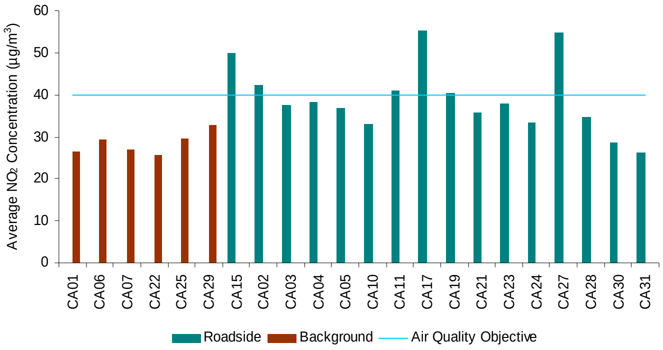
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	7.0	5.4	5.6	5.5	4.2	10.4	10.1	8.5	7.3	9.2

The elevation above background NO_2 concentration shows a steady reduction from 1993 to 1997. A marked increase in road elevation takes place from 1998 onwards. From 2001 to 2002 the roadside elevation rises by 2µg/m^3

7.5 London Borough of Camden

2002 Mean Values

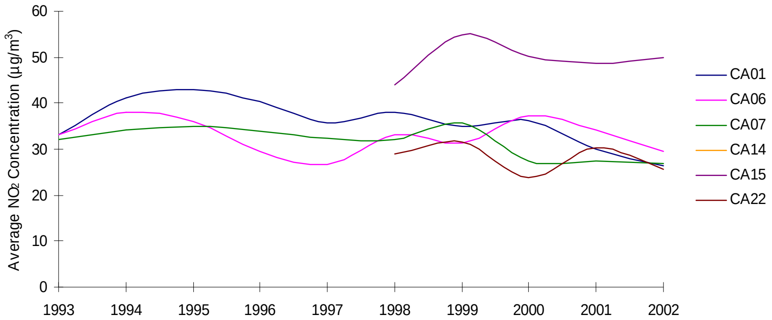
Figure 21 Camden Background and Roadside Annual Mean NO_2 Concentrations, 2002



Camden introduced to two new roadside sites in 2002, CA30 and CA31.[13] Background concentrations vary between 11 and 33 µg/m^3. Roadside concentrations vary between 26 and 55 µg/m^3. Sites CA02, CA11, CA15, CA19 and CA27 exceeded the 2005 air quality objective. [14]

Site Time Series

Figure 22 Camden Background Time Series, 1993-2002



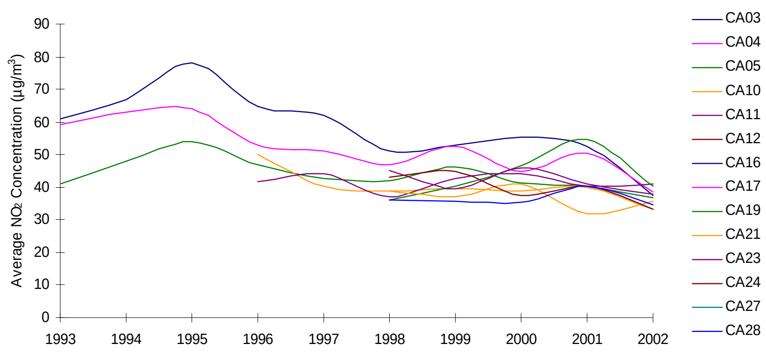
CA01 and CA06 appear to follow a similar rolling trend throughout the ten-year period. CA07 maintains a stable level of NO_2 up to 1998. The annual mean NO_2 concentration rises to its highest level in 1999, and then decreases gradually from then onwards. CA22 follows an almost identical pattern to CA07 until 2000 when levels continue to rise, and then fall in 2001. Between 2001 and 2002 all background sites reveal a slight reduction in mean NO_2 concentration.

---

[13] CA13 mentioned in previous reports was excluded from the monitoring programme in 2002.

[14] CA15 was classified as a background site in the 2001 report, the site is 6.1m from the road so should be classified as a roadside location. This is supported by the high NO_2 measurements at this site

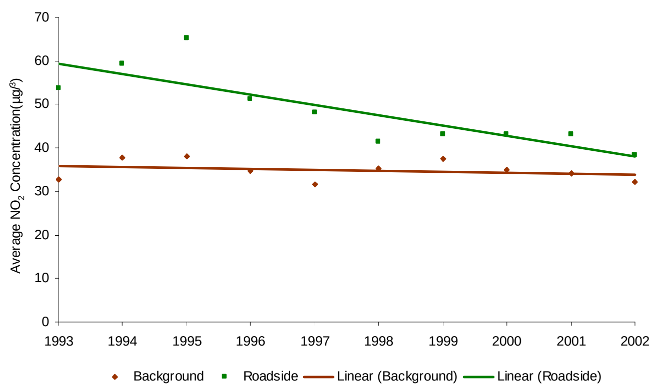
Figure 23 Camden Roadside Time Series, 1993-2002



CA03, CA04 and CA05 follow a similar trend, gradually decreasing in concentration from 1995 onwards. NO_2 concentrations at CA19 and CA28 peak in 2001 and then drop in 2002. The other sites show no clear trends. Between 2001 and 2002 sites CA11, CA15 and CA21 record an increase in annual mean NO_2 concentration, whereas the remaining sites experience a decrease.

Trend Analysis

Figure 24 Camden Trend Analysis, 1993-2002



Both background and roadside sites show a downward trend in annual mean NO_2 concentration over time. Roadside locations experience a 40% reduction in NO_2 concentration in 2002 compared to level recorded in 199. At background sites the decrease is markedly less at 2%.

Roadside Elevation

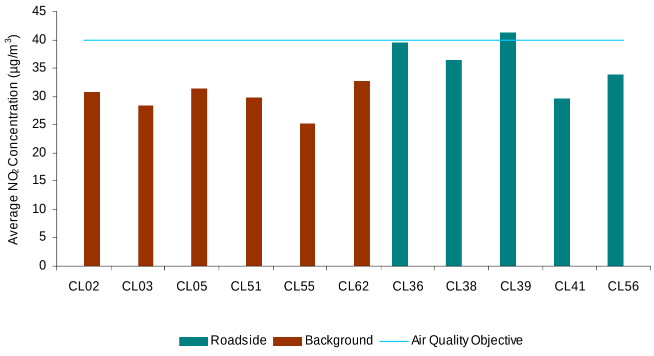
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m^3)	21.0	21.7	27.3	16.6	16.5	6.3	5.5	8.1	9.1	6.3

A clear reduction in roadside elevation is apparent over the ten-year monitoring period. The decline in roadside NO_2 contribution is most noticeable from 1998 onwards. Overall this suggests the traffic levels in the borough have gradually decreased over time.

7.6 Corporation of London

2002 Mean Values

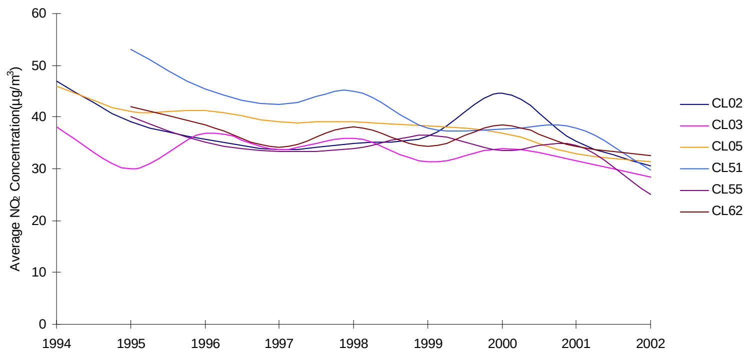
Figure 25 Corporation of London Background and Roadside Annual Mean NO_2 Concentrations, 2002



The Corporation of London did not introduce any new monitoring sites in 2002. Background concentrations vary between 25 and 31 µg/m^3. Roadside concentrations range between 30 and 41 µg/m^3. The 2005 air quality objective was exceeded at CL36 and CL39.

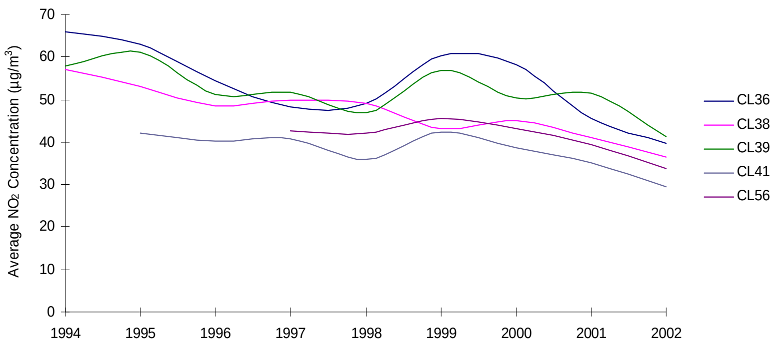
Site Time Series

Figure 26 Corporation of London Background Time Series, 1993-2002



Long-term background concentrations do not follow any particular trend. Between 2001 and 2002 NO_2 concentrations decrease at all background sites.

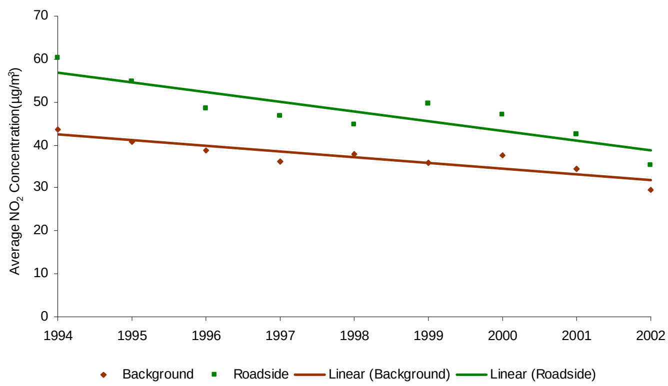
Figure 27 Corporation of London Roadside Time Series, 1993-2002



The long term monitoring data reveals a peak in annual mean NO_2 concentration at all roadside sites in 1999, except CL38. A gradual reduction in NO_2 concentration is apparent at all sites from 2000 onwards.

Trend Analysis

Figure 28 Corporation of London Trend Analysis, 1993-2002



Trend analysis indicates a decrease in NO_2 concentration at both background and roadside locations. Roadside sites have decreased by 20% and background sites by 16% since 1994.

Roadside Elevation

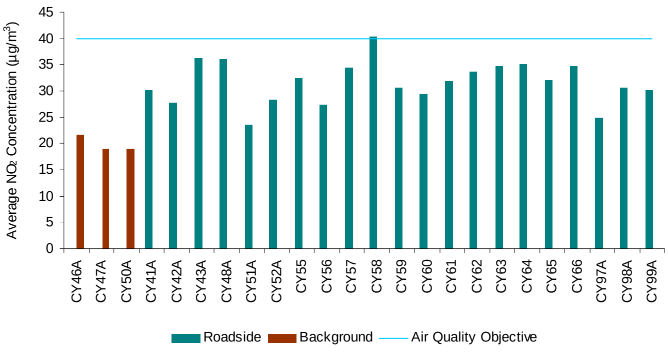
	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m^3)	16.7	13.9	9.8	10.6	6.8	13.9	9.5	8.0	5.7

The roadside elevation concentration reveals a reduction between 1994 and 1998. Following an almost 50% increase in 1999, the concentration continues to recede from 2000 onwards. In 2002 the roadside NO_2 elevation is the lowest since records began in 1994 suggesting a gradual reduction in local traffic emissions.

7.7 London Borough of Croydon

2002 Mean Values

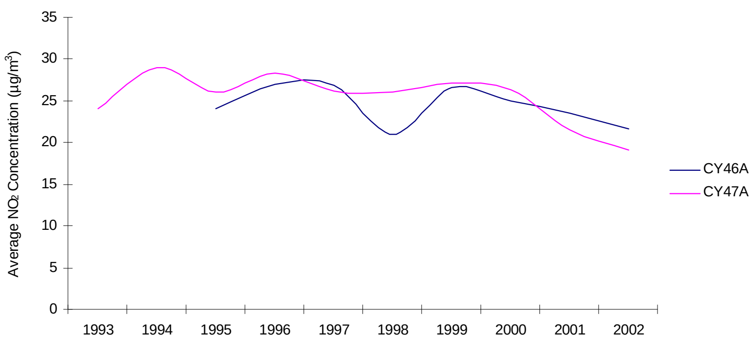
Figure 29 Croydon Background and Roadside Annual Mean NO_2 Concentrations, 2002



Croydon introduced one new monitoring site in 2002, CY99A. Background NO_2 concentrations vary between 19 and 22 µg/m^3. Roadside NO_2 concentrations range between 23 and 40 µg/m^3. The 2005 air quality objective was reached at CY58.

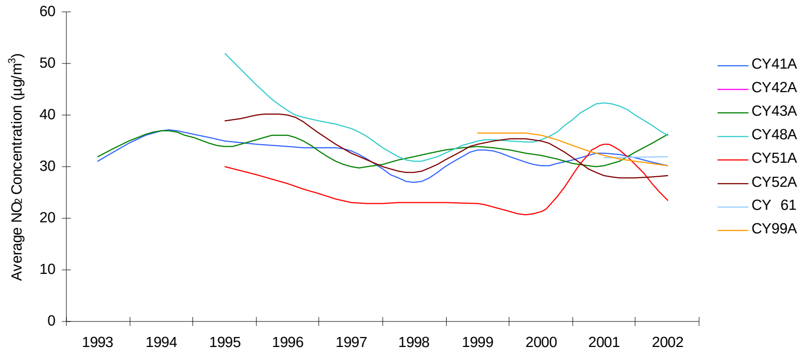
Site Time Series

Figure 30 Croydon Background Time Series, 1993-2002



Long-term background annual mean NO_2 concentrations at CY46A and CY47A do not display a distinctive trend. From 1999 onwards the mean NO_2 concentration at both sites shows a steady decrease.

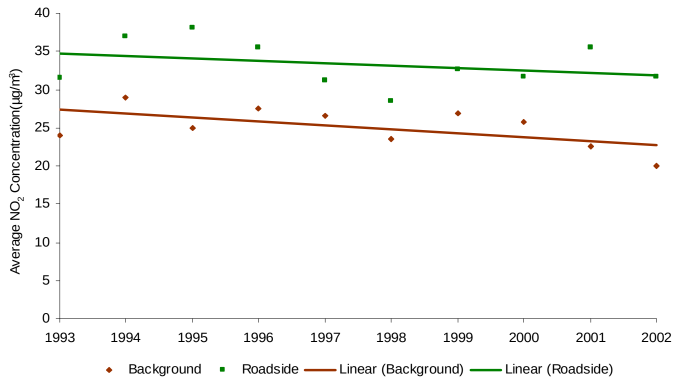
Figure 31 Croydon Roadside Time Series, 1993-2002



CY48A and CY52A follow an almost identical trend from 1995 to 2002. Sites CY41A, CY43A and CY52A display a similar rolling pattern. Sites CY43A and CY52A experience an increase in NO_2 concentration from 2001 to 2002, whereas the remaining sites show a reduction. CY48A and CY52A show the greatest decrease in NO_2 concentration from 2001 to 2002 of approximately 17%.

Trend Analysis

Figure 32 Croydon Trend Analysis, 1993-2002



Background NO_2 concentrations reveal a slight downward trend from 1993 and 2002. Roadside NO_2 concentrations however show no positive or negative long-term trend.

Roadside Elevation

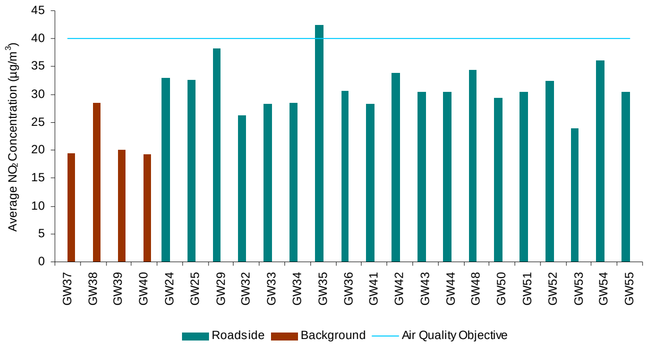
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	7.5	8.0	13.0	8.0	4.7	4.9	5.8	5.9	13.0	11.7

The elevation above background concentration fluctuates between 1993 and 1996. From 1997 to 2000 an incremental rise in this concentration takes place annually and doubles in 2001. In 2002 the concentration shows a slight decrease.

7.8 London Borough of Greenwich

2002 Mean Value

Figure 33 Greenwich Background and Roadside Annual Mean NO_2 Concentrations, 2002

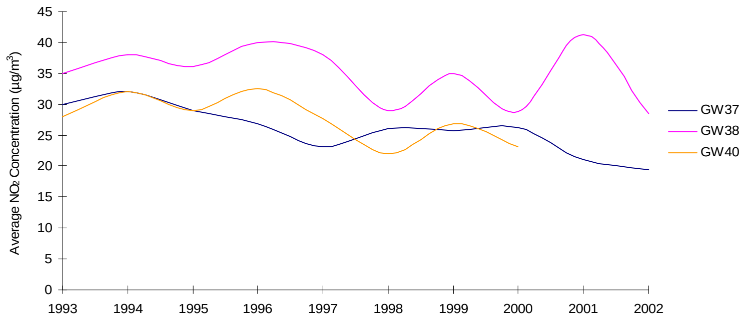


Greenwich introduced 9 new roadside sites in 2002 listed in Appendix 1. GW23, GW27, GW29, GW44 and GW56 are not included in this report as they have fewer than 6 months monitoring data.

Background concentrations vary between 19 to 28 µg/m^3. Roadside sites range between 24 to 43 µg/m^3. GW43 was the only site to exceed the 2005 air quality objective.

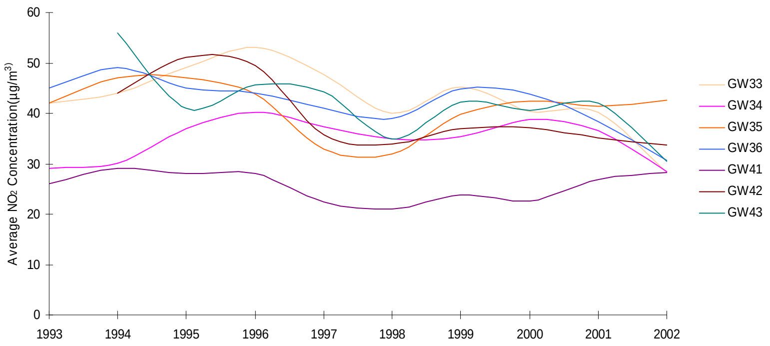
Site Time Series

Figure 34 Greenwich Background Time Series, 1993-2002



Between 1993 and 2000 GW38 and GW40 have followed an identical undulating trend. Monitoring data for GW40 was absent for 2001, however the 2002 NO_2 concentration indicates a 21% decrease compared with 2000 data. GW38 shows a 46% reduction in NO_2 concentration from 2001 to 2002. GW37 reveals two noticeable reductions in concentration from 1994 to 1997 and from 2000 to 2002.

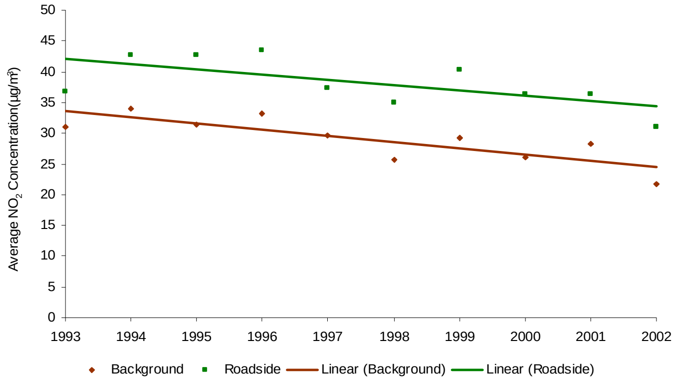
Figure 35 Greenwich Roadside Time Series, 1993-2002



NO_2 levels at roadside sites have fluctuated between 1993 and 2002. GW33, GW35 and GW36 maintained the highest NO_2 concentrations throughout the ten-year monitoring period. GW41 records the lowest concentration. From 2001 to 2002 NO_2 concentrations at GW24, GW35 and GW41 have increased, with the remaining sites undergoing a decrease. In 2002 the greatest reduction in NO_2 concentration occurs at GW34 of 43%.

Trend Analysis

Figure 36 Greenwich Trend Analysis, 1993-2002



Between 1993 and 2002 background and roadside sites indicate a downward trend in annual mean NO_2 concentration. This trend is more accentuated at background sites that experience a 42% decrease since 1993, compared to roadside sites where this is calculated at 19%.

Roadside Elevation

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	5.8	8.7	11.2	10.4	7.7	9.3	11.1	10.3	8.1	9.2

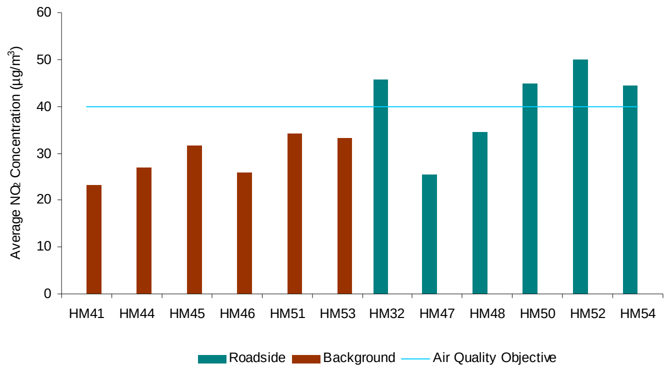
The roadside elevation records its lowest level in 1993 and after rising in 1994 fluctuates annually. From 2001 to 2002 the concentration increases by 1.1 µg/m³.

CASELLA STANGER

7.9 London Borough of Hammersmith and Fulham

2002 Mean Values

Figure 37 Hammersmith and Fulham Background and Roadside Annual Mean NO_2 Concentration, 2002

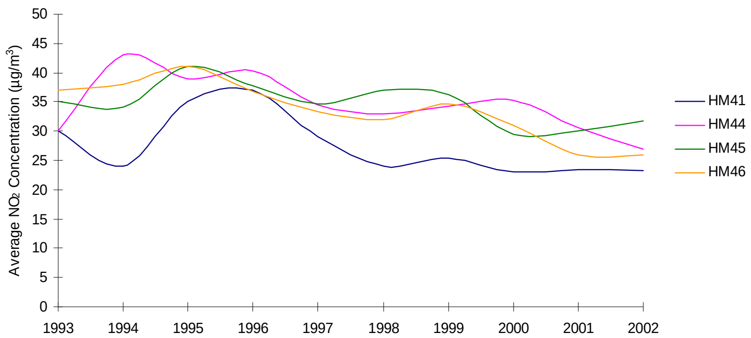


Hammersmith and Fulham introduced 8 new sites in 2002; the results can be viewed in Appendix 1. The results have not been reported due to their low data capture resulting from the late date of commencement of monitoring within the year.

Background concentrations range between 23 and 33µg/m^3. Roadside concentrations vary between 25 and 50 µg/m^3. The 2005 air quality objective was exceeded at HM32, HM50, HM52 and HM54.

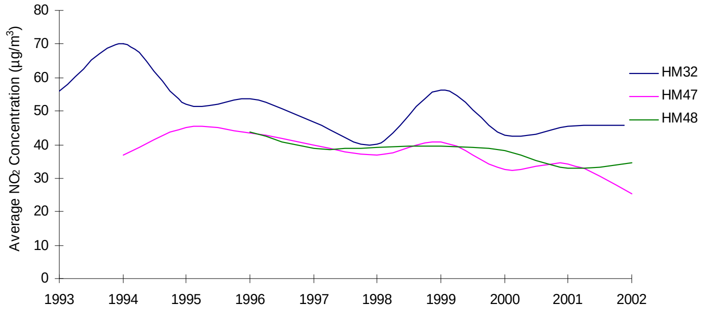
Site Time Series

Figure 38 Hammersmith and Fulham Background Time Series, 1993-2002



The long-term data shows annual mean background NO_2 level to be lowest at HM41. After peaking in 1996 the mean concentration gradually decreases, remaining relatively constant from 2000 onwards. Annual mean NO_2 concentrations at HM44, HM45 and HM46 fluctuate over the ten-year monitoring period. Mean NO_2 levels decrease at HM44 and HM46 post 2000, whereas at HM45 a steady increase is evident.

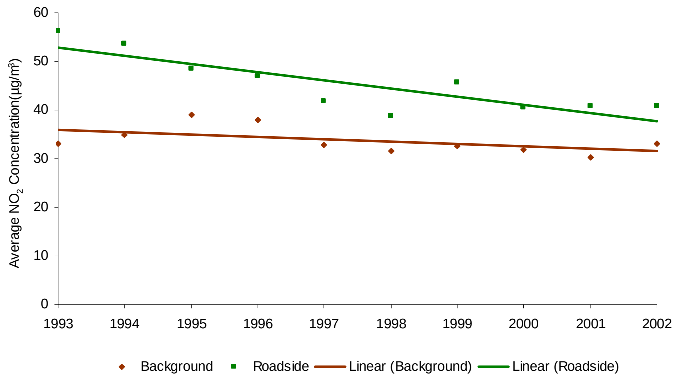
Figure 39 Hammersmith and Fulham Roadside Time Series, 1993-2002



HM32 records the highest roadside mean NO_2 concentration between 1993 and 2002 peaking in 1994 and 1999. After a sharp drop in 2000, the concentration begins to gradually increase. The annual mean NO_2 concentration at HM48 remains fairly constant from 1997 to 2000. Between 2000 and 2001 a reduction in concentration takes place followed by a small rise in 2002. HM47 indicates a gradual decrease in NO_2 concentration most apparent in 2000 and 2002.

Trend Analysis

Figure 40 Hammersmith and Fulham Trend Analysis, 1993-2002



Trend analysis does not indicate any positive or negative long tern trend for annual mean background NO_2 concentrations. Roadside sites however display a clear downward trend, reflecting a 37% reduction in annual mean NO_2 concentration since 1993.

Roadside Elevation

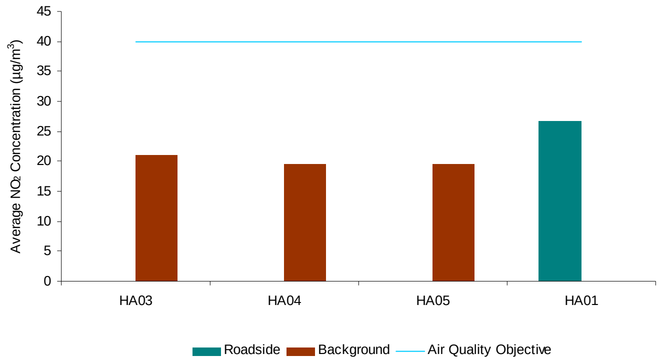
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	23.0	18.8	9.5	8.9	8.9	7.2	12.9	8.8	10.4	7.6

The elevation above background concentration decreases markedly from 1995 onwards. Two peaks however interrupt this trend in 1999 and 2001. A reduction in the elevation above background concentration takes place in 2002.

7.10 London Borough of Harrow

2002 Mean Values

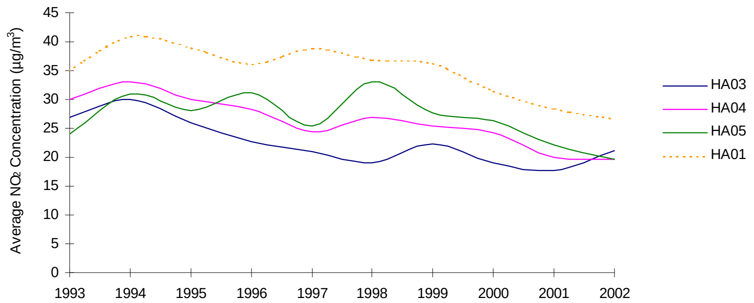
Figure 41 Harrow Background and Roadside Annual Mean NO_2 Concentrations, 2002



Harrow did not introduce any new sites during 2002. Background concentrations vary only marginally between 20 and 21 µg/m^3. The NO_2 concentration at the single roadside site, HA01, is 27 µg/m^3. The 2005 air quality objective was been exceeded at any monitoring site.

Time Series

Figure 42 Harrow Background and Roadside Time Series, 1993-2002

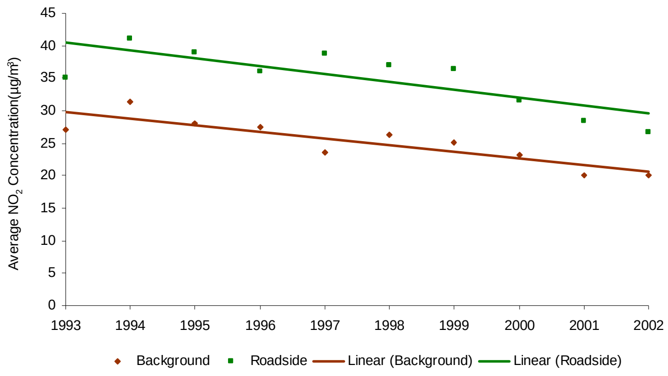


Background concentrations at HA03 and HA04 follow a similar pattern. However from 2001 to 2002 the NO_2 concentration increases at HA03 whereas at HA04 this decreases. HA05 displays a rolling trend with the mean NO_2 concentration showing a continual reduction from 1998 onwards. The roadside site, HA01, indicates a gradual decrease in NO_2 concentration after 1994 with this becoming more apparent from 1999 onwards.

CASELLA STANGER

Trend Analysis

Figure 43 Harrow Trend Analysis, 1993-2002



Trend analysis indicates a clear downward trend in NO_2 concentrations at both background and roadside sites between 1993 and 2002. Background concentrations have reduced by 35% and roadside sites slightly less by 31%.

Roadside Elevation

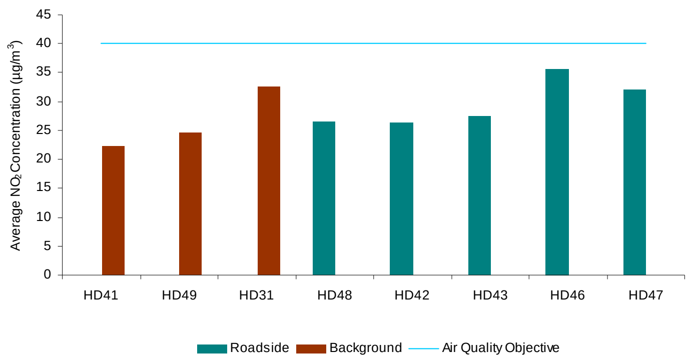
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	8	9.7	11	8.7	15.1	10.7	11.3	8.4	8.5	6.6

The roadside elevation fluctuates on an annual basis with the NO_2 contribution form road traffic peaking in 1997. There appears to be an overall reduction in roadside elevation from 1998 onwards. From 2001 to 2002 the road elevation decreases by approximately 2µg/m^3.

7.11 London Borough of Hillingdon

2002 Mean Values

Figure 44 Hillingdon Background and Roadside Annual Mean NO_2 Concentration, 2002

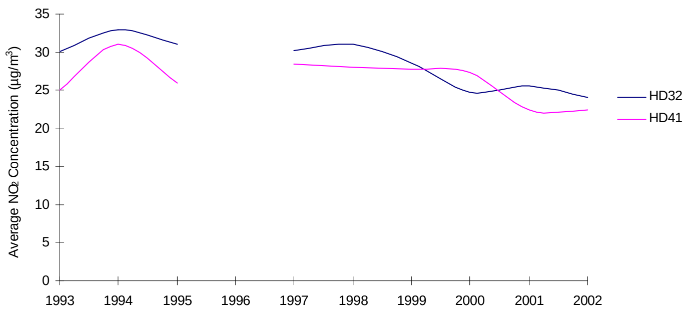


Hillingdon introduced 11 new sites in 2002, HD50 to HD61. The late commencement of monitoring at these sites has excluded them for analysis in this report. The results however can be seen in Appendix 1.

Background concentrations range between 22 to 33 µg/m^3. Roadside sites vary between 26 and 36 µg/m^3. The 2005 air quality objective was not exceeded at any site.

Site Time Series

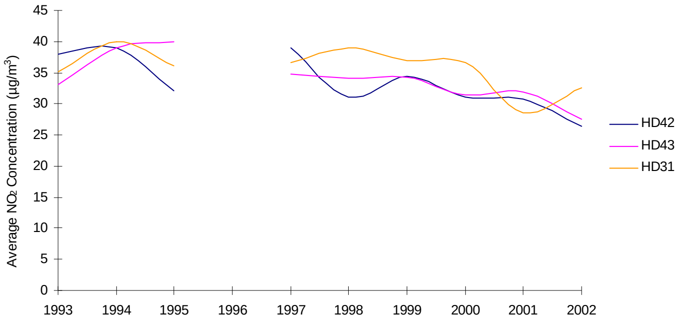
Figure 45 Hillingdon Background Time Series, 1993-2002



Background sites appear to follow an identical pattern from 1993 to 1995. HD32 reveals a gradual reduction in NO_2 concentration between 1997 and 2000, after a minor rise in 2001, this falls again 2002. The annual mean NO_2 concentration at HD41 remains relatively stable between 1997 and 2002 and then falls sharply in 2001. In 2002 a slightly rise in concentration in noticeable.

CASELLA STANGER

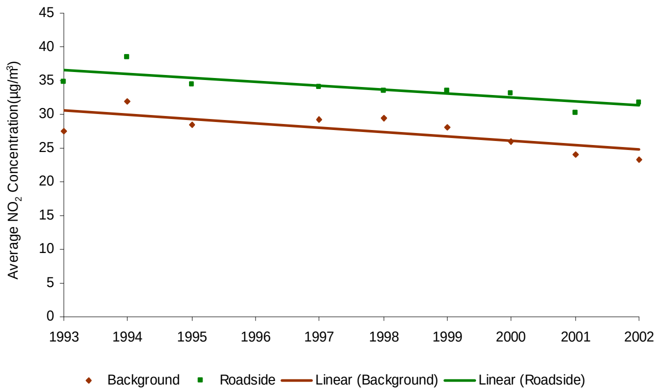
Figure 46 Hillingdon Roadside Time Series, 1993-2002



Roadside sites HD42 and HD43 show a very similar variation in annual mean NO_2 concentration from 1999 to 2002. The NO_2 concentration remains fairly stable between 1997 and 200 at HD31, recording levels higher than HD42 and HD43. Following a sharp reduction in 2001, the NO_2 concentration at HD31 rises by 15% in 2002.

Trend Analysis

Figure 47 Hillingdon Trend Series, 1993-2002



Background and roadside sites concentrations indicate a downward trend in annual mean between NO_2 concentration between 1993 and 2002.

Roadside Elevation

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	7.3	6.5	6	N/A	4.8	4.0	5.4	7.1	6.3	8.4

The roadside elevation concentration shows a gradual reduction from 1993 to 1996. After increasing in 1997, the concentration fluctuates and rises to its maximum level of 8.4 µg/m^3 in 2002.

7.12 London Borough of Hounslow

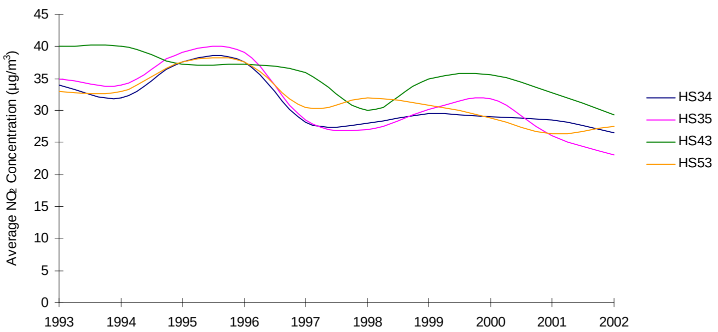
2002 Mean Values

Figure 48 Hounslow Background and Roadside Annual Mean NO_2 Concentration, 2002

Hounslow did not introduce any new sites in 2002. Background NO_2 concentrations range from 23 and 29 µg/m^3. Roadside sites vary between 24 to 40 µg/m^3. The 2005 air quality objective was reached at HS61 and closely approached at HSCHIS.

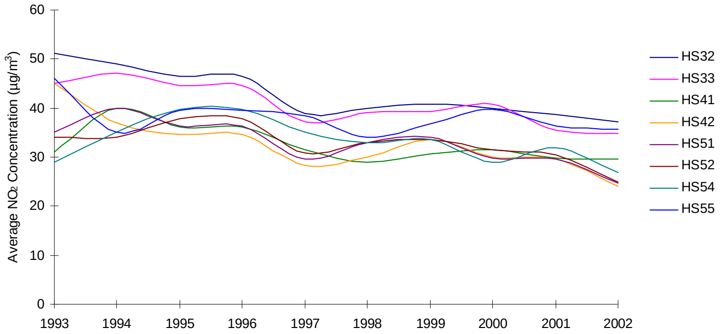
Site Time Series

Figure 49 Hounslow Background Time Series, 1993-2002



The time series reveals HS53, HS43 and HS34 to follow an identical trend from 1993 to 1997. Following a small peak in 1998 HS53 reflects a gradual decrease in NO_2 concentration until 2001 after which the concentration rises slightly. NO_2 concentration at HS34 rise between 1997 and 1999 but then begins to steadily decrease. HS35 shows a similar trend, with NO_2 concentrations falling earlier in 2000. The annual mean NO_2 concentration at HS43 shows a gradual decrease from 1993 to 1998. From 1998 onwards HS43 and HS35 are characterised by similar variations in annual mean NO_2 concentrations.

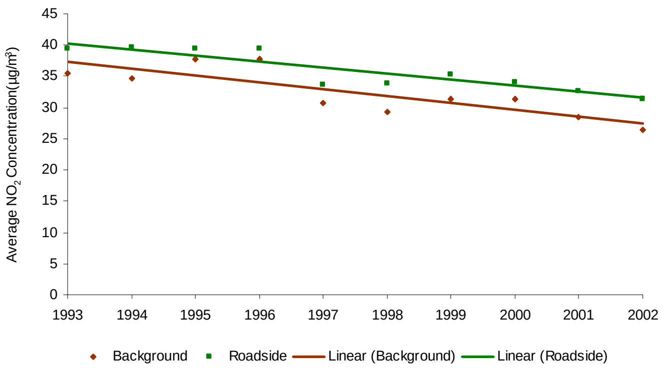
Figure 50 Hounslow Roadside Time Series, 1993-2002



HS32 and HS33 follow near identical trends with a gradual decrease in NO_2 concentrations between 1993 and 2002. With the exception of HS55, the remaining sites reflect a similar rolling pattern peaking in 1996 and 1999, then plummeting in 1997, 2000 and 2002.

Trend Analysis by Site Class

Figure 51 Hounslow Trend Analysis, 1993-2002



Trend analysis highlights that both background and roadside NO_2 concentrations have gradually decreased between 1993 and 2002. Background sites have experienced a 35% reduction of in annual mean NO_2 concentration since 1993, whereas at roadside sites this has been calculated to be lower at 25%.

Roadside Elevation

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	4.0	4.9	1.6	1.6	2.9	4.6	3.9	2.6	4.3	5.1

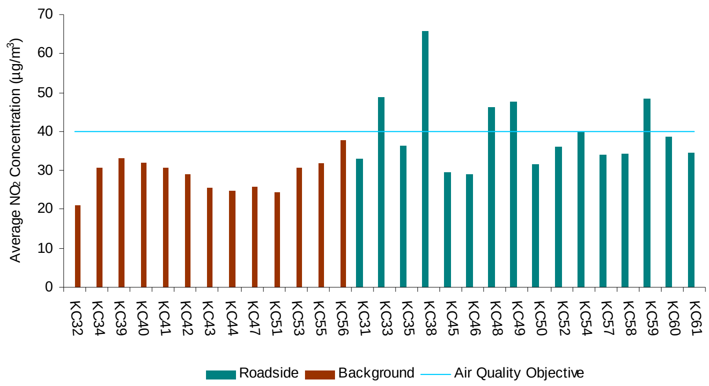
The roadside elevation has a low concentration range between 1.6 and 5.1 $\mu g/m^3$ suggesting minor contribution of NO_2 from local traffic over time. In 2002 the difference between background and roadside NO_2 concentration is the greatest it has been suggest an influx in road transport emissions has occurred this year.

CASELLA STANGER

7.13 London Borough of Kensington and Chelsea

2002 Mean Values

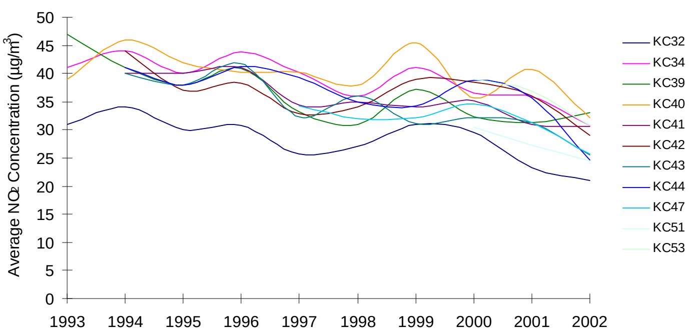
Figure 52 Kensington and Chelsea Background and Roadside Annual Mean NO_2 Concentration, 2002



Kensington and Chelsea did not introduce any new monitoring sites in 2002. Background concentrations record between 21 and 38 µg/m^3. Roadside concentrations record between 29 and 66 µg/m^3. The 2005 air quality objective is exceeded at KC33, KC38, KC48, KC49, KC54 and KC59.

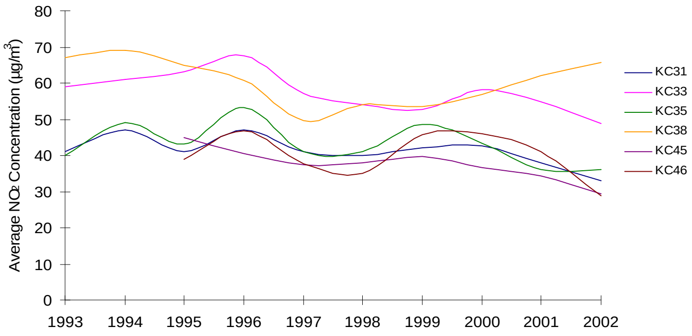
Site Time Series

Figure 53 Kensington and Chelsea Background Time Series, 1993-2002



All background sites appear to follow a similar rolling trend between 1993 and 2002. KC44 maintains the lowest annual mean NO_2 concentration over the ten-year monitoring period. From 2001 to 2002 all background sites except KC39 experience a decrease in annual mean NO_2 concentration.

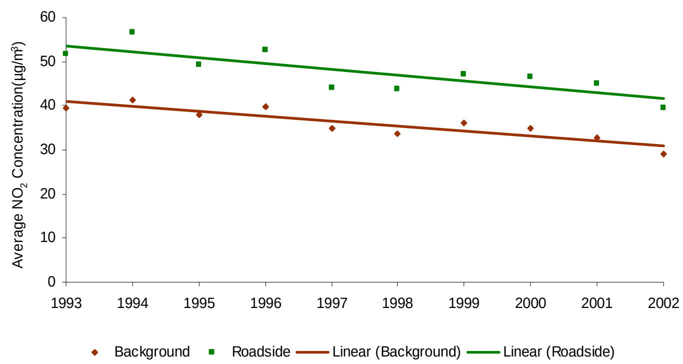
Figure 54 Kensington and Chelsea Roadside Time Series, 1993-2002



KC33 and KC38 clearly show the highest NO_2 concentrations between 1993 and 2002. KC38 is the only site to show a gradual increase in NO_2 concentration. This is takes place between 1997 and 2002. The NO_2 concentration at KC33 reveals a sharp reduction from 1997 onwards. The NO_2 concentrations at the remaining sites fluctuate over then ten-year monitoring period. Between 2001 and 2002 KC45 record a 6% increase in NO_2 concentration whereas the other roadside locations all reveal a reduction.

Trend Analysis

Figure 55 Kensington and Chelsea Trend Analysis, 1993-2002



Trend analysis indicates a downward trend in annual mean NO_2 concentration between 1993 and 2002 for roadside and background sites. Background sites have experienced a 36% reduction in NO_2 concentration over the monitoring period, with roadside sites tailing slightly behind at 31%.

Roadside Elevation

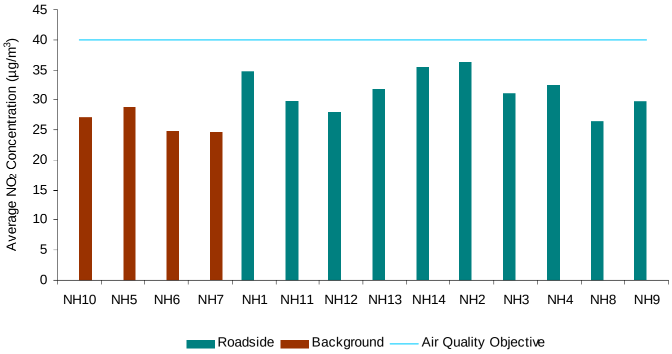
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	12.3	15.3	11.5	12.9	9.2	9.9	11.0	11.9	12.2	10.6

The variation between background and roadside NO_2 concentration highlights the obvious influence of road traffic sources at roadside sites. Roadside elevation has fluctuated between 1993 and 2002 with the concentration clearly reducing between 2001 and 2002.

7.14 London Borough of Newham

2002 Mean Values

Figure 56 Newham Background and Roadside Annual Mean NO_2 Concentration, 2002

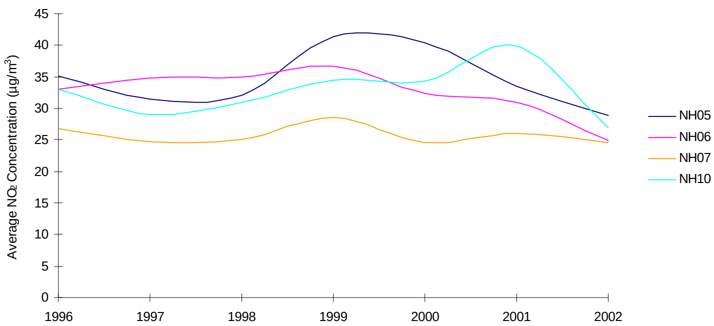


Newham introduced four new roadside sites in 2002, NH15 to NH18. The results have not been reported due to their low data capture resulting from the late date of commencement of monitoring within the year. These results are however listed in Appendix 1.

Background concentrations range between 25 and 27 µg/m^3. Roadside concentrations vary between 26 and 36 µg/m^3. The 2005 air quality objective was not exceeded at any monitoring site.

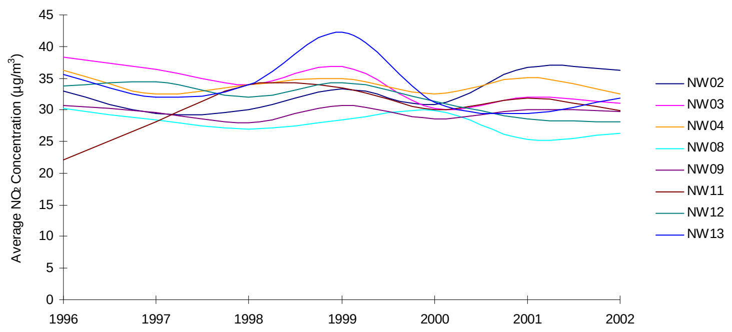
Site Time Series

Figure 57 Newham Background Time Series, 1993-2002



NH06 and NH07 follow an identical pattern, with annual mean NO_2 concentrations at both sites showing a clear decrease between 1999 and 2000. Over the next two years NH06 continues to exhibit a reduction in NO_2 concentration whereas at NH07 this increases. In 2002 both sites record identical annual mean concentrations. The NO_2 concentration at NH10 illustrates a gradual increase until 2002 when a sharp reduction takes place. The NO_2 concentration at NH05 shows a steep rise from 1997 until 1999, and then gradually decreases over the next three years.

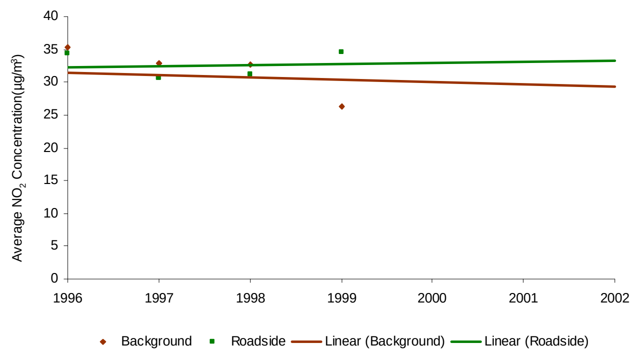
Figure 58 Newham Roadside Time Series, 1993-2002



Roadside site NO_2 concentrations appear to follow one another fairly closely. However from 2000 onwards NW08 and NW12 show a sudden drop in concentration, conversely NW02 and NW4 exhibit a sharp increase in NO_2 level that begins to decline in 2001. The NO_2 concentration at the remaining sites show limited variation over the next two years.

Trend Analysis

Figure 59 Newham Trend Analysis, 1993-2002



Trend analysis indicates a minor downward trend in NO_2 concentration at background sites between 1996 and 2002. Roadside sites however show a slight upward trend with the concentration rising by 7% over the seven-year monitoring period.

Roadside Elevation

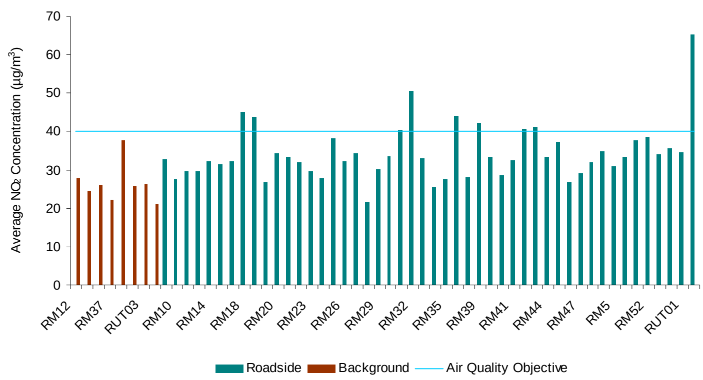
	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	0.5	1.3	0.9	-1.0	-2.3	-1.5	8.6

Between 1996 and 1998 the roadside elevation concentration is extremely low. Over the next three years background concentrations elevate above roadside concentrations, suggesting that road transport is not an influential source of NO_2 at roadside locations. However this pattern changes in 2002 with the roadside elevation significantly increasing.

7.15 London Borough of Richmond Upon Thames

2002 Mean Values

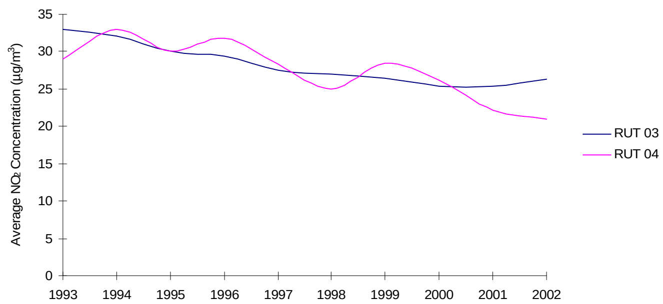
Figure 60 Richmond Upon Thames Background and Roadside Annual Mean NO_2 Concentration, 2002



Richmond Upon Thames did not introduce any new monitoring sites in 2002. Background concentrations recorded between 21 and 38 µg/m^3. Roadside concentrations ranged between 21 and 51 µg/m^3. The 2005 air quality objective was exceeded at sites RM18, RM19, RM31, RM32, RM36, RM39, RM42, RM43 and RUT04.

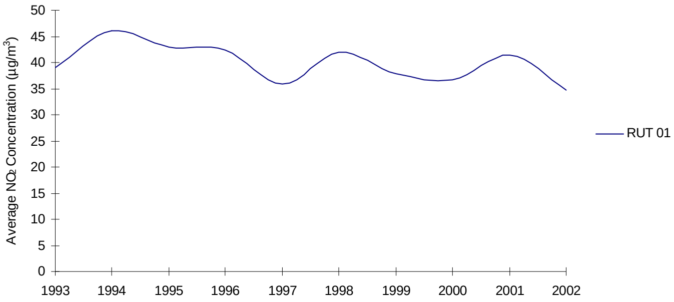
Time Series

Figure 61 Richmond Upon Thames Background Times Series, 1993-2002



Background concentrations at RUT03 show a gradual reduction from 1993 to 2001. Between 2001 and 2002 the annual mean NO_2 concentration increases. RUT04 additionally reflects an overall reduction in NO_2 concentration over the ten-year monitoring period, however three peaks in NO_2 concentration in 1994, 1996 and 1999 interrupt this trend.

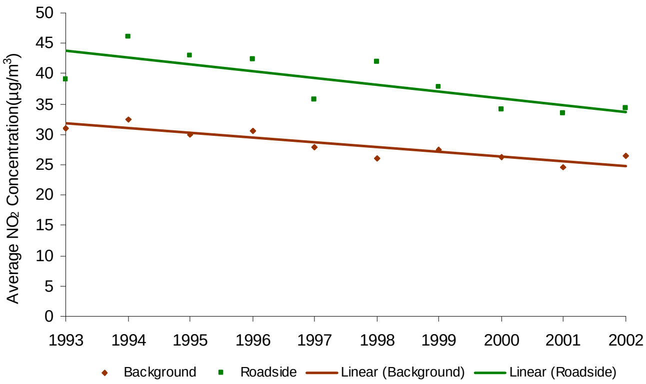
Figure 62 Richmond Upon Thames Roadside Times Series, 1993-2002



The long-term NO_2 concentration at RUT01 shows a decrease between 1994 and 1997. After a sharp increase in 1998, the NO_2 concentration decreases over the next three years, rises to 1998 levels in 2001 and drops once again in 2002.

Trend Analysis

Figure 63 Richmond Upon Thames Trend Analysis, 1993-2002



Both background and roadside sites reflect a downward trend in NO_2 concentration between 1993 and 2002. Background sites have experienced a moderately larger reduction in NO_2 concentration over time.

Roadside Elevation

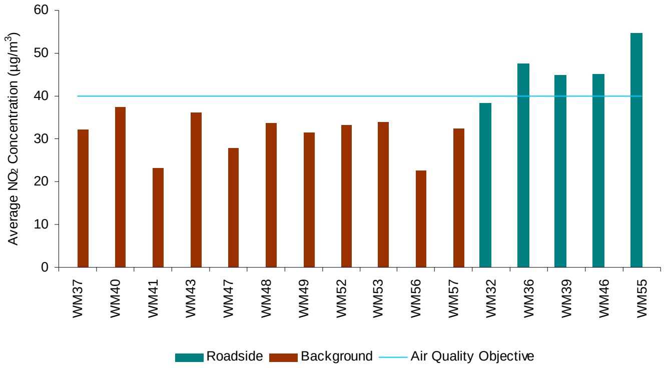
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m³)	8.0	13.5	13.0	11.7	7.9	16.0	10.4	7.7	8.8	7.8

The roadside elevation concentration fluctuates between 1993 and 2002, showing a sharp peak in 1998 at 16 µg/m^3. The NO_2 contribution from road traffic appears to reduce from 1999 onwards.

7.16 London Borough of Westminster

2002 Mean Values

Figure 64 Westminster Background and Roadside Annual Mean NO_2 Concentration, 2002

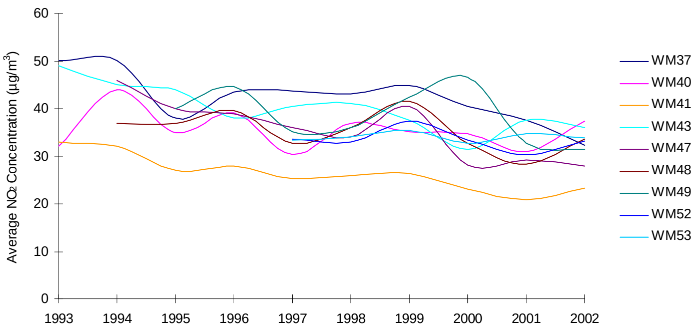


Westminster introduced one new site in 2002, WM58, this replaced WM44 that became redundant in 2001. This site only has 5 months monitoring data so has not been included in the annual average results.

Background concentrations range from 28 to 37 µg/m^3. Roadside concentrations vary between 38 and 55 µg/m^3. The 2005 air quality objective was exceeded at WM36, WM39, WM46 and WM55.[15]

Time Series

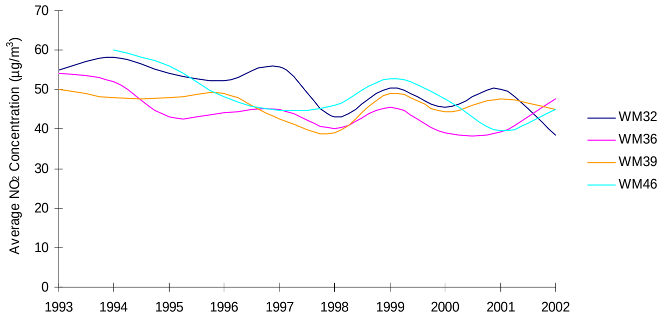
Figure 65 Westminster Background Time Series 1993-2002



WM41 records the lowest annual mean NO_2 concentration over the ten-year monitoring period. The NO_2 concentration at this site remains fairly uniform between 1996 and 1999. From 2000 onwards a slight decrease in concentration takes place. A fluctuation in NO_2 concentration can be seen at the other background sites. From 2001 to 2002 the NO_2 concentration at WM40, WM41, WM48 and WM52 increases, and reduces at the remaining sites.

[15] The following sites where appointed site codes in 2002: Oxford St-WM55, Hyde Park-WM56 and 41, Horseferry Rd-WM57.

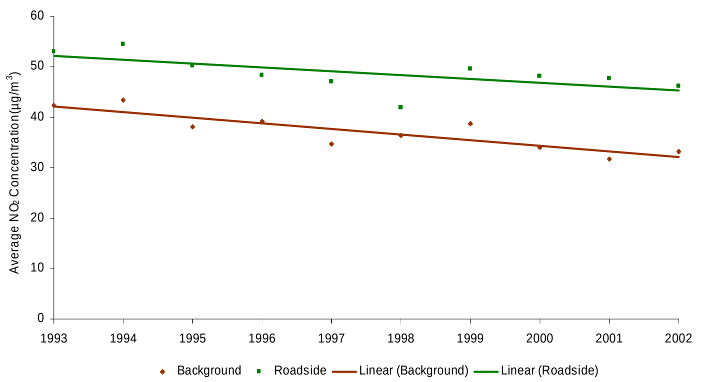
Figure 66 Westminster Roadside Time Series, 1993-2002



All roadside sites display a rolling trend in annual mean NO_2 concentration. Between 2001 and 2002 the NO_2 concentration has decreased sharply at WM32 and to a lesser degree at WM39. In 2002 an elevation in NO_2 concentration has taken place at WM36 and WM46.

Tend Analysis

Figure 67 Westminster Trend Analysis, 1993-2002



Background and roadside sites indicate a definite downward trend in NO_2 concentration between 1993 and 2002. The concentration at background sites has reduced by 27% whereas at roadside sites by 15%.

Roadside Elevation

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Elevation above background (µg/m^3)	10.6	11.2	12.3	9.1	12.4	5.6	10.8	14.2	15.8	12.8

The elevation above background NO_2 concentration fluctuates between 1993 and 2002 possibly emphasised by the variations in road traffic emissions. The lowest elevation above background concentration occurs in 1998 where this drops by approximately 50% over the previous year's result. The highest roadside elevation is in 2001. Between 2001 and 2002 the roadside elevation drops by 3 µg/m^3.

8 Overall NO_2 Diffusion Tube Concentrations

Overall there were 320 sites reporting in 2002 from 16 Boroughs. A total of 57 sites recorded an annual mean of NO_2 concentrations greater than the 2005 air quality objective of 40 $\mu g/m^3$. Of these, 8 sites belong to the category of background sites whilst 49 were classified as roadside sites. This is a reduction from the previous year where 72 sites exceeded the annual mean of NO_2 concentrations 2005 AQO (8 background sites and 64 roadside sites.)

8.1 Monthly Variation in NO_2 Concentration at Roadside and Background Sites

Figure 68 Background and Roadside Site Monthly Mean NO_2 Concentration For All Boroughs

Background and roadside monthly NO_2 concentrations reflect a near identical trend. The highest concentrations at both types of sites take place in January and November. The lowest concentrations occur in June. Concentrations appear to rise in the winter months and reduce during summer. The summer decline in NO_2 concentration may be an influence of the photochemical process involving ozone. The rise in concentrations over the winter month is likely to be caused by meteorological conditions during this time of the year that play an important role in inhibiting the dispersion ground level NO_2 concentrations.

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 2002 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 inter-comparison 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 providing consistency with comparisons between longer-term data sets.

9.2 Data Quality Objectives

The EU Daughter Directive sets data quality objectives for nitrogen dioxide along with other pollutants. Under the Directive, annual Mean NO_2 concentration data derived from diffusion tube measurements must demonstrate an accuracy of $\pm$25 % to enable comparison with the Directive air quality standards for NO_2. The NETCEN field inter-comparison exercise recognises laboratories that are within $\pm$25% of the reference concentration (i.e. that obtained from the automatic monitor) as performing satisfactorily[16].

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 8. Recognised QA/QC procedures for calibration and data ratification of the continuous monitoring data are performed by NETCEN.

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

Table 8 Location, network and CMCU of four continuous monitors included in the diffusion tube collocation study

Site Location	Network	CMCU*	Site Classification
Hillingdon	AURN	Casella Stanger	Suburban
North Kensington	LAQN	Kings ERG	Urban Background
Brent	AURN	Casella Stanger	Urban Background
Bloomsbury	AURN	Casella Stanger	Urban Centre

The triplicate tube results were averaged and compared to the period equivalent concentrations measured by continuous analyser. Period averages containing less than 90% data capture by continuous analysers over the tube exposure periods have been omitted to ensure a comparative and robust data set.

Calculation

The diffusion tube bias adjustment factor, A, has been calculated for each month as follows:

$$\mathbf{A = C_m / D_m}$$

The percentage diffusion tube bias, B, has been calculated for each month as follows:

$$\mathbf{B = (D_m / C_m) / C_m * 100}$$

N.B. The bias should always be expressed relative to the continuous analyser.

Further details of calculations and the methodology used to derive the bias and bias adjustment factor can be found in LAQM.TG (03)

9.4 Results

Details of calculations used to produce the % bias and adjustment factor can be found in the LAQM.TG(03)[17].

The study shows that the level of bias varies between –15 and –34% giving a mean bias relative to the continuous monitor of –26% across the sites (Table 9). The overall mean adjustment factor 'A' for all four sites is 1.35 (range 1.18-1.55 µg/m3). Application of this factor to diffusion tube results allows results to be corrected to the equivalent continuous analyser concentration.

[17] Source: DEFRA (2003) Technical Guidance, LAQM.TG (03)

Table 9 Casella Stanger Collocation data at 4 AURN sites

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean Conc (µg/m³)	Mean Site Precision (µg/m³)	% Bias based on continuous monitor	Correction Factor
Hillingdon																
Mean diffusion tube	42.7	26.1		36.5	15.7		31.5		37	40.7	44.9	33.2	33.1	8.6		
Mean continuous analyser	50.9	39.7		47.2	48.5		35.3		40.8	51.7	55.1	43.8	45.4		-27	
% Bias, based on continuous	-16.2	-34.4		-22.8	-67.6		-10.9		-9.5	-21.2	-18.5	-24.2				1.38
North Kensington																
Mean diffusion tube		18	15.2	19.1	19.8	22		20.8	25.1	39.1	36.3	42.7	27.6	5.3		
Mean continuous analyser		30.1	47.4	39.7	33.3	30.7		36.2	40.3	47.7	51.4	42.9	40.2		-34	
% Bias, based on continuous		-40.3	-68	-51.9	-40.6	-28.6		-42.2	-37.8	-18.1	-29.4	-0.6				1.55
Brent																
Mean diffusion tube	35.5	12.2	22.7	15.2	18.8		17.2	26.7	26.2	25.7	37.8	42.3	25.5	6.2		
Mean continuous analyser	43	18.2	30.3	20.9	17.5		22.3	24.2	28	43.7	46.7	36.4	30.1		-15	
% Bias, based on continuous	-17.6	-33.3	-25.1	-27.2	7.7		-22.7	10.6	-6.4	-14.2	-19	16.2				1.18
Bloomsbury																
Mean diffusion tube	55.6			24	22.2	26	17.2	25.7	44.6	34.2	54.7	25.1	32.4	7.7		
Mean continuous analyser	43.5			49.1	35.5	32	36.5	42.3	49.2	54.8	53.9	46.9	43.9		-26	
% Bias, based on continuous	27.8			-51.2	-37.5	-18.8	-52.9	-39.2	-9.4	-37.7	1.4	-46.5				1.35
													Overall Mean Precision	**7.1**		
													Overall % Bias (B)		**-26**	
													Mean Correction Factor (A)			**1.35**

The mean precision across all sites in 2002 was 7.1 µg/m^3 (range 5.3-8.6 µg/m^3). This value is useful for assessing the uncertainty of results due to sampling and analytical techniques. Although there is no requirement for this value in LAQM.TG (03), it may be useful for local authorities to consider such variation where NO_2 concentrations are close to the national air quality standard.

The correction factors range from 1.18 at Brent to 1.55 at North Kensington. The mean correction factor is 1.35. The influence of specific site characteristics upon the NO_2 diffusion tube efficiency is unknown and has not been quantified within this report, but may account for some of the inter-site variation and will invariably reflect the individual NO_x/NO_2 ratios for each site.

These mean % bias and correction factor results for 2002 compliment the LWEP 2001 co-location study, the results are summarised below in Table 10.

Table 10 Mean correction factor and %bias of Gradko International Ltd tubes prepared with 50% TEA v/v in acetone from LWEP Studies 2001-2002.

	Mean correction factor (A)	Mean % bias (B)
LWEP 2001	1.37	-26.6
LWEP 2002	1.35	-26

A recent study undertaken by Air Quality Consultants Ltd.[18] has shown that tubes prepared by Gradko International Ltd 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.

Ideally local authorities are recommended to derive their own bias adjustment factors from locally obtained data, however this is not always possible. In these circumstances a default factor will have to be applied. It is therefore proposed that in absence of any local co-location data, local authorities using Gradko International Ltd tubes prepared with 50% v/v TEA in Acetone could apply as adjustment factor of 1.35 to their 2002 NO_2 concentrations.

[18] 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

10 Conclusion

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 inter-comparison can be made and levels of NO_2 assessed over time.

A triplicate study carried out by collocation with automatic analysers at four sites in London showed that the diffusion tubes used in the current work under-read by 26%. This slightly outside the criteria of $\pm$25% set by the NETCEN intercomparison 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%. 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 2002, NO_2 concentrations reduced 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 57 sites of the total 320 reporting sites exceeded this value in 2002 of which 49 were classed as roadside sites, and 8 background sites. This represents a decrease in exceedences compared to 2001. 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 1.35 is applied, anything above 30 $\mu g\ m^{-3}$ is equivalent to an exceedence of the 2005 AQO. Appendix 1 lists all the sites where NO_2 concentrations were annual mean 30 $\mu g\ m^{-3}$ or above. Therefore, realistically, the number of exceedences include a further 101 roadside sites and 28 background 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.

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 roadside elevation provides an indication of the contribution of road traffic to total NO_2 concentrations. Contribution from road traffic to annual average NO_2 concentrations has shown a general decrease in many Boroughs, though seven Boroughs have displayed a general increase since 2000. These are:

- London Borough of Barnet
- London Borough of Bexley
- London Borough of Brent
- London Borough of Greenwich
- London Borough of Hillingdon
- London Borough of Hounslow
- London Borough of Newham.

However, some of these increases were not significant and may just reflect short-term changes in traffic patterns rather than long-term trends.

The monthly variation in NO_2 concentration at background and roadside sites averaged out for all participating boroughs indicated a seasonal pattern. The highest NO_2 concentrations where recorded in the winter months of January and November. The lowest concentrations occur in the summer month of June.

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.

Casella Stanger cannot accept responsibility to any parties whatsoever, following issue of this report, for any matters arising, which may be considered outside the agreed scope of works.

This report is issued in confidence to the Client and Casella Stanger cannot accept any responsibility to any third party to whom this report may be circulated, in part or in full, and any such parties rely on the contents of the report at their own risk. (Unless specifically assigned or transferred within the terms of the contract, Casella Stanger asserts and retains all copyright, and other Intellectual Property Rights, in and over the report and its contents).

Any questions or matters arising from this report may be addressed in the first instance to the Project Manager.

Appendix 1 Annual mean NO_2 concentration recorded all background and roadside sites, 2002

Site Code = Existing sites exceeding 2005 air quality objective
Site Code = New sites introduced in 2002 exceeding 2005 air quality objective
Site Code = Sites recording over 30 µg/m³ which are likely to exceed the 2005 air quality when corrected with 1.35 adjustment factor.

	Background Sites			Roadside Sites		
	Site Code	Annual Mean (NO_2 µg/m³)	Monitoring period (month)	Site Code	Annual Mean (NO_2 µg/m³)	Monitoring period (month)
Barking	BD35	39	11	BD32	27	11
	BD38	28	8	BD39	36	11
	BD40	27	9			
	BD41	22	10			
Barnet	**BA56**	**38**	**3**	BA51	33	11
	BA59	21	10	BA52	29	9
	BA62	25	10	BA53	18	11
	BA64	29	7	BA60	35	9
	BA67	25	10	**BA63**	**51**	**11**
	BA69	25	8	**BA65**	**43**	**10**
	BA71	25	8	**BA66**	**44**	**9**
	BA72	29	6	BA68	26	10
	BA73	26	10	BA70	29	9
	BA75	13	6			
Bexley	BX31	22	11	BX34	33	7
	BX32	25	10	BX35	30	12
	BX33	24	12	BX36	29	11
	BX37	27	8			
Brent	**BR31**	**41**	**11**	BR42	39	11
	BR41	27	10	BR43	39	12
	BR51	25	11	BR52	28	12
				BR53	**44**	**12**
				BR54	34	11
				BR55	**62**	**9**
				BR56	34	12
				BR57	**43**	**11**
				BR58	36	12
Camden	CA01	26	12	**CA02**	**42**	**3**
	CA06	29	11	CA03	37	11
	CA07	27	12	CA04	38	10
	CA14	37	3	CA05	37	12
	CA15	**50**	**12**	CA10	33	12
	CA22	26	12	**CA11**	**41**	**12**
	CA25	30	12	CA12	28	3
	CA29	33	12	**CA16**	**50**	**3**
				CA17	**55**	**3**
				CA19	**40**	**11**
				CA21	36	9
				CA23	38	10
				CA24	33	12
				CA27	**55**	**7**
				CA28	35	11
				CA30	**29**	**10**
				CA31	**26**	**6**

CASELLA STANGER

Corporation of London	CL02	31	11	**CL36**	**40**	**11**
	CL03	28	9	CL38	36	11
	CL05	31	9	**CL39**	**41**	**12**
	CL51	30	11	CL41	30	11
	CL55	25	11	CL56	34	11
	CL62	33	12			
Croydon	CY46A	22	10	CY41A	30	10
	CY47A	19	9	CY42A	28	6
	CY50A	19	11	CY43A	36	10
				CY48A	36	10
				CY51A	23	9
				CY52A	28	11
				CY55	32	10
				CY56	27	10
				CY57	34	11
				CY58	**40**	**9**
				CY59	31	10
				CY60	29	10
				CY61	32	11
				CY62	34	11
				CY63	35	10
				CY64	35	2
				CY65	32	9
				CY66	35	9
				CY97A	25	11
				CY98A	31	10
				CY99A	30	9
Greenwich	GW37	19	12	**GW23**	**42**	**3**
	GW38	28	9	GW24	33	11
	GW39	20	12	GW25	33	12
	GW40	19	12	**GW26**	**29**	**4**
				GW27	**41**	**4**
				GW29	38	12
				GW32	26	6
				GW33	28	11
				GW34	28	11
				GW35	**43**	**12**
				GW36	31	10
				GW41	28	12
				GW42	34	12
				GW43	31	12
				GW44	**30**	**4**
				GW48	34	11
				GW49	**49**	**3**
				GW50	29	11
				GW51	30	12
				GW52	32	12
				GW53	24	11
				GW54	36	11
				GW55	30	12
				GW56	**43**	**1**
				GW101	**52**	**3**
				GW102	**50**	**3**

	HD52	**38**	**2**	**HD50**	**35**	**1**
	HD53	**38**	**2**	**HD51**	**33**	**2**
Hammersmith and Fulham	HM41	23	11	**HM32**	**46**	**11**
	HM44	27	10	HM47	25	11
	HM45	32	11	HM48	35	11
	HM46	26	11	**HM50**	**45**	**11**
	HM51	34	11	**HM52**	**50**	**11**
	HM53	33	11	**HM54**	**44**	**11**
	HM60	**38**	**3**	**HM61**	**43**	**5**
	HM63	**45**	**5**	**HM62**	**36**	**5**
	HM66	**36**	**5**	**HM64**	**47**	**5**
	HM67	**36**	**5**	**HM65**	**37**	**5**
Harrow	HA03	21	12	HA01	27	12
	HA04	20	12			
	HA05	20	11			
	HD31	33	10	HD42	26	9
	HD32	24	5	HD43	27	8
	HD41	22	11	HD46	36	11
	HD48	26	11	HD47	32	9
	HD54	**38**	**1**	HD49	25	11
	HD55	**60**	**2**			
	HD56	**44**	**2**			
	HD57	**40**	**2**			
	HD58	**50**	**2**			
	HD59	**45**	**2**			
	HD60	**38**	**2**			
	HD61	**39**	**2**			
Hounslow	HS34	27	12	HS32	37	12
	HS35	23	12	HS33	35	12
	HS43	29	11	HS41	30	11
	HS53	27	12	HS42	24	12
	HS65	28	12	HS51	25	12
	HS66	24	12	HS52	25	12
	HSCRAN	26	12	HS54	27	12
				HS55	36	12
				HS61	**40**	**12**
				HS62	32	12
				HS63	36	12
				HS64	24	12
				HSBREN	31	12
				HSCHIS	39	12

Kensington and Chelsea	KC32	21	12	KC31	33	11
	KC34	31	11	**KC33**	**49**	**12**
	KC39	33	12	KC35	36	12
	KC40	32	11	**KC38**	**66**	**10**
	KC41	31	12	KC45	29	12
	KC42	29	12	KC46	29	12
	KC43	25	12	**KC48**	**46**	**12**
	KC44	25	11	**KC49**	**48**	**12**
	KC47	26	11	KC50	32	12
	KC51	24	12	KC52	36	12
	KC53	31	12	**KC54**	**40**	**12**
	KC55	32	12	KC57	34	11
	KC56	38	12	KC58	34	12
				KC59	**49**	**10**
				KC60	38	12
				KC61	34	12
Newham	NH10	27	12	NH1	35	11
	NH5	29	12	NH11	30	12
	NH6	25	12	NH12	28	11
	NH7	25	12	NH13	32	8
				NH14	35	11
				NH15	**49**	**3**
				NH16	**50**	**3**
				NH17	**36**	**3**
				NH18	**37**	**3**
				NH2	36	11
				NH3	31	11
				NH4	33	10
				NH8	26	11
				NH9	30	9
Richmond-upon-Thames	RM12	28	12	RM1	33	12
	RM17	24	12	RM10	27	**7**
	RM30	26	12	RM11	30	12
	RM37	22	12	RM13	30	12
	RM7	38	12	RM14	32	11
	RM8	26	12	RM15	31	12
	RUT03	26	12	RM16	32	12
	RUT04	21	12	**RM18**	**45**	**12**
				RM19	**44**	**12**
				RM2	27	12
				RM20	34	11
				RM21	33	12
				RM22	32	12
				RM23	30	12
				RM24	28	12
				RM25	38	12
				RM26	32	12
				RM27	34	10
				RM28	21	12
				RM29	30	12
				RM3	33	12
				RM31	**41**	**12**
				RM32	**51**	**12**
				RM33	33	12
				RM34	25	12

				RM35	27	12
				RM36	**44**	**12**
				RM38	28	12
				RM39	**42**	**12**
				RM4	33	12
				RM40	29	12
				RM41	33	11
				RM42	**41**	**11**
				RM43	**41**	**12**
				RM44	33	12
				RM45	37	12
				RM46	27	12
				RM47	29	12
				RM48	32	12
				RM49	35	12
				RM5	31	12
				RM50	33	12
				RM51	38	12
				RM52	38	12
				RM6	34	12
				RM9	36	12
				RM01	35	12
				RM02	**65**	**11**
Westminster	WM37	32	11	WM32	38	10
	WM40	37	11	**WM36**	**48**	**7**
	WM41	23	11	**WM39**	**45**	**11**
	WM43	36	10	**WM46**	**45**	**11**
	WM47	28	11	**WM55**	**55**	**8**
	WM48	34	11			
	WM49	31	11			
	WM52	33	11			
	WM53	34	11			
	WM54	36	4			
	WM56	23	10			
	WM57	32	10			
	WM58	**37**	**4**			