London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2011

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1 Introduction

AECOM was commissioned by the London Borough of Lewisham to install and maintain a network of NO_2 diffusion tubes to assess the spatial variation of nitrogen dioxide (NO_2) concentration within the Borough. The diffusion tube network comprises of 49 NO_2 diffusion tubes at 47 locations. One of these locations is a triplicate site and the remaining locations are single sites. The diffusion tubes were exposed for periods of between 4 and 5 weeks in accordance with the UK NO_2 Survey Timetable. The results of the survey provide Lewisham Borough Council with valuable monitoring data for use in their Local Air Quality Review and Assessment (LAQM) process.

This report outlines the results of the survey for January 2011 to December 2011, inclusive. The spatial variation in NO_2 concentration throughout the Borough is discussed and the annual mean values for each location are compared against the annual mean objective for NO_2 to indicate locations that may be likely to exceed the objective. Monthly concentrations are examined for evidence of seasonal trends.

2 Legislative Background

Limit values and air quality objectives for nitrogen dioxide and oxides of nitrogen (NO_X) were set out in the First Daughter Directive (1999/30/EC) and subsequent revisions. An annual mean NO_2 objective was set at 40 µg/m^3 to be achieved by 1stJanuary 2010. A 200 µg/m^3 hourly mean standard not to be exceeded more than 18 hours per year was also outlined, to be achieved by the same compliance date. These objectives were reiterated in the 2008 Directive on ambient air quality and cleaner air for Europe (2008/50/EC).

The UK has published its own Air Quality Strategy[1], which detailed the UK's position on nitrogen dioxide. The UK air quality objectives differ from the European objectives only in their compliance dates; the UK objectives were to be achieved by the end of 2005. European and UK air quality objectives have also been set for oxides of nitrogen for the protection of vegetation and ecosystems. A summary of the principal air quality objectives for NO_2 and NO_X is given in Table 1.

Table 1 UK and EU Air Quality Objectives for NO_2 and NO_X

Pollutant	UK Air Quality Objectives		
	Standard / Concentration	**Measured as**	**Date to be achieved by and maintained thereafter**
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times a year	1 Hour Mean	31.12.2005
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (for the protection of vegetation)	30 µg/m^3	Annual Mean	31.12.2000
	EU Air Quality Objectives		
	Standard / Concentration	**Measured as**	**Date to be achieved by and maintained thereafter**
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times per year	1 Hour Mean	1 January 2010
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (assuming as nitrogen dioxide)	30 µg/m^3	Annual Mean	19 July 2001

[1] Defra, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007.

3 Monitoring Methodology

3.1 Description of Network

The Lewisham Diffusion Tube Network has been maintained by AECOM since January 2011. During the January 2011 – March 2011 period, 12 diffusion tubes at 12 locations throughout the Borough have been deployed and collected at 4 to 5 weeks intervals in accordance with the UK NO_2 Diffusion Tube calendar[2]. In April 2011, an additional 37 tubes were deployed at 35 locations within the Borough. The final network consists of 47 locations, in which one of these is a triplicate co-located site at the automatic monitoring stations in New Cross Road and the remaining are single sites, using a total 49 diffusion tubes.

The locations of the diffusion tubes are geographically illustrated in Appendix A.

3.2 Procedures and Site Changes

All diffusion tubes used in the network were stored in a refrigerator prior to deployment and after collection to reduce the possibility of degradation of the chemicals involved. Tubes subject to contamination (e.g. spider webs, foreign bodies, etc.) or vandalised have also been excluded from the final dataset.

There were a number of changes to the network in 2011 to avoid vandalism, these are detailed below:

- In October 2011, the diffusion tube at Whitburn Road (L10), located at the façade of Bentley Court, was relocated to the lamp post number 2.
- In November 2011, the diffusion tubes at Forster Park School (SCH006), located inside the school area, were relocated to the lamp post 28 on Waters Road.

3.3 Tube Preparation, Analysis and Laboratory QA/QC

The diffusion tubes were supplied and analysed by Gradko International Ltd, using a 50% Triethanolamine (TEA) in acetone method. Gradko participates in the Health and Safety Laboratory's (HSL) Workplace Analysis Scheme for Proficiency (WASP) programme for diffusion tubes, which provides a Quality Assurance / Quality Control (QA/QC) framework for local authorities carrying out diffusion tube monitoring as a part of their local air quality management process. The percentage (%) of results submitted from Gradko International Ltd which were subsequently determined to be satisfactory was 100% for all tests between round 105 (April-June 2009) and round 113 (April-June 2011), except for round 109 (April-June 2010) in which the satisfactory percentage was 87.5%[3] .

3.4 Factors Affecting Diffusion Tube Performance

NO_2 diffusion tubes are an indicative monitoring technique, as they do not offer the same accuracy as the reference method for NO_2, the automatic chemiluminescence analyser. NO_2 diffusion tubes are affected by several factors, which may cause them to exhibit bias relative to the reference technique.

Over-estimation may be attributed to one of the following three interfering factors:

- The shortening of the diffusive path length caused by the wind;
- The blocking of UV light resulting in reduced NO_2 photolysis in the tube; and
- The interference effects of peroxyacetyl nitrate (PAN).

Under-estimation can be caused by the following factors:

- Increasing exposure period, and is thought to be due to degradation of the absorbed nitrate with time;
- Insufficient extraction of nitrite from the meshes;

[2] Defra, Local Air Quality Management, Diffusion Tubes, Nitrogen Dioxide Diffusion Tube Monitoring, Calendar of Suggested Exposure Periods 2011. Available at http://laqm.defra.gov.uk/documents/no2cal11.pdf

[3] WASP – Summary of Laboratory Performance in WASP NO2 Proficiency Testing Scheme for Rounds 105-113. June 2011. Available at http://laqm.defra.gov.uk .

- The photochemical degradation of the triethanolamine-nitrite complex by light, although this is minimised by the use of opaque end-caps; and
- The solution used. For example, 50% solution of TEA in water has been reported to lead to comparatively reduced NO_2 uptake.

There are a number of additional factors that may also affect diffusion tube performance including time of the year, the exposure setting (i.e. sheltered or open sites), the proximity to roads, the preparation method and analytical laboratory used, the exposure concentration and the ratio of NO_2 to NO_X.

3.5 Data Validation and Data QA / QC

Validation of diffusion tube readings is vital to ensure public confidence in the measurements produced. Validation is achieved through the following steps described in sub-sections below.

3.5.1 Blanks

The laboratory reserved a set of diffusion tubes for use as laboratory blanks for each dispatches of tubes to the user. These are kept in sealed containers in a refrigerator and analysed with the exposed tubes to provide a measure of nitrite concentration on unexposed tubes.

One travelling blank was taken to site during each of the monthly changeovers. These tubes accompany the user during tubes changeover but are not themselves exposed. The purpose of using field blanks is to identify possible contamination of the tubes during transportation or in storage by the user.

Laboratory and field blanks were routinely screened by AECOM to ensure quality of data. Neither the laboratory blanks nor the travel blank results were subtracted from the results of exposed tubes, in accordance to the Local Air Quality Management Technical Guidance (LAQM.TG(09))[4] and the Diffusion Tube Practical Guidance.

3.5.2 Rejection of Diffusion Tube Results

Diffusion tube results obtained for each month were checked to meet the following criteria for inclusion in the final dataset:

- Correct calculation of exposure hours;
- Concentrations less than 3 $\mu g/m^3$ were rejected as these concentrations are unlikely to occur in an urban area.
- Concentrations at the high end were not routinely rejected unless good evidence can be shown to prove the spurious results.
- Exposure records were checked for possible explanation of any unusual results (e.g. foreign objects, bonfires, pollution episodes, construction works, tampering, etc.).
- For triplicate site, diffusion tube that exhibits poor precision (> 20%) was excluded from the final dataset. For single sites, professional judgement was used to accept or reject the results based on observations made during site visits.

3.5.3 Bias Adjustment Factor

Diffusion tube monitoring is indicative and does not offer the same accuracy as the reference method for monitoring NO_2 i.e. using an automatic chemiluminescence analyser. Several factors could affect NO_2 concentrations measured with diffusion tubes, which may cause them to exhibit bias (over-read or under-read readings) relative to the reference method (see Section 3.4). To correct this bias, comparison of the NO_2 concentration as measured by diffusion tubes is made with continuous monitoring data to derive a bias-adjustment factor.

Bias adjustment factor can be obtained using the Nitrogen Dioxide Diffusion Tube Bias Adjustment spreadsheet[5], which is updated periodically and collates the bias-adjustment factors obtained in co-location studies conducted nationally. It can also be derived locally through co-location of diffusion tubes with automatic analysers and compared the results obtained from both methods of monitoring.

[4] Defra, Local Air Quality Management Technical Guidance LAQM.TG(09), 2009.
[5] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet (Version 04, February 2011). Available at http://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html

Further details of the monitoring sites used and the derivation of the factor can be found in Appendix C. The local bias factor was applied to all diffusion tube results in the period unless indicated otherwise.

3.6 Site Designations

3.6.1 Site Designations

The designation of site types is used to compare different locations statistically. Sites were categorised as kerbside, roadside, near road (intermediate) and urban background sites according to the definitions given in the "Practical Guidance for Diffusion Tube Monitoring" [6] report. These definitions are reproduced in Table 2 below.

Table 2 Site Type Designation Criteria

Type	Definition
Kerbside	Within 1m of the kerb.
Roadside	1-5m from the kerb edge.
Intermediate (or 'Near Road' sites)	More than 5m from the kerb of a busy road but air quality is likely to be affected by the nearby busy road.
Urban Background	> 50m from any major source of NO_2, such as multi-storey car parks; > 30m from any very busy road (> 30000 vehicles per day); > 20m from any busy road (10000 – 30000 vehicles per day); > 10m from any main road (quiet roads e.g. within residential estates are acceptable; and > 5m from any area where vehicles are likely to be idling.

[6] Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users. AEAT, February 2008.

4 Results and Discussion

4.1 Data Capture

Data capture rates for the Lewisham Diffusion Tube Survey Network during 2011 were generally high, achieving an overall average of 94% for all site types. The lowest data capture was reported for the tubes at Forster Park School (SCH006) with 67% and at Whitburn Road (L10) with 75% capture rate (Appendix B). The tube sited at Forster Park School location was found missing in May, June, September and October; while the tube at Whitburn Road was found missing between July and September inclusive. In October 2011, steps were taken to relocate the tubes at Whitburn Road to a greater height to avoid vandalism, and in November 2011 the tube at Forster Park School was relocated outside the school area to a greater height.

Sites recording lower than 100% data capture were as a result of tubes being stolen, clips being vandalised or data not being included in the final dataset (see Section 3.5.2). Sites achieving less than 75% capture rate, as listed above, are all located at easily accessible areas where missing tubes are persistently found on the ground because of vandalism.

4.2 Bias Adjustment

4.2.1 Local Bias Adjustment Factor

The co-location site annual mean NO_2 concentrations measured by the diffusion tubes and the continuous monitors are displayed in Table 4.

The AEA Diffusion Tube Precision Accuracy Bias Spreadsheet[7] tool was used to calculate bias adjustment factors for the co-location site. Continuous monitoring data was sourced from the London Air Quality Network (LAQN) website[8]. It should be noted that the continuous monitoring data used in the bias adjustment calculations have not been ratified for the entirety of 2011 and may therefore be subject to change. Further details can be found in Appendix C. An average bias adjustment factor of 0.59 (provisional as data from continuous monitoring station have not been fully ratified) was obtained and this value has been applied to all diffusion tube concentrations unless otherwise stated. The complete diffusion tube results without the application of a bias adjustment factor can be found in Appendix B.

Table 3 Comparisons of Diffusion Tube Measurement and Continuous Monitors at Collocated Site

Site Name	2011 Annual Mean NO_2 Concentration ($\mu g/m^3$)	
	Unadjusted Diffusion Tube	Continuous Monitor
Lewisham – New Cross	80.9	**48.4**

Note: Continuous monitoring results at Lewisham New Cross have not been fully ratified.

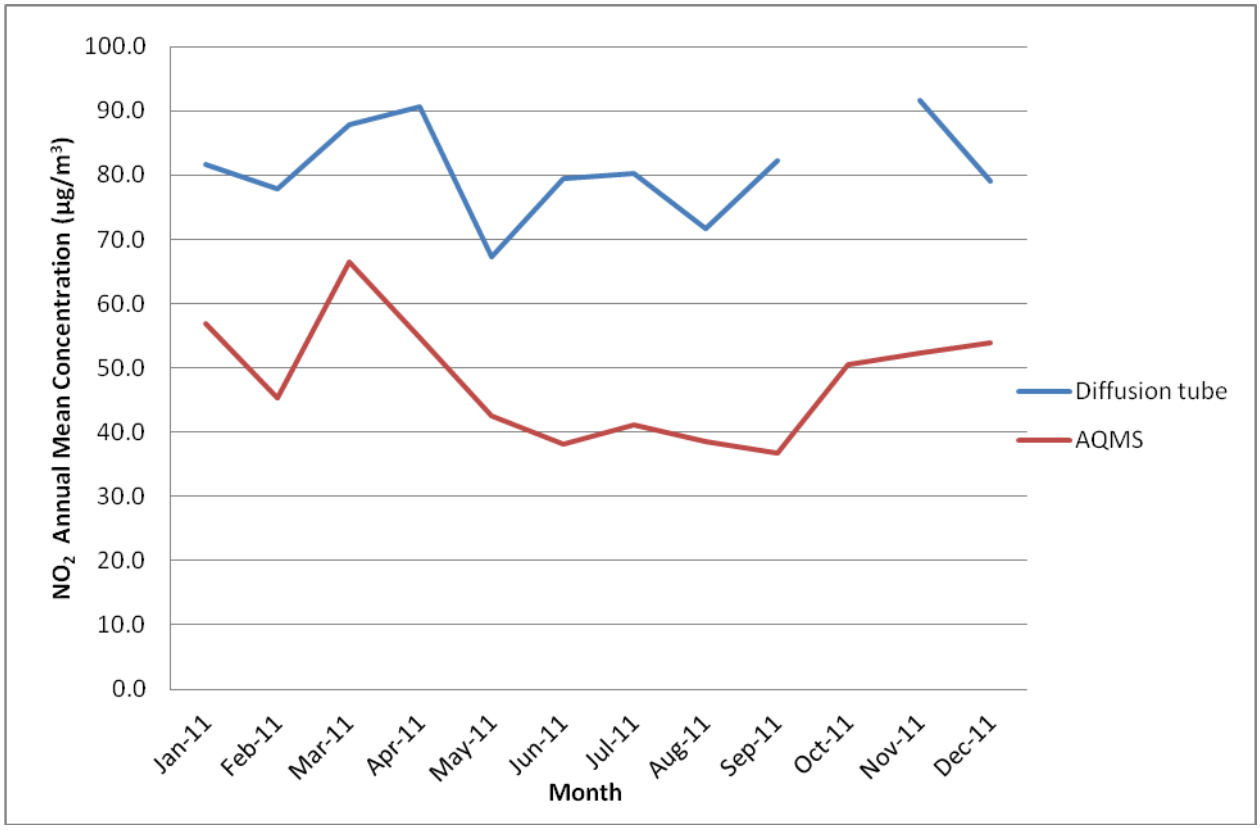
Exceedences of the UK air quality objectives for NO_2 is highlighted in bold in Table 3. It can be seen that the measurements made with diffusion tubes was not in good agreement at the co-located site in New Cross monitoring station, where diffusion tube readings were significantly higher than the reference measurements. Results for October 2011 have not been included in the local bias adjustment factor due to poor precision (Appendix C). Monthly readings from the diffusion tubes were compared with concentration at Lewisham New Cross (Figure 1). This illustrates a systematic over-reading by the tube with results being much higher than the continuous analyser for all months. The positive bias exhibited by the diffusion tubes at this location may be due to turbulence and inhomogeneities of sampled air. Moreover the tubes were not located sufficiently close to the NO_X analyser inlet. For the 2012 these tubes have been moved to a location much closer to this inlet. At locations close to sources of NO such as roadside and kerbside sites, within-tube chemical reactions of NO and O_3 have been found to result in over-reading in relation to reference method[9].

[7] AEA Diffusion Tube Precision Accuracy Bias Spreadsheet. Downloaded from http://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html 09/02/2011.
[8] London Air Quality Network Website. Available at http://www.londonair.org.uk.
[9] Cape, J.N., Review of the Use of Passive Diffusion Tubes for Measuring Concentrations of Nitrogen Dioxide in Air, 2005. Available at http://uk-air.defra.gov.uk/reports/cat05/0810141025_NO2_review.pdf

4.2.2 National Bias Adjustment Factor

Due to the low value of the local bias adjustment factor (0.59) and the concerns about the positioning of the co-located tubes, it is recommended that the bias adjustment factor obtained from national co-location studies[10] be used. The national bias adjustment factor for 2011 is 0.93 for the laboratory and preparation method, based on 20 studies (spreadsheet version 03/12).

Figure 1: Comparisons of Chemiluminescence and Diffusion Tube Measurements at AQMS New Cross for 2011



[10] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet, Spreadsheet Version Number: 03/12. Available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

4.3 Annual Mean NO_2 Concentrations

The mean NO_2 concentration over the whole network during 2011 was 21.9 µg/m^3 after applying a provisional bias adjustment of 0.59 or 34.6 µg/m^3 using the national bias adjustment factor. This mean concentration was below the annual mean NO_2 objective of 40 µg/m^3. The maximum annual mean NO_2 concentration was measured at the triplicate site (LWS005, LWS006, LWS007) at New Cross Road (47.7 µg/m^3, using the co-location study bias adjustment factor or 75.2 µg/m^3 using the national bias adjustment factor). The second highest annual mean NO_2 concentration was measured at LWS011 site in Catford Hill (33.9 µg/m^3 – co-location study bias adjusted or 53.5 µg/m^3 – national bias adjusted), which is a roadside site.

Table 4 Annual Mean NO_2 Concentration (Bias-Adjusted), 2011

Site Type	Annual Mean NO_2 Concentration (µg/m^3)		
	Raw	Bias adjusted (Provisional), using New Cross co-location tubes (Factor = 0.59)	Bias adjusted, using National Bias Adjustment Factor (Factor = 0.93)
All Sites	37.2	21.9	34.6
Roadside	47.7	28.2	44.4
Urban Background	30.0	17.7	27.9

4.3.1 Comparison with Limit Values and Objectives

The air quality objectives and limit values of relevance to NO_2 in the UK are detailed in Section 2. The results in Table 4,obtained after applying the co-location study adjustment factor, indicate that the annual mean NO_2 objective of 40µg/m^3 was not generally exceeded within the diffusion tube network during 2011. While results obtained using the national bias adjustment factor show that the annual mean NO_2 objective at roadside sites was exceeded. From Appendix B, it can be seen that at just at one of the 47 diffusion tube locations, the bias-adjusted annual mean NO_2 concentrations obtained after applying the co-location adjustment factor was greater than 40 µg/m^3. On the other hand, results based on the national bias adjustment factor, show that 13 sites exceeded the NO_2 objective.

A report issued by Air Quality Consultants[11] analysed the relationship between annual mean and hourly mean NO_2 concentrations, concluding that locations where the annual mean concentration is greater than 60 µg/m^3 may be susceptible to breaches of the hourly mean objective (hourly mean NO_2 concentration of 200 µg/m^3 or more not to be exceeded more than 18 occasions per year). There are no sites with measured NO_2 concentrations greater than 60 µg/m^3 in 2011, using the co-located bias adjustment factor, while after applying the national bias factor the only site with measured NO_2 concentrations greater than 60 µg/m^3 is the triplicate site at New Cross Road (LWS005, LWS006 and LWS007).

[11] Air Quality Consultants (2007). Deriving NO_2 from NO_X for Air Quality Assessments of Roads.

Seasonal Variation

The seasonal variation in NO_2 concentrations during 2011 are shown in Table 5 and Figure 2. Due to seasonal variations in the bias adjustment that can occur at diffusion tube sites the results that have been presented are the raw concentrations with no bias adjustment applied.

The highest mean concentration occurred in November followed by March and April at roadside sites. For urban background sites, the highest mean concentration was measured in January, followed by November and March. Mean NO_2 concentration was the lowest in June and May for all site types.

Table 5 Monthly Mean NO_2 Concentrations in Lewisham, 2011 (µg/m^3; Unadjusted)

Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All Sites	44.8	40.2	43.8	41.7	29.4	29.0	33.3	30.0	30.3	39.1	45.5	37.4
Roadside	51.6	51.0	55.2	52.4	39.6	40.4	47.4	40.7	40.4	50.2	56.1	45.1
Urban Background	39.9	33.0	37.1	34.1	21.9	22.0	24.0	23.2	23.1	31.7	38.2	31.9

Table 6 Unadjusted Winter and Summer Period Mean Concentrations in Lewisham, 2011

Site Type	Winter Mean Concentration (October – March) (µg/m^3)	Summer Mean Concentration (April – September) (µg/m^3)	Ratio Winter : Summer
All Sites	41.8	32.3	1.3
Roadside	51.5	43.5	1.2
Urban Background	35.3	24.7	1.4

Table 6 shows that the ratio of winter to summer mean NO_2 concentration was 1.2 for roadside sites, indicating higher mean concentrations in the winter than summer periods. The urban background sites display higher winter: summer ratio compared to roadside sites. The value was 1.4 in 2011. For all sites collectively the ratio of winter to summer mean NO_2 concentration was 1.3.

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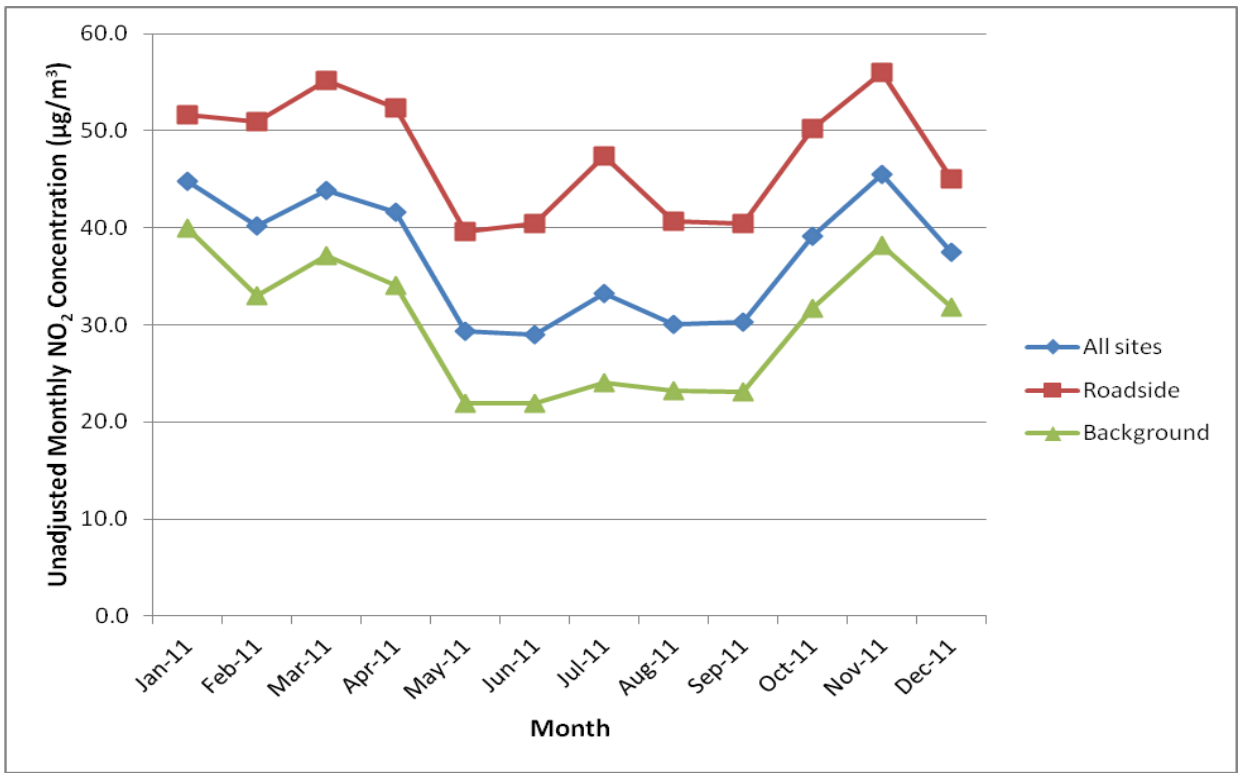
Figure 2: Seasonal Trend of NO_2 Concentrations in Lewisham, 2011



5 Conclusions

The main conclusions of the 2011 Lewisham Diffusion Tube Network study are:

- The mean NO_2 concentration for the whole network, based on provisional bias adjustment factor was 21.9 µg/m^3 or 34.6 µg/m^3 based on the national bias adjustment factor.
- NO_2 concentrations were greatest at roadside monitoring locations, followed by urban background sites. The highest annual mean concentration in 2011 was measured at the triplicate site in New Cross Road (LWS005, LWS006, LWS007). The mean concentration is 47.7 µg/m^3, based on provisional bias adjustment factor, or 75.2 µg/m^3 using the national bias factor. The second highest concentration occurred at the site LWS011 (Catford Hill), with a value of 33.9 µg/m^3, after applying the provisional bias adjustment factor, or 53.5 µg/m^3 using the national bias adjustment factor.
- The mean roadside NO_2 concentration across the network was 28.2 µg/m^3, based on provisional bias adjustment factor, or 44.4 µg/m^3 based on the national bias adjustment factor, and the mean urban background concentration was 17.7 µg/m^3 using provisional bias adjustment factor or 27.9 µg/m^3 using the national bias adjustment factor.
- Results based on the provisional adjustment factor show that just one diffusion tube location recorded annual mean NO_2 concentrations exceeding the annual mean NO_2 objective of 40 µg/m^3. While results obtained after applying the national bias adjustment factor show that 13 sites exceeded the annual mean NO_2 objective.

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Appendix A: Diffusion Tube Monitoring Locations in Lewisham

Figure 3: LB of Lewisham Diffusion Tube Network in 2011

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Appendix B: Monitored NO_2 Concentrations

Table 7 Lewisham Diffusion Tube Network 2010 – Raw and Bias Adjusted Results

Ref	Location	x	y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 0.59)	Bias-Adjusted[b] (Factor = 0.93)	
Existing Network								
L1	Lamp post,1-16 Chubworthy Street	536111	177579	Roadside	38.7	22.8	36.0	100
L2	Façade Bronze Street/Creekside	537549	177444	Urban Background	31.6	18.6	29.4	83
L3	Lamp post, 20 Oxestalls Road/Grove Street	536558	178470	Urban Background	36.9	21.8	34.3	100
L4	Lamp post, Plough Way/Grove Street	536542	178921	Urban Background	39.6	23.3	36.8	100
L5	Façade305 Lee High Road	539664	175061	Roadside	38.9	23.0	36.2	100
L6	Drainpipe 2a Baring Road/Le May Avenue	540618	172340	Urban Background	38.2	22.6	35.5	83
L7	Façade 65 Bell Green	536555	171804	Roadside	51.4	30.3	**47.8**	100
L8	Façade 107 Stondon Park	536229	174021	Roadside	47.3	27.9	**44.0**	92
L9	Façade Adelaide Avenue/Ladywell Road	537491	174913	Roadside	42.5	25.1	39.5	100
L10	Façade Bentley Court, Whitburn Road (moved to Lamp post 2)	538101	175073	Roadside	46.0	27.1	**42.7**	75
L11	Lamp post Lewisham Road/Sparta Street	538007	176517	Roadside	47.7	28.2	**44.4**	83
L12	Footpath, Montague Avenue	537147	175353	Urban Background	32.7	19.3	30.4	100
SCH001	All Saints Primary School	539250	176402	Urban Background	28.1	16.6	26.1	100
SCH002	Lee Manor	539348	174477	Urban Background	28.0	16.5	26.1	92
SCH003	Cooper's Lane	540545	172840	Urban Background	24.4	14.4	22.7	100
SCH004	Launcelot	540149	171652	Urban Background	24.4	14.4	22.7	92

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Ref	Location	x	y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 0.59)	Bias-Adjusted[b] (Factor = 0.93)	
SCH005	Bonus Pastor	539063	171632	Urban Background	24.6	14.5	22.9	100
SCH006	Forster Park	539369	172480	Urban Background	28.8	17.0	26.8	67
SCH007	Sandhurst Juniors & Infants	539089	173398	Urban Background	28.8	17.0	26.8	100
SCH008	Holy Cross	537817	173323	Roadside	31.8	18.7	29.6	100
SCH009	Catford High School	538456	172426	Urban Background	27.3	16.1	25.3	92
SCH010	Athelney JMI	537453	172410	Urban Background	25.2	14.9	23.5	83
SCH011	St Michael's CE	536245	171849	Urban Background	26.3	15.5	24.5	83
SCH012	St William of York	536241	173493	Urban Background	26.8	15.8	25.0	100
SCH013	Christchurch	535563	172740	Roadside	29.6	17.4	27.5	100
SCH014	Perrymount	535862	172685	Urban Background	28.3	16.7	26.3	92
SCH015	Holbeach	537438	173941	Urban Background	29.8	17.6	27.7	100
SCH016	St Mary Magdalen's RC	536412	175131	Urban Background	24.7	14.5	22.9	92
SCH017	Turnham	536118	175119	Urban Background	25.8	15.2	24.0	100
SCH018	Grinling Gibbons	536924	177707	Urban Background	33.6	19.8	31.2	92
SCH019	St Saviour's	538311	175304	Urban Background	30.6	18.0	28.4	100
SCH020	St Mary's CE	538025	174749	Roadside	50.1	29.6	**46.6**	100
SCH021	Sydenham School	535028	172327	Urban Background	29.3	17.3	27.3	100
LWS053	Drainpipe on property (50 Mayow Road)	535798	171576	Urban Background	31.7	18.7	29.4	100
LWS002	Lamp post 23 Boyne Road	538475	175785	Urban Background	35.6	21.0	33.1	100

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Ref	Location	x	y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 0.59)	Bias-Adjusted[b] (Factor = 0.93)	
LWS003	Drainpipe 155 Lewisham Road	538220	176100	Roadside	46.4	27.4	**43.2**	100
LWS004	Gaspipe,122 Loampit Vale	537740	155920	Roadside	51.8	30.5	**48.1**	100
LWS005, LWS006, LWS007	Automatic monitoring station, New Cross Road	536241	176932	Roadside	80.9	**47.7**	**75.2**	92
LWS008	Signpost outside The Five Bells PH, Hatcham Park Road	535759	176982	Roadside	45.2	26.6	**42.0**	83
LWS009	15 Brockley Rise	536130	173337	Roadside	56.0	33.0	**52.1**	92
LWS010	Lamp post 68 Ringstead Road	538055	173810	Urban Background	37.6	22.2	35.0	100
LWS11	Lamp post 33B Catford Hill	537180	173370	Roadside	57.5	33.9	**53.5**	100
LWS014	Downpipe to 8 Stanstead Road	535536	173192	Urban Background	30.2	17.8	28.0	100
LWS015	Lamp post 205 Shardloes Road	536523	175925	Roadside	52.9	31.2	**49.2**	83
LWS016	20 Selwyn Court, Lawn Terrace	539640	175934	Roadside	36.8	21.7	34.3	100
LWS017	Roadsign, 7 Baring Road	540037	173748	Roadside	55.2	32.6	**51.4**	92
LWS018	Torridon Junior School	538960	172740	Urban Background	30.9	18.2	28.7	92

Note:
[a] Bias adjustment factor is provisional, calculated based on provisional results from Lewisham,-New Cross monitoring station.
[b] National Bias adjustment factor.

Appendix C: Diffusion Tube Bias Adjustment

A local bias adjustment factor was calculated in order to apply bias correction to the raw diffusion tube results for 2011. Triplicate tubes were co-located alongside the continuous NO_2 monitoring sites in New Cross Road (LW2), and this site has been used to calculate the bias adjustment factor 2011.

The continuous monitoring site listed above is part of the London Air Quality Network (LAQN reference is given in brackets). NO_2 concentration data from the continuous monitoring sites between 05/01/2011 and 05/01/2012 to cover the period of diffusion tube monitoring was collated. Period mean NO_2 concentrations were calculated for each diffusion tube exposure period during 2011. Data capture statistics for the same periods were also determined.

The continuous monitoring data and raw triplicate tube concentrations were inputted into the Bias Adjustment Calculator[3] tool to calculate bias adjustment factors

The bias adjustment calculations for the monitoring site are shown in Figure 4. Table 8 provides a summary of the bias factor calculated for the site, and the comparison with national bias adjustment factors for the past years are also shown.

Table 8 Summary of Local and National Bias Adjustment Factors for Lewisham NO_2 Diffusion Tube Surveys, 2008 to 2011

Year	Mean Local Factor	National Factor[a]
2008	0.93	0.94
2009	0.84	0.97
2010	0.69	1.03
2011	0.60	0.93

Notes: [a] National factor obtained from Bias Adjustment Factor spreadsheet[3] version 03/12 based on Gradko as the analysing laboratory using the 50% TEA in acetone method. [b] Spreadsheet version 03/12. [e] Provisional mean local factor has been calculated based on LW2 data, that has not been fully ratified at the time of writing.

Capabilities on project:
Environment

Figure 4: Local Bias Adjustment Factor Calculation, Lewisham – New Cross (LW2)

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements

Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean
1	05/01/2011	02/02/2011	71.1	87.4	86.5	82	9.2	11	22.8
2	02/02/2011	28/02/2011	65.6	86.0	81.8	78	10.8	14	26.8
3	28/02/2011	01/04/2011	73.1	84.9	105.3	88	16.2	19	40.4
4	01/04/2011	28/04/2011	85.2	102.9	83.7	91	10.7	12	26.5
5	28/04/2011	07/06/2011	68.2	60.4	73.3	67	6.5	10	16.2
6	07/06/2011	01/07/2011	82.8	85.3	70.6	80	7.9	10	19.6
7	01/07/2011	03/08/2011	72.4	94.5	74.2	80	12.3	15	30.5
8	03/08/2011	03/09/2011	67.7	64.8	82.3	72	9.4	13	23.3
9	03/09/2011	28/09/2011	68.7	83.6	94.7	82	13.0	16	32.4
10	28/09/2011	03/11/2011	96.7	47.7	73.2	73	24.5	34	60.9
11	03/11/2011	01/12/2011	93.7	75.1	106.2	92	15.6	17	38.9
12	01/12/2011	05/01/2012	78.1	77.0	82.2	79	2.7	3	6.7
13									

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

Automatic Method		Data Quality Check	
Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
57.0	89.7	Good	Good
45.4	88.5	Good	Good
66.6	100.0	Good	Good
54.8	77.8	Good	Good
42.6	77.5	Good	Good
38.1	100.0	Good	Good
41.2	100.0	Good	Good
38.6	87.1	Good	Good
36.7	100.0	Good	Good
50.4	100.0	Poor Precision	Good
52.4	100.0	Good	Good
53.9	94.1	Good	Good
Overall survey -->		Good precision	Good Overall DC

(Check average CV & DC from Accuracy calculations)

Site Name/ ID:

Precision 11 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval) without periods with CV larger than 20%

Bias calculated using 11 periods of data
Bias factor A 0.59 (0.53 - 0.67)
Bias B 69% (50% - 88%)

Diffusion Tubes Mean: 81 μgm^{-3}
Mean CV (Precision): 13 caution

Automatic Mean: 48 μgm^{-3}
Data Capture for periods used: 92%

Adjusted Tubes Mean: 48 (43 - 54) μgm^{-3}

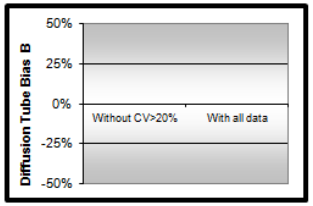
Accuracy (with 95% confidence interval) WITH ALL DATA

Bias calculated using 12 periods of data
Bias factor A 0.6 (0.54 - 0.68)
Bias B 67% (48% - 85%)

Diffusion Tubes Mean: 80 μgm^{-3}
Mean CV (Precision): 14 caution

Automatic Mean: 48 μgm^{-3}
Data Capture for periods used: 93%

Adjusted Tubes Mean: 48 (43 - 55) μgm^{-3}



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