Report

Extended Investigation of Air Pollution from Transport Operations at Heathrow Airport

Report to British Airways

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Address for Correspondence

netcen
Culham Science Park
Abingdon
Oxfordshire
OX14 3ED
Telephone 0870 190 6432
Facsimile 0870 190 6607

ken.stevenson@aeat.co.uk

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	Name	Signature	Date
Author	Tony Clark		
Reviewed by	Ken Stevenson		
Approved by	Ken Stevenson		

Executive Summary

British Airways has undertaken dispersion modelling of aircraft emissions at Heathrow Airport. In order to compare modelling results with measurements, netcen (part of AEA Technology) was commissioned to undertake a preliminary study of air pollution concentrations on a transect across Heathrow Airport and extending into the residential areas to the north east of the airport. As a result of this preliminary study, netcen was further commissioned to undertake a 12-month survey, in collaboration with BA staff, at an extended number of locations. This report presents the results from this monitoring, undertaken during the period October 2002 to October 2003.

Diffusion tube samplers for nitrogen dioxide (NO_2) were deployed for 12 monthly periods at each of 19 monitoring locations (plus BA Waterside) and, in addition, diffusion tube samplers for hydrocarbons (BTEX) were deployed at six collocated sites for the final 10 months.

The results show that NO_2 concentrations continued to be generally higher at on-airport (airside) sites, compared to off-airport (land-side) sites. The exceptions being the land-side sites at Neptune Road, between the northern perimeter road and the A4 and also at Shepiston Lane, close to the M4 motorway. The highest bias-corrected 12-month mean NO_2 concentrations on-airport, continue to be found at the monitoring sites close to Terminal 2.

The benzene results, from the BTEX tubes, show that the highest overall average was observed at the site alongside the M4 motorway. This was, however, still less than 10% of the recently introduced Air Quality Objective level. The only airside BTEX site, at the GA9 windsock, in the centre of the northern runways, produced a benzene level in the region of half that of the ‘M4’ site.

Contents

1 Introduction

British Airways has undertaken dispersion modelling of aircraft emissions at Heathrow Airport. In order to compare modelling results with measurements, netcen (part of AEA Technology) was commissioned to undertake a preliminary study of air pollution concentrations on a transect across Heathrow Airport and extending into the residential areas to the north of the airport. Following the preliminary study, netcen was subsequently commissioned (in collaboration with BA staff) to undertake an extended Survey.

The study was undertaken over a 12-month period from October 2002 to October 2003 at an eventual total of 20 monitoring locations across the airport and the residential areas to the north. The 20th site was located at the BA Waterside offices.

Sampling began using nitrogen dioxide (NO_2) diffusion tubes and from period 3, hydrocarbon (BTEX) diffusion tubes were collocated at six of the NO_2 tube sites (one airside and 5 non-airside) primarily to assess the likely benzene levels. Results for toluene, ethylbenzene, m,p-xylene and o-xylene are also reported. Examples of these diffusion samplers are shown in Figure 1.

Both NO_2 and benzene are covered by Air Quality Objectives or limit values, set by the EC or the UK Government. The EC Directives cover NO_2, and other species. More recently, the UK Government has defined Objectives[1] for various pollutants, including NO_2 and benzene. This Air Quality Strategy defines levels for air pollutants, that must be met in the UK by specific dates. These are formally incorporated into English law by the Air Quality (England) Regulations 2000 and the Air Quality (England) (Amendment) Regulations 2002. These Objectives are shown in Appendix 4.

The analysis is carried out by Harwell Scientifics Ltd, formerly AEA Technology's Analytical Services Group (ASG), who have been awarded UKAS accreditation (Testing Laboratory No 0322) for this analysis.

Figure 1: ***Diffusion tubes for (left to right) SO_2, BTX and NO_2***

2 Survey Methodology

Triplicate diffusion tube samplers for nitrogen dioxide (NO_2) were exposed at monthly intervals at selected sites over a 12-month period. Single hydrocarbon (BTEX) diffusion tubes were also collocated at 6 sites, over the final 10 months of the survey. Figure 1 shows examples of the diffusion samplers used in the survey. A summary of the exposure dates for each period are shown in table 1.

Table 1: Summary of diffusion tube exposure periods – Oct. 02 to Oct. 03

Period	Diffusion tube exposure dates
1	21st. Oct. to 20th. Nov. 2002
2	20th. Nov. to 19th. Dec. 2002
3	19th. Dec. 02 to 20th. Jan. 03
4	20th. Jan. to 19th. Feb. 2003
5	19th. Feb. to 20th. Mar. 2003
6	20th. Mar to 22nd. Apr. 2003
7	22nd. Apr. to 21st. May 2003
8	21st. May to 19th. Jun. 2003
9	19th. Jun. To 21st Jul. 2003
10	21st. Jul. to 20th. Aug. 2003
11	20th. Aug. to 18th. Sep. 2003
12	18th. Sep to 20th. Oct. 2003

2.1 DIFFUSION TUBE MEASUREMENTS

Diffusion tubes are passive sampling devices, which require no mains or battery power and hence are ideal for this type of survey at a number of locations. Some details of diffusion tube samplers for NO_2 are provided in Appendix 1. For this extended survey, three NO_2 tubes were, again, deployed at each site in order to increase the reliability and accuracy of the data. Also, in line with general guidance on the use of diffusion tube samplers, one site was co-located with a continuous automatic monitor for NO_2 at the on-airport air quality monitoring site operated by netcen on behalf of BAA at LHR2. A scaling factor for the NO_2 diffusion tubes exposed at LHR2, was calculated each sampling period, from the comparison of the diffusion tube measurements and the collocated automatic NO_2 measurements, at this site. For monthly submission of data to BA, all other diffusion tube results were re-scaled, each period, with a monthly-derived factor and hence, should provide reliable measurements closely aligned with data from the automatic reference method. For the results presented in this report an overall scaling factor for the whole year of monitoring has been calculated and applied to all of the NO_2 diffusion tube results. This is in line with the Defra Technical Guidance[3] on the use of diffusion tubes. The benzene results from the BTEX diffusion tubes have not been subjected to any such re-scaling.

Diffusion tube samplers are generally referred to as an indicative method of measurement. In terms of the EC Directive for NO_2 concentrations, indicative methods of measurement should be accurate to ±25%. The automatic monitoring of NO_2 at the LHR2 site is undertaken with a chemiluminescent analyser, which is defined as the EU reference method of monitoring. Under the Directive, this reference method is required to have an accuracy of ±15%. In this study, the NO_2 diffusion tubes were scaled to agree with the automatic monitoring result at the co-located monitoring site at LHR2. Hence, it is anticipated that the NO_2 diffusion tube results in the report will have an uncertainty between ±15% and ±25% and, given that the tubes were exposed in triplicate we would expect the uncertainty to be towards the lower end of this range.

Hydrocarbon diffusion tubes are often referred to as BTEX tubes. This acronym refers to the commonly reported species, from their exposure, being benzene, toluene, ethylbenzene and the xylenes (split into 'm&p' and 'o' xylene). These are measured by adsorption onto Chromosorb 106, contained in a stainless steel tube. A mesh diffusion cap is fitted over the open end during exposure. The tubes are typically exposed for four weeks, then recapped and returned to Harwell Scientifics for analysis.

The samples are analysed by thermal desorption on a cold trap, followed by thermal desoption into a gas chromatograph using mass spectrometry detection. Harwell Scientifics have been awarded UKAS accreditation for this analysis. The results are quoted in micrograms per cubic metre ($\mu g\ m^{-3}$), after subtraction of any control tube blank result, and conversion from the reported ppb values, using accepted conversion factors for each species.

The Limit of Detection (LOD) for analysis of individual tubes in the laboratory is in the order of 0.1 ppb. However, uncertainties in the exposure and sampling may give an overall LOD of nearer 0.5 ppb, for the method. The uncertainty on values significantly above the LOD is in the region of ±20% relative, although this may be higher for results close to or below 0.5 ppb.

The following uptake rates have been used for the calculation of the ambient uptake rates, for the sampled hydrocarbon species:

Benzene:…… 1.72 ng ppm^{-1} min^{-1}	Toluene:……..1.94 ng ppm^{-1} min^{-1}
Ethyl Benzene:…1.9 ng ppm^{-1} min^{-1}	m,p-Xylene…….2.1 ng ppm^{-1} min^{-1}
o-Xylene……2.1 ng ppm^{-1} min^{-1}	

These rates are based on theoretical absorption rates for the particular sorbant (Chromosorb 106) and have been validated against automatic chromatographic measurements.

2.2 MONITORING LOCATIONS

The majority of locations from the Preliminary study were retained for the extended exercise. Further locations, were also identified by British Airways staff, resulting in a total of 19 sites. These are listed in Table 2. They continue to follow a general transect of the airport from north east to south west, with 11 sites on the airport and 8 sites located outside of the airport to extend the transect to the residential areas to the north east. One further monitoring site continued to be located at the BA Waterside offices. The tubes were supported in aluminium blocks, fixed at a height of approximately 2 metres, where possible, using street-furniture or available supports.

The 12-month survey began with NO_2 tubes only, at 18 locations plus tubes at the BA Waterside offices. From period 3, BTEX tubes were also exposed at 6 of the existing locations (marked with an asterisk, in table 1). Finally, the Cranford Lane site was added from period 7. Figure 2 is a map extract showing all the monitoring locations.

Table 2: Monitoring Locations.

Site	Easting	Northing	Comment
Shepiston Lane *	508582	178453	Close to M4 motorway
Imp. Coll. 1	508270	177831	Opposite sports ground
Harlington f/p *	508030	177670	On f/p in centre of field
Cranford Lane	509534	177449	Easterly comparison site
West End Lane *	508455	177383	
Boltons Lane	508014	177147	
Cheviot Close *	508728	177124	
Neptune Road *	508496	176869	North of Northern perim
LHR2	508382	176749	Close to perimeter fence
W/sock GA 9 *	508467	176363	Centre of north r/ways
C32	508210	176198	
CP11	508312	176048	
E40	508017	175736	In vicinity of Term. 2
E9	507920	175548	" "
F15	507767	175456	" "
GA26	507517	175268	
GA16	507571	175025	
Royal Suite	507239	174891	
CP17	506662	174508	
BA Waterside	505127	177559	Additional site

(*) Denotes a collocated NO_2 and BTEX tube location, from period 3 onwards

NO_2 monitoring commenced at the Cranford Lane site from Period 7. Hence, the survey-mean concentration is from only 6 periods. West End Lane site-mean is from 11 periods, due to theft in period 6. GA9 Wind Sock site-mean is from 11 periods, due to an unexplained 90-degree rotation of support block, during period 8. For LHR2, period 10 – one tube produced a null result.

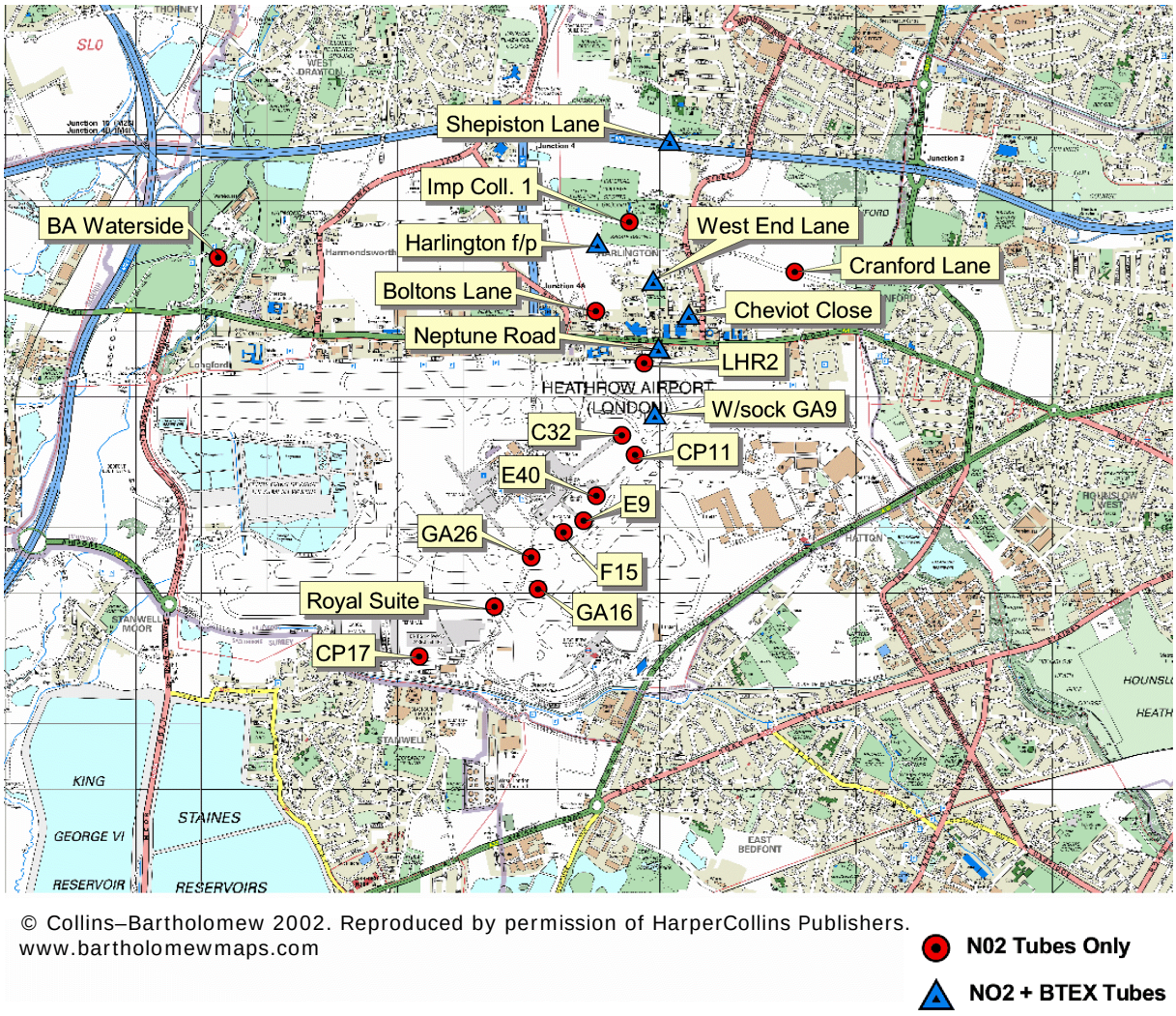


Figure 2: Geographic representation of NO_2 and collocated BTEX diffusion tube monitoring sites, used in the 2002/03 survey.

(It should be noted that the hand-held GPS, used to obtain the readings shown in Table 2, is reported as having a working accuracy of ±10 Metres. Therefore, the locations, as shown, are only indicative).

3 Results

In this Chapter, the basic results from the diffusion tubes are tabulated. These results are discussed in Chapter 4.

3.1 NO_2 DIFFUSION TUBE RESULTS

All individual monthly NO_2 diffusion tube results are given in Appendix 2. The mean, standard deviation and coefficient of variation (CoV) for each set of 3 tubes have been calculated. In addition, as explained in Section 2.1 and in line with standard guidance on the use of diffusion tubes, all measurement data have been scaled by the ratio of the co-located measurements at the LHR2 site. However, for this annual report, the NO_2 tube results have, again, been treated as per the appropriate Technical Guidance procedures[3]. These indicate that where 12 consecutive months of data are available, a, **bias-corrected**, 12-month mean factor should be derived; rather than, continuing to use the monthly factors, as used in the monthly results files. This bias-corrected 12-month mean factor has then been calculated and applied to the 12-month mean NO_2 tube results, from each site and the results are shown in Table 3 and Figure 3. The derivation of the bias-correction applied to the NO_2 tube data is explained in Section 3.2.

It should be noted that, the individual monthly results-tables in Appendix 2, each display a 'bias-corrected' final column. Such a calculation is not strictly applicable to monthly results (under the Technical Guidance instructions). However, it enables monthly histograms to be produced, from results derived by the application of a common factor, throughout the report. Such histograms are useful in reviewing both the monthly results and any overall trends across the 12 months of NO_2 sampling. These histograms are shown in Figure 4(a to l).

The bias-corrected 12-month mean NO_2 concentrations from the diffusion tubes exposed at each location, are shown in Table 3. Details of the applied statistical methods employed to scrutinise the data, are described in Section 3.2.

Table 3. 12-month mean, bias-corrected NO_2 diffusion tube results, in $\mu g\ m^{-3}$, from October 2002 to October 2003.

Site	NO_2 tube bias-corrected 12-month mean result ($\mu g\ m^{-3}$)
Shepiston Lane	56
Imp Coll.1	36
Cranford Lane	27
Harlington f/p	39
West End Lane	40
Boltons Lane	35
Cheviot Close	36
Neptune Rd	59
LHR2	57
W/sock GA9	50
C32	55
CP11	58
E40	67
E9	63
F15	52
GA26	48
GA16	45
Royal Suite	50
CP17	46
BA Waterside	33

A discussion of all the results is given in section 4.

For comparison, average NO_2 concentrations at a range of automatic air quality monitoring stations in London are given in Table 4 below.

Table 4. Mean NO_2 concentration at LHR2 & selected AURN sites for the period: October 2002 to October 2003.

Monitoring site:	Location:	12-month mean NO_2 concentration ($\mu g\ m^{-3}$) 21st Oct 02 to 20th Oct 03
Heathrow LHR2	North perimeter of Heathrow Airport	**57** (95.4% data capture)
London Hillingdon	A suburban site approximately 30m from the M4 in Hillingdon	**53** (82.6% data capture)
London N. Kensington	An Urban Background location	**44**(94.0% data capture)
London Marylebone Rd	Kerbside of Marylebone Road - a 6-lane urban highway	**106** (93.8% data capture)

3.2 DIFFUSION TUBES BIAS CORRECTION

A collocation study was carried out for the full period of diffusion tubes monitoring at the LHR2 automatic monitoring station. The data capture of the automatic station for each period is well above 75% with the majority of periods above 99%. The bias correction factor has been worked out following the Technical Guidance LAQM.TG(03) by which the average of the chemiluminescence results are compared to the average of the diffusion tubes results.

As can be seen from table 5, a bias correction adjustment factor of *0.55* has been calculated from the co-location study at LHR2 (12 months worth of data).

Table 5: Bias-correction calculations for collocation study at LHR2

Period	Tube1 ($\mu g\ m^{-3}$)	Tube2 ($\mu g\ m^{-3}$)	Tube3 ($\mu g\ m^{-3}$)	Mean ($\mu g\ m^{-3}$)	St Dev	CoV	Ref Conc ($\mu g\ m^{-3}$)	% Data Capture	Bias adjustment (A)	Bias adjustment (B)
1	135	112	137	128	14	11	57	99.6	-	-
2	102	99	127	109	15	14	56	99.6	-	-
3	114	107	121	114	7	6	56	94.2	-	-
4	108	101	107	105	4	4	59	96.8	-	-
5	98	120	101	106	12	11	67	99.0	-	-
6	95	101	99	98	3	3	66	77.2	-	-
7	112	121	120	118	5	4	50	85.8	-	-
8	94	86	91	90	4	4	48	99.9	-	-
9	85	88	91	88	3	3	50	99.4	-	-
10	-	90	91	91	1	1	55	96.0	-	-
11	88	95	92	92	4	4	59	99.3	-	-
12	96	85	102	94	9	9	61	99.6	-	-
Mean	-	-	-	102	-	-	57	-	0.55	80%

A: Bias-adjustment factor (Ref conc ÷ Mean diffusion tube result)
B: Diffusion tube bias ((Mean diffusion tube - Ref conc) ÷ Ref conc)%

Shepiston Lane diffusion tube site is not strictly collocated with London Hillingdon AURN Station. However, it is located at a similar distance from the M4. A similar exercise as shown in table 5 was carried out to identify a bias correction factor from this site. Table 6 shows that a bias adjustment factor of 0.54 was calculated from 9 months of monitoring data. This bias correction factor is similar to the one calculated for LHR2.

Table 6: Bias-correction calculations for collocation study at Shepiston Lane site near London *Hillingdon AURN station.*

Period	Tube1 ($\mu g\ m^{-3}$)	Tube2 ($\mu g\ m^{-3}$)	Tube3 ($\mu g\ m^{-3}$)	Mean ($\mu g\ m^{-3}$)	St Dev	CoV	Ref Conc ($\mu g\ m^{-3}$)	% Data Capture	Bias adjustment (A)	Bias adjustment (B)
1	113	119	95	109	12	11	53	99.3	-	-
2	99	116	114	110	9	8	48	99.4	-	-
3	92	95	95	94	2	2	47	92.3	-	-
4	96	104	96	99	5	5	48	99.1	-	-
5	86	113	85	95	16	17	65	99.0	-	-
6	95	94	92	94	2	2	58	98.4	-	-
7	114	124	112	117	6	6	61	74.4	-	-
8	118	103	122	114[1]	10	9	-	-	-	-
9	108	108	111	109[1]	2	2	56[1]	38.0	-	-
10	95	104	100	100	5	5	49	96.0	-	-
11	93	95	96	95	2	2	53	90.6	-	-
12	89	73	83	82	8	10	49	99.4	-	-
Mean	-	-	-	97	-	-	53	-	0.54	87%

A: Bias-adjustment factor (Ref conc ÷ Mean diffusion tube result)
B: Diffusion tube bias ((Mean diffusion tube - Ref conc) ÷ Ref conc)%
[1] Data omitted due to low data capture or non-existence of monitoring data

Harlington trailer started monitoring NO_X during period 5. The *Imp Coll 1* diffusion tube site is nearby. Due to initial low data capture at Harlington and the late start of the monitoring, it is inappropriate to use this dataset for any bias-correction. However, for information the data for these sites are presented in Table 7.

Table 7: Bias-correction calculations for co-location study at *Imp Coll 1* site near *Harlington trailer.*

Period	Tube1 ($\mu g\ m^{-3}$)	Tube2 ($\mu g\ m^{-3}$)	Tube3 ($\mu g\ m^{-3}$)	Mean ($\mu g\ m^{-3}$)	St Dev	CoV	Ref Conc ($\mu g\ m^{-3}$)	% Data Capture	Bias adjustment (A)	Bias adjustment (B)
1	80	88	79	82[1]	5	6	-	-	-	-
2	302	100	94	97[1]	4	4	-	-	-	-
3	40	43	39	41[1]	2	5	-	-	-	-
4	53	79	79	70[1]	15	21	-	-	-	-
5	73	76	83	77[1]	5	7	-	-	-	-
6	64	69	68	67[1]	3	4	52	46.8	-	-
7	59	60	59	59	1	1	35	99.7	-	-
8	54	54	53	54	1	1	30	97.9	-	-
9	58	51	57	55	4	7	32	81.4	-	-
10	60	58	62	60[1]	2	3	45	63.4	-	-
11	56	59	62	59	3	5	44	98.1	-	-
12	62	65	56	61	5	8	42	99.6	-	-
Mean	-	-	-	58	-	-	37	-	0.63	58%

A: Bias-adjustment factor (Ref conc ÷ Mean diffusion tube result)
B: Diffusion tube bias ((Mean diffusion tube - Ref conc) ÷ Ref conc)%
[1] Data omitted due to low data capture or non-existence of monitoring data

Where an individual tube result, from the triplicate set, is considered inconsistent, this is usually highlighted by a high Coefficient of Variance. In order to confirm a result as a possible outlier, a Dixon's Q test can be used. This test is generally used for detecting a small number of outliers, when the sample size is between 3 and 25 observations. This test has been applied to triplicate results with a CoV greater than 10%. After further scrutiny, 8 individual tube results were discounted from the triplicates shown in the monthly summary tables in Appendix 2. A confidence level of 90% accompanies the results of the Q test and the final table of 12-month NO_2 concentrations is displayed in Table 3.

3.3 NO_2 DIFFUSION TUBE RESULTS - PERIODS 1 TO 12

Figure 3 shows the bias-corrected 12-month mean NO_2 concentrations at each site. Figures 4a to 4l show the individual monthly bias-corrected results. (Please note that, strictly speaking, the Technical Guidance indicates that the bias-correction technique, is applicable only to annual or 12-month data-sets, rather than to individual months).

Land-side sites are shown in blue and air-side sites are shown in red, throughout.

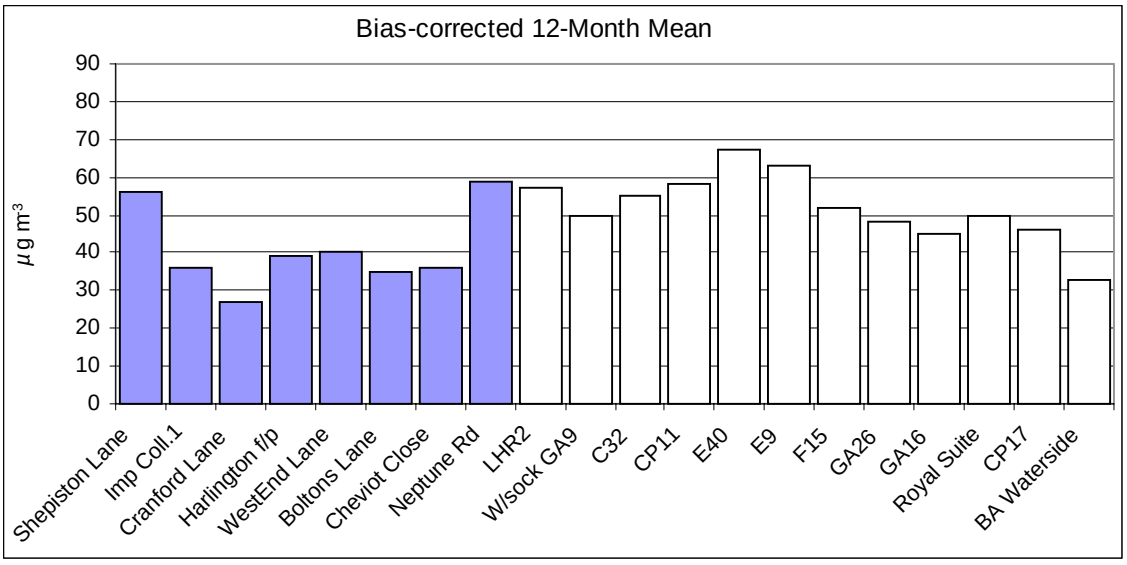
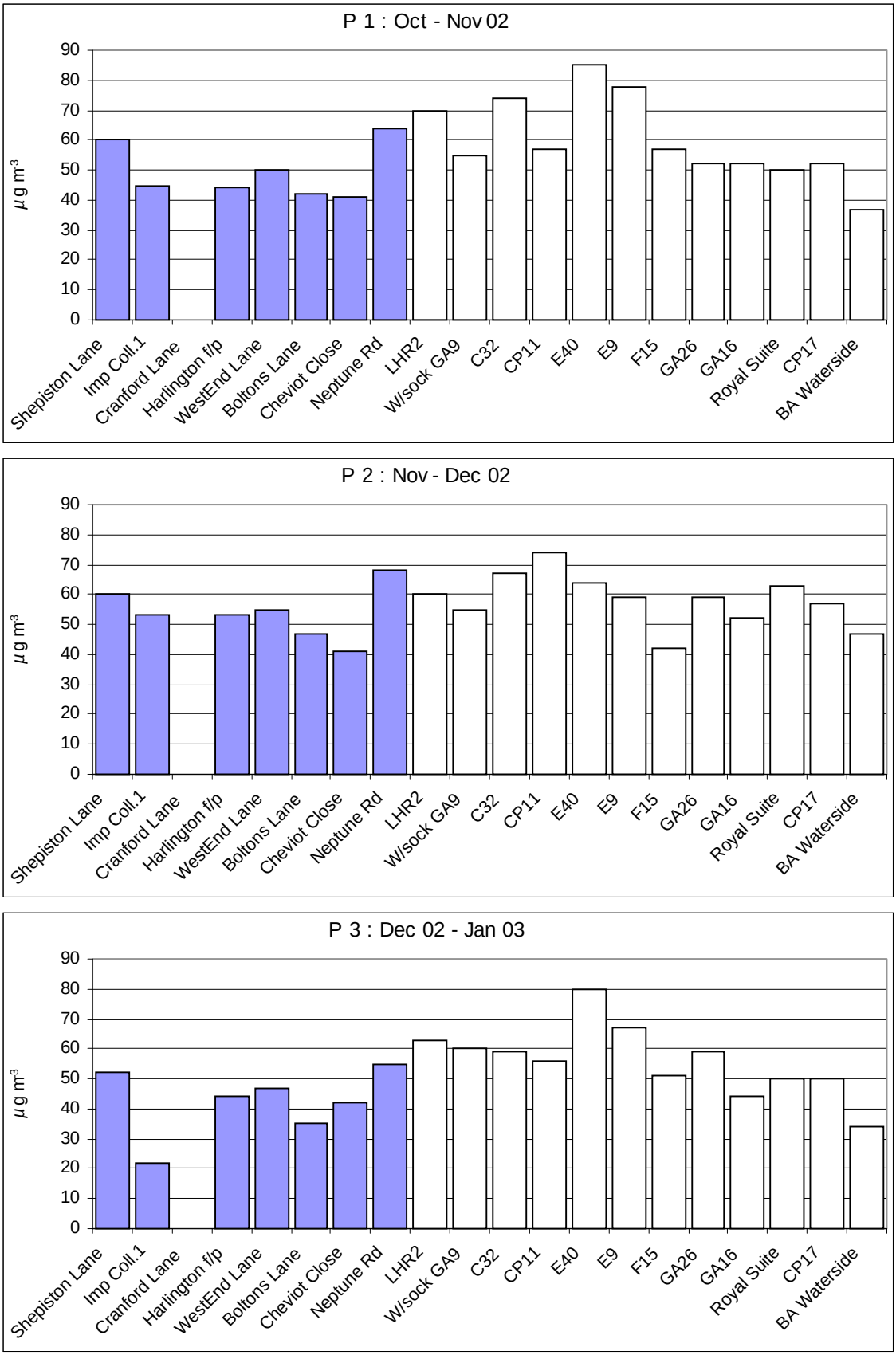
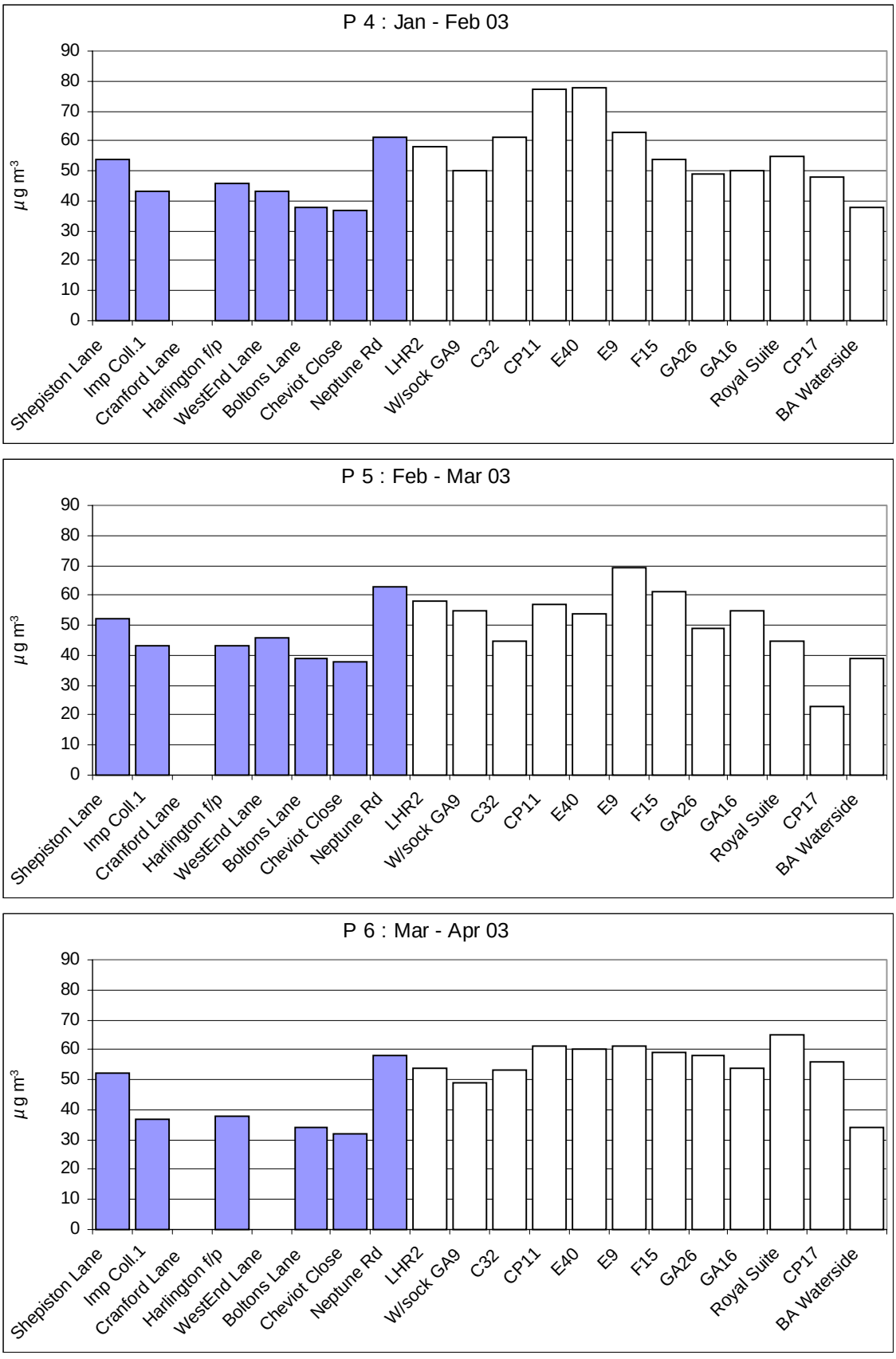


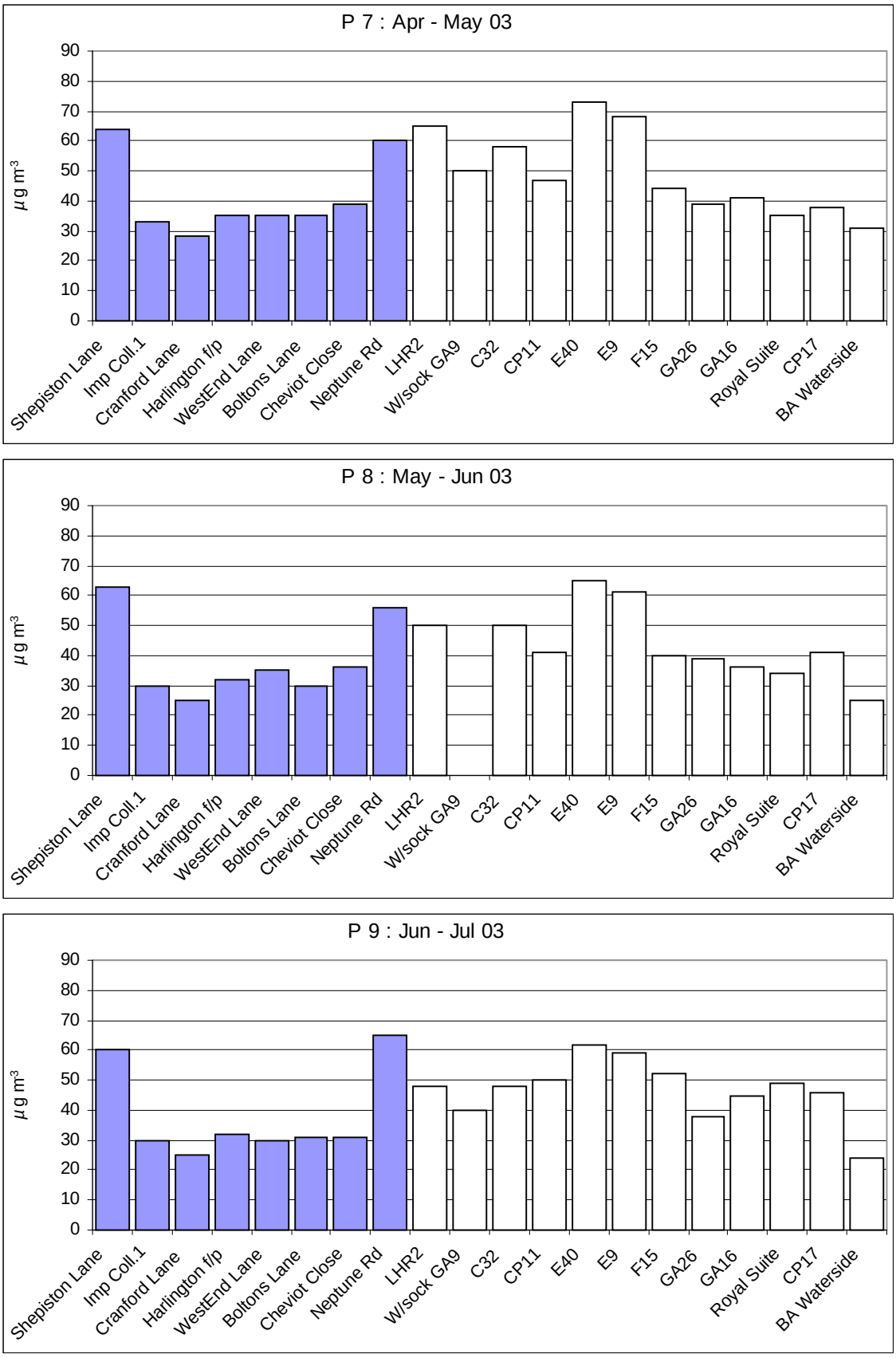
Figure 3: Bias-corrected 12-month mean NO_2 concentrations in $\mu g\ m^{-3}$, Oct.02 to Oct. 03



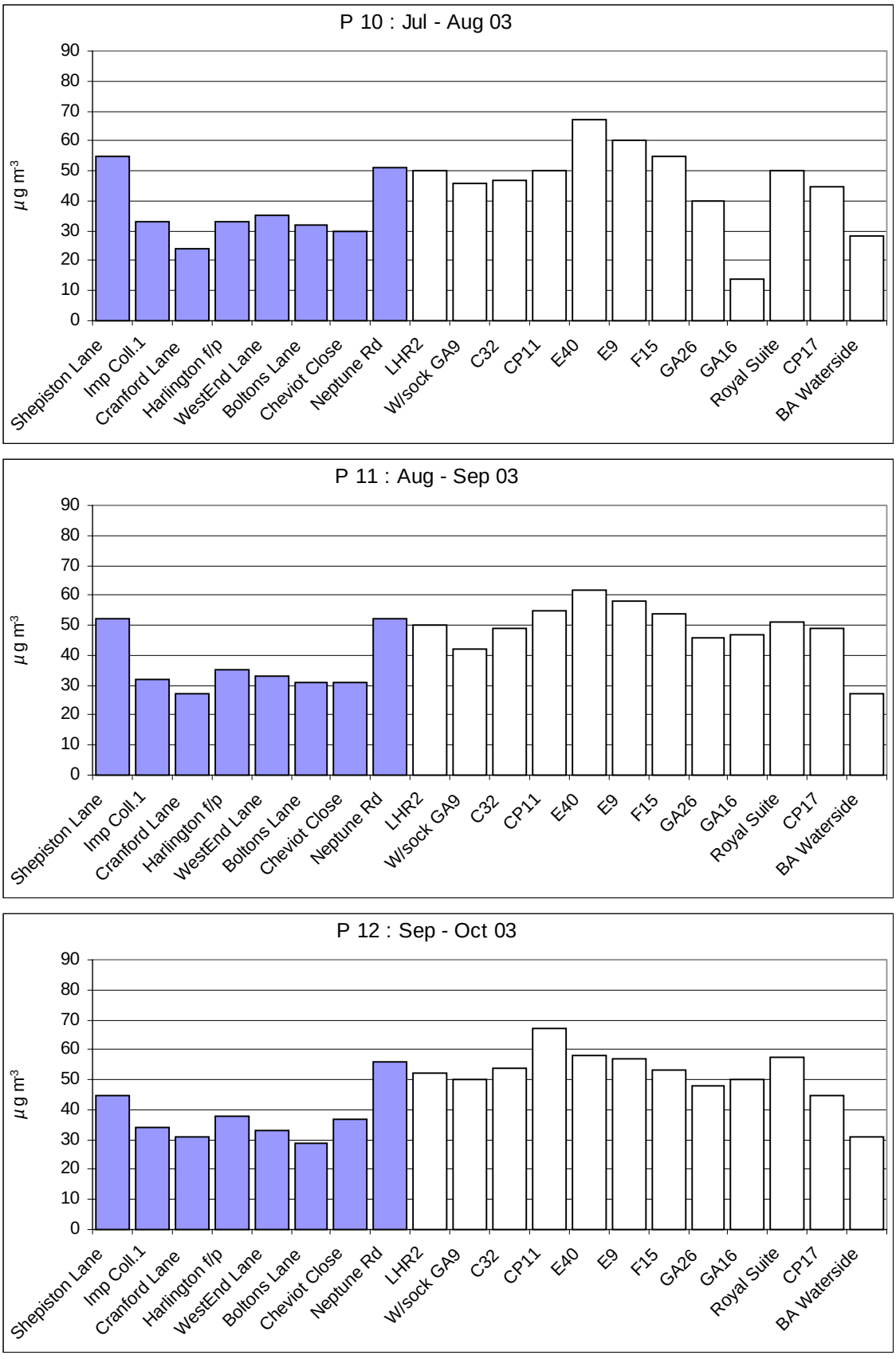
Figures 4a-c. Graphical representation of the bias-corrected mean NO_2 concentrations. for periods 1 to 3 – in $\mu g\ m^{-3}$.



Figures 4d-f. Graphical representation of the bias-corrected mean NO_2 concentrations .for periods 4 to 6 – in $\mu g\ m^{-3}$.



Figures 4g-i. Graphical representation of the bias-corrected mean NO_2 concentrations, for periods 7 to 9 – in $\mu g\ m^{-3}$.



Figures 4j-l. Graphical representation of the bias-corrected mean NO_2 concentrations for periods 10 to 12 – in $\mu g\ m^{-3}$.

3.4 BTEX DIFFUSION TUBE RESULTS

Of the hydrocarbon diffusion tube results presented, those for benzene, are of most significance, as this is covered by an Air Quality Objective. A running annual mean benzene concentration of 16.25 μg m^{-3} came into effect at the end of 2003 and an annual mean of 5 μg m^{-3} is to be achieved by 2010.

The annual mean BTEX diffusion tube results are shown in Table 8 and for comparison, the ratified mean benzene results (from the same period as the transect tube-monitoring) from the continuous hydrocarbon analysers at Harwell rural site and the London Marylebone Road site, are shown in Table 9.

Table 8: Heathrow Transect, 10-month mean hydrocarbon tube results.

HEATHROW TRANSECT AIR QUALITY MONITORING, BTEX tube mean results over the 10 months Hydrocarbon monitoring. (μg m^{-3})					
Location	Benzene	Toluene	Ethylebenzene	m,p-Xylene	o-Xylene
Shepiston Lane	1.3	6.0	1.4	3.8	1.4
Harlington f/p	0.7	2.9	0.9	1.8	0.7
West End Lane	0.8	4.0	1.6	3.1	1.3
Cheviot Close	0.9	4.2	1.0	2.4	0.9
Neptune Rd.	0.9	4.5	1.3	3.1	1.3
W/Sock GA9	0.7	4.1	0.7	1.8	0.7

Table 9: Ratified benzene data, from the Harwell and Marylebone Road continuous monitors, from 19/12/02 to 20/10/03 (midday to midday).

Location	Periods equivalent to NO_2 diffusion tube exposure.												
	1	2	3	4	5	6	7	8	9	10	11	12	Ave
Harwell	-	-	1.09	0.79	1.00	0.83	0.26	0.24	0.25	0.48	-	-	0.62
Marylebone Rd	-	-	3.48	3.76	4.32	2.96	3.81	3.14	2.28	2.35	3.26	2.82	3.22

The results from the hydrocarbon diffusion tube monitoring are discussed in Section 4.2, where the main emphasis is on the benzene.

4 Discussion

4.1 NO_2 RESULTS AND COMPARISONS WITH OTHER UK NO_2 CONTINUOUS MONITORING SITES

Figure 3 shows a histogram of the bias-corrected 12-month mean NO_2 diffusion tube concentrations from all locations. The results are shown from the north to the south of the transect. The site at the BA Waterside offices, is included for reference, but is some way off the transect-line, as is Cranford Lane. The results-tables for each exposure period, and the 12-month summary table are given in Appendix 2.

From Figure 3, it can be seen that sites E40 and E9 recorded the highest bias-corrected 12-month mean NO_2 results, with concentrations of 67 and 63 μg m^{-3}, respectively. Site CP11 was slightly lower, at 58 μg m^{-3}. These results confirm that the highest NO_2 levels were in the vicinity of Terminal 2 and its surrounds. It is also clearly evident that concentrations were generally higher on-airport (airside) compared to off-airport (land-side), confirming the results of the preliminary study. The exceptions are Shepiston Lane (close to the M4 motorway hard-shoulder) and also, the Neptune Road location. This site is in an area particularly influenced by motor vehicles, being located close to an access road, and midway between the northern perimeter Road and the main A4 road. These sites produced levels of 56 and 59 μg m^{-3}, respectively. The remaining land-side sites recorded mean levels in the region of 30 to 40 μg m^{-3}, with the lowest 12-month mean of 27 μg m^{-3}, recorded at the Cranford Lane site. Worthy of note, are the comparative results from Cranford Lane and The Harlington footpath sites. It might be expected that the relatively quite roadside location, would still produce a higher 12-month mean than the footpath location, which is not immediately influenced by traffic emissions, being located a few hundred metres from the nearest road. The histogram also shows that the location of the LHR2 continuous monitoring trailer may be influenced by vehicular emissions from the northern perimeter road. The map-extract in Figure 5, shows the bias-corrected 12-month mean NO_2 concentrations for each site. It should be noted that the centre of each bar depicts the GPS point allocated to each site.

Figure 3 also demonstrates that, apart from the two highest traffic-influenced locations at Shepiston Lane and Neptune Road, the majority of the more residential land-side locations recorded 12-month mean levels just below the annual mean Air Quality Objective value of 40 μg m^{-3}. This Objective is to be achieved by the end of 2005. By contrast, all the air-side locations in this survey, recorded 12-month means above the 40 μg m^{-3} Objective level.

The 12 histograms comprising Figure 4 (a to l), show the variation of $N0_2$ concentrations across each of the 12 ‘monthly’ periods. It should be noted that, although they show bias-corrected results, the Technical Guidance instructions normally advise the application of ‘bias-correction’ procedures to 12-month or annual data-sets only. However, as a way of assessing the variation across the 12 periods, consistent with the 12-month mean results, the bias-correction was applied.

From these individual ‘period’ histograms, it is evident that the highest mean NO_2 concentrations were generally observed during the winter and spring. During 7 of the periods, site E40 measured the highest air-side mean NO_2 concentrations. These were spread evenly throughout the 12 periods. On one occasion, the ‘Royal Suite’ site recorded

the highest period-mean of all the 20 sites. This occurred in period 6, when 65 μg m^{-3} was measured. During all periods, the highest land-side concentrations were observed at either the Shepiston Lane or Neptune Road sites. The latter was higher during periods 1 to 6, although, this trend was reversed, in three of the remaining periods. It is also evident that the general levels at these two sites were less variable, (at around $\pm$ 5 μg m^{-3}) from period to period, than the other land-side sites. The differential between these two sites and the other land-side sites is noticeably increased, during the warmer sampling periods. The majority of off-airport sites showed either lower concentrations than the on-airport sites, or concentrations similar to those of the southern transect sites.

In the majority of the 12 periods, the mean NO_2 concentration observed at GA9 Windsock, in the centre of the northern runways, was lower than at either of the sites immediately to the north or south of GA9 (LHR2 & C32, respectively). During periods 3,6,10 and 12, the GA9 concentrations were very similar to those of LHR2 and C32. Although site C32 was located on one of the Terminal 1 piers, it was quite distant from the central terminal area and, perhaps, this explains why concentrations at this site were generally between those of the perimeter sites and the other Terminal sites.

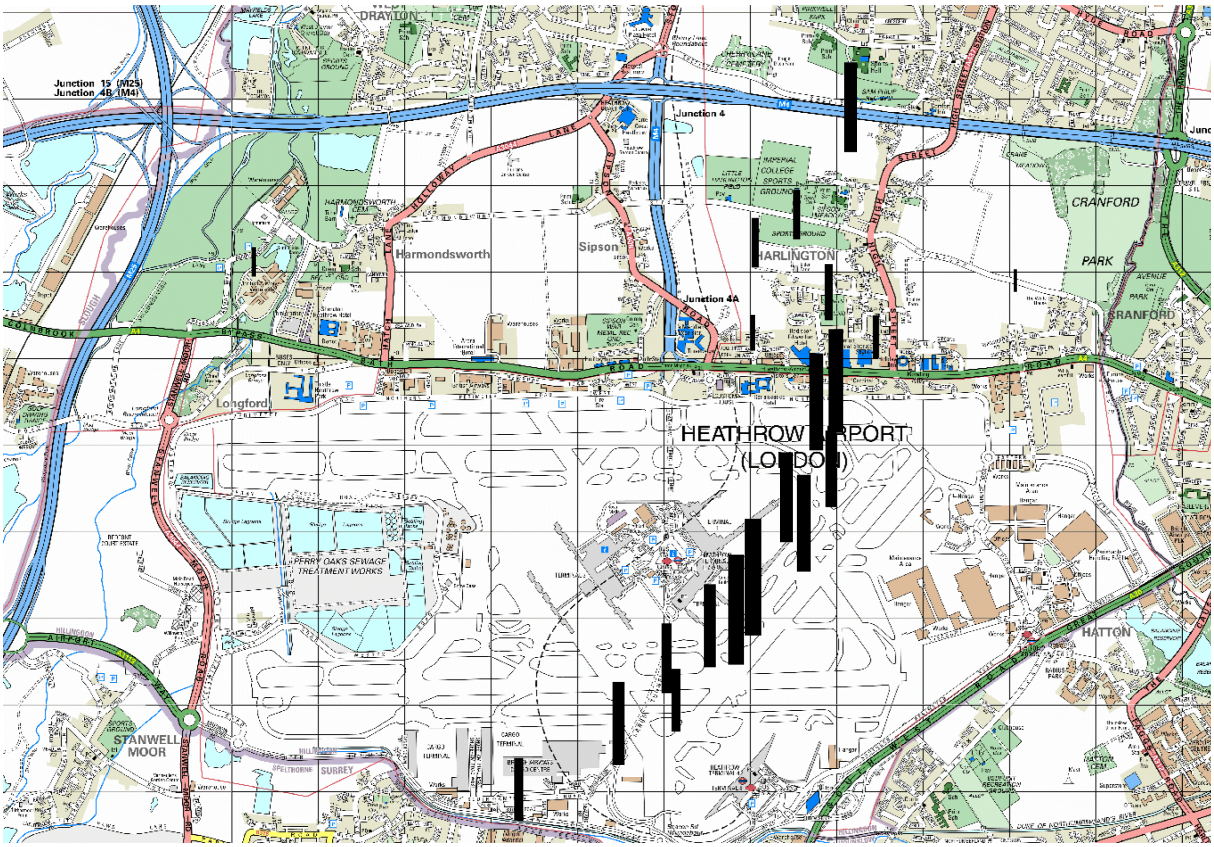


Figure 5. Geographic representation of NO_2 tube bias-corrected 12-month mean results (μg m^{-3}), from Oct. 02 to Oct. 03.

It should be noted that, on the map extract above, the centres of the concentration-indicator bars signifies the site-location point, as derived from the hand-held GPS. Also, that the NO_2 concentration is proportional to both the bar width, as well as height.

The results from the CP17 site, in the south of the airport, showed that, with the exception of the period 5 concentration of 23 μg m^{-3}, the mean NO_2 levels remained between approximately 45 and 55 μg m^{-3}, during the winter and early spring (p1 to p6). This then dropped to around 40 to 50 μg m^{-3} from late spring to the end of summer (p7 to p12). Although the CP17 location is some distance from the southern perimeter road, resulting traffic emissions may influence the measured NO_2 levels, along with vehicle-movements in the vicinity of the control post.

4.2 BENZENE RESULTS AND INTERCOMPARISONS WITH OTHER UK HYDROCARBON-MONITORING SITES

The results in Appendix 3 and Table 8 show that the site with both the highest monthly-mean and the highest overall mean benzene concentration, over the ten months of monitoring, was the Shepiston Lane location, close to the M4 hard-shoulder (2.0 and 1.3 μg m^{-3}, respectively). The annual average benzene concentrations are shown on the map plot in Figure 6.

The overall (10-month) mean is less than 10% of the Air Quality Objective to be achieved by 2003 and also well below that to be achieved by 2010. By comparison, the only airside BTEX tube sited at the GA9 Wind Sock (in the centre of the northern runways) produced a 10-month mean of only 0.7 μg m^{-3} – half that of Shepiston Lane.

Figure 6. Geographic representation of yearly mean benzene concentrations, at each BTEX tube location, for the period Oct. 02 to Oct.

The averages of the measured concentrations of benzene, over the 10-month monitoring period, presented in Table 8, are significantly less than the average concentrations observed at the Marylebone Road site, Table 9. The Marylebone Road site is a kerbside location in central London. Most of the benzene averages from the Heathrow Transect monitoring are close to those observed at the Harwell rural site.

Only at the Shepiston Lane location, is the reported average, significantly more than at the Harwell site.

The ratios of the concentrations of the measured hydrocarbons in Table 8, are typical of the ratios observed for data collected by the UK Hydrocarbon Network. The primary source of the measured hydrocarbons, at such network sites, is emissions from motor vehicles, both exhaust and evaporative emissions.

The measured concentrations and the ratios of these concentrations, are typical of those observed at urban background locations. It is therefore, likely that the major source of the measured hydrocarbons is emissions from motor vehicles.

Although a hydrocarbon tube is exposed on an approximate monthly basis at the LHR2 trailer, this is under a separate work program. As a result, the exposure periods do not coincide with those in this report. No strict comparison is, therefore, possible. However, periods of variable length have been combined into roughly 3-month values and are shown in Table 10.

Table 10. Approximately '3-month mean' values, in $\mu g\ m^{-3}$, from LHR2 BTEX tubes.

Period	Benzene	Toluene	Ethyl Benzene	m,p Xylene	o Xylene
24/09/02 – 19/12/02	2.2	7.8	1.8	5.0	1.7
19/12/02 – 31/03/03	2.0	4.9	1.0	2.5	0.8
31/03/03 – 25/06/03	0.5	2.5	0.7	1.6	0.6
18/07/03 – 05/09/03	0.8	3.4	0.8	2.1	0.7

The number of tubes which make up each period, varies between 1 and 3, the earlier two being three discrete tubes but the later two are only 1 tube per period. Again, these results are only indicative, in terms of comparing their levels with those obtained from the main survey-sites.

5 Conclusions

The 12 month extended study of pollutant concentrations at 20 sites forming a transect across Heathrow Airport and the residential areas to the north east, has been undertaken using triplicate NO_2 diffusion tube samplers. Single hydrocarbon diffusion tube samplers were also collocated at 6 of the 20 sites.

From the results presented in this report, the following conclusions can be drawn:

- The extended 12-month monitoring period confirms the general results of the preliminary study, showing that NO_2 concentrations are generally higher at on-airport (airside) sites, compared to off-airport (landside) sites.

- The highest monthly-mean bias-corrected NO_2 concentration was 85 μg m^{-3} measured at the E40 site in period 1. This site also had the highest 12-monthly average NO_2 concentration of 67 μg m^{-3}. These results confirm the findings of the preliminary study, that the highest air-side concentrations are observed in the vicinity of Terminal 2.

- Of the non-airside sites, Neptune Road NO_2 levels were slightly above those of Shepiston Lane in the majority of sampling periods.

- The GA9 Windsock location, in the centre of the two northern runways, produced a bias-corrected 12-month mean NO_2 concentration noticeably lower than the air-side sites immediately to the north or south (LHR2 &C32).

- The NO_2 results from the LHR2 trailer, may be influence by its proximity to the northern perimeter road.

- With the exception of Shepiston Lane and Neptune Road, the land-side 12-month mean NO_2 levels are below but approaching the Air Quality Objective of 40 μg m^{-3} (measured as an annual mean).

- All the air-side 12-month mean NO_2 levels are above the Air Quality Objective level of 40 μg m^{-3} (measured as an annual mean).

- The highest benzene levels were measured at the Shepiston Lane site. Generally, the individual period mean and 10-month mean benzene levels from the GA9 Windsock appear similar to those from the non-airside locations (excluding Shepiston Lane).

- From the results of the benzene monitoring, concentrations from all sites are well below the current benzene Air Quality Objective level of 16.25 μg m^{-3}, (measured as a running mean) which was to be achieved by the end of 2003 as part of the National Air Quality Strategy. Levels are also well below the 5 μg m^{-3} annual average to be achieved by 2010.

- The measured concentrations of the reported hydrocarbon species, including benzene, and the ratios of these concentrations, are typical of those observed at urban background locations. It is therefore, likely that the major source of the measured hydrocarbons is emissions from motor vehicles.

6 References

1. The Air Quality Strategy for England, Scotland, Wales and northern Ireland. January 2000. ISDN 0-100-145482 + Addendum 2003, Ref. PB7874.
2. Investigation of Air Pollution from Transport Operations at Heathrow Airport. October 2002. Report Reference. AEAT/ENV/R/1237 Issue 1
3. Technical Guidance document LAQM TG(03). Product Code PB7514 ISBN code 0-85521-021-4.

Appendices

CONTENTS

Appendix 1
NO_2 Diffusion Tubes

NO_2 Diffusion Tube Samplers

Passive sampling involves the collection of air pollutants using an absorbing material without the use of pumps; hence, no power supply is required. This makes these samplers very easy to deploy and flexible in terms of siting.

A passive sampler for gaseous species is defined as a device which is capable of sampling gas or vapour pollutants from the atmosphere, at a rate controlled by a physical process such as diffusion through a static layer or permeation through a membrane, but which does not involve the active movement of air through the sampler

Samplers are available for a wide range of pollutant species. The NO_2, SO_2, NH_3 and O_3 diffusion tubes supplied by AEA Technology are based on the work of Palmes, and consist of a cylindrical plastic tube, approximately 71 mm long and 11 mm in diameter. During sampling, one end is open and the other end holds an absorbent for the gaseous species to be monitored.

The basic principle on which diffusion tube samplers operate is that of molecular diffusion, with molecules of a gas diffusing from a region of high concentration (open end of the sampler) to a region of low concentration (absorber end of the sampler). The movement of molecules of gas (1) through gas (2) is governed by Fick's law, which states that the flux is proportional to the concentration gradient:

$$J = -D_{12}\frac{dc}{dz} \qquad (1)$$

Where:

J = the flux of gas (1) through gas (2) across unit area in the Z direction ($\mu g/m^2/s$)
c = the concentration of gas (1) in gas (2) ($\mu g\ m^{-3}$)
z = the length of the diffusion path (m)
D_{12} = the molecular diffusion coefficient of gas (1) in gas (2) (m^2/s)

For a cylinder of cross-sectional area **a** (m^2) and length **l** (m), then **Q** (μg) the quantity of gas transferred along the tube in **t** seconds (taken as the quantity of gas absorbed during **t**) is given by

$$Q = \frac{D_{12}(C_1 - C_o)at}{l} \qquad (2)$$

Where C_o and C_1 are the gas concentrations at either end of the tube.

In a diffusion tube, the concentration of gas (1) is maintained at zero by an efficient absorber at one end of the tube (i.e. C_o = zero) and the concentration C_1 is the average concentration of the gas (1) at the open end of the tube over the period of exposure.

Hence:

$$C = \frac{Ql}{D_{12}at} \qquad (3)$$

The diffusion coefficient for the gas to be monitored must be determined, or obtained from the literature. A best estimate of the area and length of a typical tube must be determined by measurement using Vernier callipers. Nominal tube dimensions are set at 11mm (diameter) and 71mm (length). The gas concentration C, can be readily derived from the quantity of gas absorbed Q, (assessed by desorption & chemical analysis of the tube), and the exposure time t.

Appendix 2
NO_2 Diffusion Tube Individual Results

HEATHROW TRANSECT AIR QUALITY MONITORING, 21 OCT - 20 NOV 2002.(Period 1)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	113	119	95	109	12.5	11.5%	60
Imp Coll.1	80	88	79	82	4.9	6.0%	45
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	83	79	77	80	3.1	3.8%	44
WestEnd Lane	93	95	86	91	4.7	5.2%	50
Boltons Lane	79	72	77	76	3.6	4.7%	42
Cheviot Close	78	74	70	74	4.0	5.4%	41
Neptune Rd	114	120	113	116	3.8	3.3%	64
LHR2	135	112	137	128	13.9	10.9%	70
W/sock GA9	105	92	103	100	7.0	7.0%	55
C32	134	134	137	135	1.7	1.3%	74
CP11	101	99	109	103	5.3	5.1%	57
E40	154	176	136	155	20.0	12.9%	85
E9	142	149	135	142	7.0	4.9%	78
F15	98	106	107	104	4.9	4.7%	57
GA26	88	97	96	94	4.9	5.2%	52
GA16	84	103	97	95	9.7	10.2%	52
Royal Suite	93	93	87	91	3.5	3.8%	50
CP17	92	99	93	95	3.8	4.0%	52
BA Waterside	59	70	71	67	6.7	9.4%	37

HEATHROW TRANSECT AIR QUALITY MONITORING, 20th NOV - 19th DEC 2002.(Period 2)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	99	116	114	110	9.3	8.5%	60
Imp.Coll. 1*	-	100	94	97	4.2	4.4%	53
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	102	96	89	96	6.5	6.8%	53
West End Lane	98	102	100	100	2.0	2.0%	55
Boltons Lane	87	86	84	86	1.5	1.8%	47
Cheviot Close	79	79	67	75	6.9	9.2%	41
Neptune Rd.	123	131	117	124	7.0	5.7%	68
LHR2	102	99	127	109	15.4	14.1%	60
W/sock GA9	84	117	101	101	16.5	16.4%	55
C32	124	113	130	122	8.6	7.0%	67
CP11	137	145	119	134	13.3	10.0%	74
E40	119	119	111	116	4.6	4.0%	64
E9	115	110	96	107	9.8	9.2%	59
F15	105	10	112	76	57.0	75.3%	42
GA26	101	119	100	107	10.7	10.0%	59
GA16	95	89	102	95	6.5	6.8%	52
Royal Suite	135	114	94	114	20.5	17.9%	63
CP17	90	112	111	104	12.4	11.9%	57
BA Waterside	84	88	86	86	2.0	2.3%	47

* Mean produced from two valid tubes, after application of the Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th DEC. - 20th JAN. 2003.(Period 3)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	92	95	95	94	1.7	1.8%	52
Imp.Coll. 1	40	43	39	41	2.1	5.1%	22
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	77	78	86	80	4.9	6.1%	44
West End Lane	87	86	83	85	2.1	2.4%	47
Boltons Lane	58	72	61	64	7.4	11.6%	35
Cheviot Close	76	75	79	77	2.1	2.7%	42
Neptune Rd.	90	98	113	100	11.7	11.6%	55
LHR2	114	107	121	114	7.0	6.1%	63
W/sock GA9	117	107	101	108	8.1	7.5%	60
C32	115	120	89	108	16.6	15.4%	59
CP11	93	111	99	101	9.2	9.1%	56
E40	145	163	129	146	17.0	11.7%	80
E9	123	126	119	123	3.5	2.9%	67
F15	95	85	96	92	6.1	6.6%	51
GA26	101	119	100	107	10.7	10.0%	59
GA16	83	65	91	80	13.3	16.7%	44
Royal Suite	89	95	90	91	3.2	3.5%	50
CP17	85	97	88	90	6.2	6.9%	50
BA Waterside	68	59	60	62	4.9	7.9%	34

HEATHROW TRANSECT AIR QUALITY MONITORING, 20th. JAN. - 19 th. FEB. 2003.(Period 4)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	96	104	96	99	4.6	4.7%	54
Imp.Coll. 1*	-	79	79	79	0.0	0.0%	43
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	77	93	82	84	8.2	9.7%	46
West End Lane	80	79	78	79	1.0	1.3%	43
Boltons Lane	66	71	68	68	2.5	3.7%	38
Cheviot Close	66	68	69	68	1.5	2.3%	37
Neptune Rd.	118	111	103	111	7.5	6.8%	61
LHR2	108	101	107	105	3.8	3.6%	58
W/sock GA9	104	91	75	90	14.5	16.1%	50
C32	99	120	115	111	11.0	9.9%	61
CP11	157	149	113	140	23.4	16.8%	77
E40	143	161	124	143	18.5	13.0%	78
E9	107	119	120	115	7.2	6.3%	63
F15	96	96	101	98	2.9	3.0%	54
GA26	86	94	88	89	4.2	4.7%	49
GA16	90	91	94	92	2.1	2.3%	50
Royal Suite	106	114	80	100	17.8	17.8%	55
CP17	80	94	90	88	7.2	8.2%	48
BA Waterside	63	70	74	69	5.6	8.1%	38

* Mean produced from two valid tubes, after application of the Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th. Feb. - 20 th. Mar. 2003.(Period 5)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	86	113	85	95	15.9	16.8%	52
Imp.Coll. 1	73	76	83	77	5.1	6.6%	43
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	78	70	85	78	7.5	9.7%	43
West End Lane	75	86	88	83	7.0	8.4%	46
Boltons Lane*	69	70	-	70	0.7	1.0%	39
Cheviot Close	66	78	63	69	7.9	11.5%	38
Neptune Rd.	115	124	106	115	9.0	7.8%	63
LHR2	98	120	101	106	11.9	11.2%	58
W/sock GA9	127	96	79	101	24.3	24.2%	55
C32	106	80	59	82	23.5	28.8%	45
CP11*	102	-	103	103	0.7	0.7%	57
E40	124	117	55	99	38.0	38.5%	54
E9	121	137	119	126	9.9	7.9%	69
F15	112	112	108	111	2.3	2.1%	61
GA26	89	83	96	89	6.5	7.3%	49
GA16	83	106	110	100	14.6	14.6%	55
Royal Suite	78	86	84	83	4.2	5.0%	45
CP17	41	47	38	42	4.6	10.9%	23
BA Waterside	83	71	58	71	12.5	17.7%	39

* Mean produced from two valid tubes, after application of the Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, 20th Mar. - 22nd Apr. 2003.(Period 6)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	95	94	92	94	1.5	1.6%	52
Imp.Coll. 1	64	69	68	67	2.6	3.9%	37
Cranford Lane	-	-	-	-	-	-	-
Harlington f/p	64	68	73	68	4.5	6.6%	38
West End Lane	-	-	-	-	-	-	-
Boltons Lane	61	64	63	63	1.5	2.4%	34
Cheviot Close	57	58	61	59	2.1	3.5%	32
Neptune Rd.	110	108	99	106	5.9	5.5%	58
LHR2	95	101	99	98	3.1	3.1%	54
W/sock GA9	93	89	83	88	5.0	5.7%	49
C32	97	103	90	97	6.5	6.7%	53
CP11	114	118	102	111	8.3	7.5%	61
E40	114	107	107	109	4.0	3.7%	60
E9	104	118	110	111	7.0	6.3%	61
F15	103	112	108	108	4.5	4.2%	59
GA26	104	115	95	105	10.0	9.6%	58
GA16	88	108	99	98	10.0	10.2%	54
Royal Suite	116	115	126	119	6.1	5.1%	65
CP17	104	102	98	101	3.1	3.0%	56
BA Waterside	66	57	62	62	4.5	7.3%	34

HEATHROW TRANSECT AIR QUALITY MONITORING, 22nd Apr. - 21nd May. 2003.(Period 7)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	114	124	112	117	6.4	5.5%	64
Imp.Coll. 1	59	60	59	59	0.6	1.0%	33
Cranford Lane	56	48	51	52	4.0	7.8%	28
Harlington f/p	59	76	57	64	10.4	16.3%	35
West End Lane	67	70	55	64	7.9	12.4%	35
Boltons Lane	64	62	65	64	1.5	2.4%	35
Cheviot Close	70	76	65	70	5.5	7.8%	39
Neptune Rd.	115	118	95	109	12.5	11.4%	60
LHR2	112	121	120	118	4.9	4.2%	65
W/sock GA9*	92	-	90	91	1.4	1.6%	50
C32	112	107	100	106	6.0	5.7%	58
CP11	84	84	86	85	1.2	1.4%	47
E40	122	167	111	133	29.7	22.3%	73
E9	126	128	117	124	5.9	4.7%	68
F15	83	79	78	80	2.6	3.3%	44
GA26	74	72	66	71	4.2	5.9%	39
GA16	69	82	73	75	6.7	8.9%	41
Royal Suite	64	72	55	64	8.5	13.4%	35
CP17	69	72	64	68	4.0	5.9%	38
BA Waterside	65	49	55	56	8.1	14.3%	31

* Mean produced from two valid tubes, after application of the Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, 21st May. - 19th June. 2003.(Period 8)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	118	103	122	114	10.0	8.8%	63
Imp.Coll. 1	54	54	53	54	0.6	1.1%	30
Cranford Lane	47	45	46	46	1.0	2.2%	25
Harlington f/p	59	61	53	58	4.2	7.2%	32
West End Lane	61	70	59	63	5.9	9.3%	35
Boltons Lane	54	53	58	55	2.6	4.8%	30
Cheviot Close	63	70	65	66	3.6	5.5%	36
Neptune Rd.	105	108	91	101	9.1	9.0%	56
LHR2	94	86	91	90	4.0	4.5%	50
W/sock GA9†	40	34	34	-	-	-	-
C32	89	92	91	91	1.5	1.7%	50
CP11	81	81	64	75	9.8	13.0%	41
E40	105	148	101	118	26.1	22.1%	65
E9	100	111	120	110	10.0	9.1%	61
F15	77	77	66	73	6.4	8.7%	40
GA26	86	66	63	72	12.5	17.4%	39
GA16	62	68	68	66	3.5	5.2%	36
Royal Suite	65	69	54	63	7.8	12.4%	34
CP17	73	74	76	74	1.5	2.1%	41
BA Waterside	47	46	43	45	2.1	4.6%	25

† Results have not been used from these tubes, as support block found to have rotated by 90° during exposure

HEATHROW TRANSECT AIR QUALITY MONITORING, 19th June - 21st July 2003.(Period 9)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	108	108	111	109	1.7	1.6%	60
Imp.Coll. 1	58	51	57	55	3.8	6.8%	30
Cranford Lane	41	49	47	46	4.2	9.1%	25
Harlington f/p	53	61	61	58	4.6	7.9%	32
West End Lane	59	54	51	55	4.0	7.4%	30
Boltons Lane	54	57	57	56	1.7	3.1%	31
Cheviot Close	53	59	57	56	3.1	5.4%	31
Neptune Rd.	91	99	162	117	38.9	33.1%	65
LHR2	85	88	91	88	3.0	3.4%	48
W/sock GA9	75	71	71	72	2.3	3.2%	40
C32	91	92	78	87	7.8	9.0%	48
CP11	88	100	86	91	7.6	8.3%	50
E40	114	124	101	113	11.5	10.2%	62
E9	108	111	101	107	5.1	4.8%	59
F15	94	95	94	94	0.6	0.6%	52
GA26	74	67	66	69	4.4	6.3%	38
GA16	74	88	85	82	7.4	9.0%	45
Royal Suite	92	103	72	89	15.7	17.7%	49
CP17	83	85	85	84	1.2	1.4%	46
BA Waterside	49	44	40	44	4.5	10.2%	24

HEATHROW TRANSECT AIR QUALITY MONITORING, 21st July - 20th Aug. 2003.(Period 10)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	95	104	100	100	4.5	4.5%	55
Imp.Coll. 1	60	58	62	60	2.0	3.3%	33
Cranford Lane	46	44	43	44	1.5	3.4%	24
Harlington f/p	56	61	64	60	4.0	6.7%	33
West End Lane	62	66	63	64	2.1	3.3%	35
Boltons Lane	56	58	59	58	1.5	2.6%	32
Cheviot Close	40	59	63	54	12.3	22.8%	30
Neptune Rd.	108	87	83	93	13.4	14.5%	51
LHR2*	-	90	91	91	0.7	0.8%	50
W/sock GA9	89	87	75	84	7.6	9.1%	46
C32	70	89	95	85	13.1	15.4%	47
CP11	85	106	83	91	12.7	14.0%	50
E40	98	157	111	122	31.0	25.4%	67
E9	107	115	107	110	4.6	4.2%	60
F15	102	97	102	100	2.9	2.9%	55
GA26	62	74	81	72	9.6	13.3%	40
GA16*	-	26	24	25	1.4	5.7%	14
Royal Suite	92	98	82	91	8.1	8.9%	50
CP17	78	85	84	82	3.8	4.6%	45
BA Waterside*	-	51	50	51	0.7	1.4%	28

* Mean produced from two valid tubes, after application of the Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, 20th Aug - 18th Sept. 2003.(Period 11)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	93	95	96	95	1.5	1.6%	52
Imp.Coll. 1	56	59	62	59	3.0	5.1%	32
Cranford Lane	51	49	49	50	1.2	2.3%	27
Harlington f/p	62	64	64	63	1.2	1.8%	35
West End Lane	56	63	60	60	3.5	5.9%	33
Boltons Lane	54	59	56	56	2.5	4.5%	31
Cheviot Close	57	56	54	56	1.5	2.7%	31
Neptune Rd.	102	99	85	95	9.1	9.5%	52
LHR2	88	95	92	92	3.5	3.8%	50
W/sock GA9	81	74	72	76	4.7	6.2%	42
C32	93	91	81	88	6.4	7.3%	49
CP11	97	110	93	100	8.9	8.9%	55
E40	113	124	102	113	11.0	9.7%	62
E9	102	107	109	106	3.6	3.4%	58
F15	103	99	95	99	4.0	4.0%	54
GA26	79	89	83	84	5.0	6.0%	46
GA16	84	84	88	85	2.3	2.7%	47
Royal Suite	94	93	91	93	1.5	1.6%	51
CP17	87	89	89	88	1.2	1.3%	49
BA Waterside	53	50	43	49	5.1	10.5%	27

HEATHROW TRANSECT AIR QUALITY MONITORING, 18th Sept. - 20th Oct. 2003.(Period 12)							
Location	NO_2 TUBE 1 ($\mu g\ m^{-3}$)	NO_2 TUBE 2 ($\mu g\ m^{-3}$)	NO_2 TUBE 3 ($\mu g\ m^{-3}$)	Mean of all valid tubes	Standard deviation	Coefficient of variation (%)	Bias-corrected monthly mean
Shepiston Lane	89	73	83	82	8.1	9.9%	45
Imp.Coll. 1	62	65	56	61	4.6	7.5%	34
Cranford Lane	52	61	56	56	4.5	8.0%	31
Harlington f/p	64	74	68	69	5.0	7.3%	38
West End Lane	59	61	62	61	1.5	2.5%	33
Boltons Lane	55	53	48	52	3.6	6.9%	29
Cheviot Close	65	70	68	68	2.5	3.7%	37
Neptune Rd.	108	104	94	102	7.2	7.1%	56
LHR2	96	85	102	94	8.6	9.2%	52
W/sock GA9	98	91	85	91	6.5	7.1%	50
C32	107	94	96	99	7.0	7.1%	54
CP11	114	114	135	121	12.1	10.0%	67
E40*	106	-	104	105	1.4	1.3%	58
E9	89	110	114	104	13.4	12.9%	57
F15	102	89	97	96	6.6	6.8%	53
GA26	91	89	83	88	4.2	4.7%	48
GA16	85	94	91	90	4.6	5.1%	50
Royal Suite*	-	106	104	105	1.4	1.3%	58
CP17	85	79	80	81	3.2	4.0%	45
BA Waterside	55	61	52	56	4.6	8.2%	31

* Mean produced from two valid tubes, after application of Q test.

HEATHROW TRANSECT AIR QUALITY MONITORING, NO_2 tube bias-corrected mean results ($\mu g\ m^{-3}$)													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Bias-corrected 12-month mean
Shepiston Lane	60	60	52	54	52	52	64	63	60	55	52	45	56
Imp Coll.1	45	53	22	43	43	37	33	30	30	33	32	34	36
Cranford Lane	-	-	-	-	-	-	28	25	25	24	27	31	27
Harlington f/p	44	53	44	46	43	38	35	32	32	33	35	38	39
West End Lane	50	55	47	43	46	-	35	35	30	35	33	33	40
Boltons Lane	42	47	35	38	39	34	35	30	31	32	31	29	35
Cheviot Close	41	41	42	37	38	32	39	36	31	30	31	37	36
Neptune Rd	64	68	55	61	63	58	60	56	65	51	52	56	59
LHR2	70	60	63	58	58	54	65	50	48	50	50	52	57
W/sock GA9	55	55	60	50	55	49	50	-	40	46	42	50	50
C32	74	67	59	61	45	53	58	50	48	47	49	54	55
CP11	57	74	56	77	57	61	47	41	50	50	55	67	58
E40	85	64	80	78	54	60	73	65	62	67	62	58	67
E9	78	59	67	63	69	61	68	61	59	60	58	57	63
F15	57	42	51	54	61	59	44	40	52	55	54	53	52
GA26	52	59	59	49	49	58	39	39	38	40	46	48	48
GA16	52	52	44	50	55	54	41	36	45	14	47	50	45
Royal Suite	50	63	50	55	45	65	35	34	49	50	51	58	50
CP17	52	57	50	48	23	56	38	41	46	45	49	45	46
BA Waterside	37	47	34	38	39	34	31	25	24	28	27	31	33

Mean Ratified Chemiluminescent NO_2 concentrations(for equivalent periods) from LHR2 and selected AURN sites - in $\mu g\ m^{-3}$.													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
LHR2	57	56	56	59	67	66	50	48	50	55	59	61	57
Hillingdon	53	48	47	48	65	58	61	-	56	49	53	49	53
Bloomsbury Pk	-	-	-	-	-	66	48	39	50	55	60	64	55
Marylebone Rd	99	84	80	93	113	93	124	125	103	102	113	106	103

Hillingdon P8 and Bloomsbury P1 to P5 are NULLED data, in the Ratified data set.
Also, the P12 values for the three AURN sites are from, as yet, unratified data sets.

Appendix 3 Hydrocarbon Diffusion Tube Individual Results

HEATHROW TRANSECT AIR QUALITY MONITORING, Benzene in $\mu g\ m^{-3}$													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
Shepiston Lane	-	-	1.6	1.6	2	1.5	1.2	1.2	0.8	1	0.62	1.5	1.3
Harlington f/p	-	-	0.7	1	1.4	0.9	0.2	0.6	0.1	0.3	1.23	0.7	0.7
West End lane	-	-	0.5	1.3	0.4	-	0.6	0.8	0.4	0.6	1.4	0.9	0.8
Cheviot Close	-	-	0.5	1.4	1.3	1	0.5	0.9	0.4	0.5	1.2	1.1	0.9
Neptune Rd.	-	-	0.5	1.2	1.7	1.2	0.7	0.9	0.5	0.5	1.1	1.1	0.9
W/sock GA9	-	-	0.4	0.9	1.1	1	0.3	0.7	0.4	0.5	1.3	0.8	0.7

HEATHROW TRANSECT AIR QUALITY MONITORING, Toluene in $\mu g\ m^{-3}$													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
Shepiston Lane	-	-	7.3	6.1	8.6	6.9	5.7	1	5.7	5.4	5.7	7.7	6.0
Harlington f/p	-	-	3.1	3.1	5.1	4.2	1.4	1.2	1.5	2.2	4.2	3.4	2.9
West End Lane	-	-	3.3	5	5.5	-	2.3	1.4	3.6	3.7	6.9	4.2	4.0
Cheviot Close	-	-	2.8	5.7	7	5.4	2	1.1	3.3	2.7	5	6.5	4.2
Neptune Rd.	-	-	3.8	4.2	7.4	5.7	3.1	1.6	4.2	3.1	6.5	5.7	4.5
W/Sock GA9	-	-	2	3.2	9	5.4	1.4	0.5	8.4	2.2	4.6	3.8	4.1

HEATHROW TRANSECT AIR QUALITY MONITORING, Ethylebenzene in $\mu g\ m^{-3}$													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
Shepiston Lane	-	-	1.5	1.4	1.7	1.5	1.3	1.2	1.5	1.4	1.1	1.5	1.4
Harlington f/p	-	-	0.7	0.7	1	1	0.4	1.4	0.4	1.8	1.1	0.7	0.9
West End lane	-	-	5.3	1.3	0.8	-	0.7	1.6	0.9	1	1.6	0.8	1.6
Cheviot Close	-	-	0.7	1.2	1.3	1.1	0.6	1.3	0.7	0.7	1.1	1.3	1.0
Neptune Rd.	-	-	0.8	1	2.1	1.3	0.8	1.9	1.2	1	1.5	1.1	1.3
W/sock GA9	-	-	0.5	0.7	1.1	1	0.4	0.6	0.7	0.6	1.1	0.7	0.7

HEATHROW TRANSECT AIR QUALITY MONITORING, m,p-Xylene in $\mu g\ m^{-3}$													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
Shepiston Lane	-	-	4.4	3.7	4.9	4.2	3.5	1	4.1	3.3	3.8	4.8	3.8
Harlington f/p	-	-	1.9	1.8	2.8	2.4	0.8	1.3	1.1	1.3	2.3	2	1.8
West End Lane	-	-	7.5	3.2	3.6	-	1.4	1.4	2.2	2.3	4.1	2.6	3.1
Cheviot Close	-	-	1.7	3.1	3.7	2.9	1.1	1.2	1.5	1.6	2.7	4	2.4
Neptune Rd.	-	-	2.7	2.5	5.4	3.3	2	1.7	3.6	2.3	3.8	3.2	3.1
W/Sock GA9	-	-	1.2	1.9	3.3	2.6	0.8	0.6	1.6	1.3	2.3	2.2	1.8

HEATHROW TRANSECT AIR QUALITY MONITORING, o-Xylene in $\mu g\ m^{-3}$													
Location	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Period 11	Period 12	Mean
Shepiston Lane	-	-	1.6	1.3	1.9	1.4	1.3	1	1.5	1.15	1.4	1.6	1.4
Harlington f/p	-	-	0.7	0.7	1.1	0.8	0.3	1.3	0.4	0.4	0.8	0.7	0.7
West End Lane	-	-	3.1	1.2	1.4	-	0.5	1.4	0.8	0.8	1.4	0.9	1.3
Cheviot Close	-	-	0.7	1.1	1.3	1	0.4	1.2	0.5	0.6	0.9	1.4	0.9
Neptune Rd.	-	-	1	0.9	1.9	2.6	0.7	1.7	1.1	0.8	1.3	1.1	1.3
W/Sock GA9	-	-	0.5	0.7	1.1	0.8	0.3	0.6	0.5	0.4	0.8	0.8	0.7

Appendix 4
Relevant Air Quality Standards

Pollutant	Objective	Measured as	To be achieved by
Benzene	16.25 μg m^{-3} (5 ppb)	Running Annual Mean	31 December 2003
	5 μg m^{-3} (1.5 ppb)	Annual Mean	2010
Nitrogen dioxide	200 μg m^{-3} (105 ppb) Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 μg m^{-3} (21 ppb)	Annual Mean	31 December 2005
Nitrogen Oxides*	(V) 30 μg m^{-3} (16 ppb)	Annual Mean	31 December 2000
Notes: μg m^{-3} - micrograms per cubic metre. * (V) = Applies only to 'rural' areas, for protection of vegetation.			