



Air Pollution at Stansted Airport: Annual Report for 2009

Report to Stansted Airport Ltd

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Executive summary

AEA has undertaken air pollution measurements around Stansted airport on behalf of Stansted Airport Ltd. This report presents a summary and analysis of the data for 2009. The aim of the programme is to monitor air pollution at the airport, to provide a reliable assessment in relation to current and proposed air quality standards and guidelines, and to determine trends in air pollution concentrations over time.

Automatic monitoring of oxides of nitrogen (nitric oxide and nitrogen dioxide) and PM₁₀ particulate matter were carried out at the Stansted 3 site (High House). Monitoring of oxides of nitrogen was also undertaken at Stansted 4 (north of the runway). Automatic monitoring was supplemented by indicative monitoring of NO₂ and a suite of hydrocarbons (benzene, toluene, ethylbenzene and xylenes) using diffusion tubes at five sites to the north, south, east and west of the airport, and at Stansted 3.

Data capture of at least 97% was achieved for NO₂ and PM₁₀ at Stansted 3 and for NO₂ at Stansted 4, which meant that the EC Directive data capture requirement of 90% was met.

The UK Air Quality Strategy objectives for daily mean and annual mean PM₁₀ concentration were achieved at Stansted 3. The AQS Objectives for annual mean and hourly mean NO₂ were achieved at Stansted 3 and Stansted 4. Stansted 4 saw 13 exceedences of the hourly Objective which is within the allowable limit of 18 exceedences. All of the exceedences of the NO₂ Objective look to be associated with the diesel-powered emergency generator located close to the Stansted 4 monitoring site.

The NO₂ diffusion tube data indicate that all of the diffusion tube sites meet the Air Quality Strategy objective of 40 µg m⁻³ for annual mean NO₂ concentration. The annual mean benzene concentrations measured by diffusion tubes were all well within the Air Quality Strategy objective for this pollutant.

An investigation was undertaken into the source of pollutants by plotting hourly pollutant concentrations against the corresponding wind speed and wind direction. These indicated that NO₂ concentrations measured at Stansted 3 and Stansted 4 originated mainly for airport emissions (i.e. highest concentrations were measured when the wind was blowing towards the monitoring stations from the direction of the airport) whilst elevated PM₁₀ concentrations were caused by emissions from predominantly non-airport sources (i.e. highest concentrations were measured when the wind was blowing towards the monitoring stations from directions other than from the airport).

Average concentrations of NO₂ at the Stansted sites were generally comparable to those measured at urban background air pollution monitoring sites in Northampton and Southend and lower than those measured at London Heathrow and London Gatwick airports. Average concentrations of PM₁₀, however, were higher than urban background sites and comparable to concentrations recorded at London Heathrow. PM₁₀ measured at the site was found to be heavily influenced by non-airport sources which will have contributed to the elevated concentrations.

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1 Introduction

AEA (part of the AEA Group) is undertaking air pollution measurements at Stansted Airport on behalf of Stansted Airport Ltd. This report presents a summary and analysis of the data for 2009.

The aim of the programme is to monitor air pollution at the airport, to provide a reliable assessment in relation to current and proposed air quality standards and guidelines and to determine any trends in air pollution concentrations over time. It should be noted that the pollutants measured in this study will have originated from a variety of sources, both local and long range i.e. not all of these sources will be directly connected with the airport.

This report presents and summarises the fully validated and quality controlled dataset for the period 1st January to 31st December 2009. The pollutants monitored were as follows:

- oxides of nitrogen (nitric oxide NO and nitrogen dioxide NO₂)
- particulate matter (PM₁₀)
- selected volatile organic compounds (VOCs) – benzene, toluene, ethylbenzene and xylenes.

This monitoring was carried out using automatic monitoring techniques at two locations, supplemented by indicative monitoring of NO₂ and hydrocarbons using diffusion tubes at five locations. The locations used for automatic monitoring were the sites Stansted 3 (High House) and Stansted 4 (Runway).

Monitoring data collected at Stansted are compared in this report with:

- relevant UK air quality guidelines and standards, including the UK Government's Air Quality Objectives set out in the UK Air Quality Strategy and Addendum¹;
- corresponding results from a selection of national air pollution monitoring sites;
- statistics related to airport activity.

In addition, periods of relatively elevated pollutant concentrations are examined in more detail.

The Air Quality Strategy adopts standards published in the EC Directive on Ambient Air Quality and Cleaner Air for Europe² (2008/50/EC) and its predecessors, and/or previously recommended by the Expert Panel on Air Quality Standards (EPAQS)³⁻⁷. These standards have been adopted into UK law in the Air Quality Regulations 2000⁸ and the Air Quality (Amendment) Regulations 2002⁹. The UK Air Quality Strategy Objectives are at least as stringent as the corresponding EC Limit Values. The currently applicable Air Quality Objectives are summarized in Appendix 1.

1.1 BACKGROUND

Stansted Airport is London's third international airport, handling around 20 million passengers a year. The airport is situated approximately 40 miles to the north of London, in north east Hertfordshire. It is situated outside the general urbanised area of Greater London, and its surroundings are rural.

Stansted Airport Ltd is required, under the terms of its Section 106 Planning Agreement with the Local Authority (Uttlesford District Council), to carry out monitoring of oxides of nitrogen and particulate matter at an agreed site. Prior to 2006, three months monitoring per year were required: from 2006 onwards, continuous monitoring throughout the year has been required.

This report presents and analyses the data for 2009, the fourth full year of continuous monitoring. Data in this annual report have been fully subjected to the rigorous quality assurance and quality control procedures adopted by AEA, to ensure data of the highest quality, accuracy and traceability to UK national measurement standards.

In addition to this report, Stansted Airport has access to provisional data from both Stansted monitoring sites, and to National Monitoring Network sites operated by AEA on behalf of the Department for Environment, Food and Rural Affairs (Defra), via the National Air Quality Archive (www.airquality.co.uk).

2 Pollutants monitored and monitoring locations

2.1 POLLUTANTS MONITORED

The monitoring programme concentrates on the pollutants which may be of concern in and around airports. These were identified by considering those pollutants listed in the UK Air Quality Strategy, which have significant health effects reported by EPAQS; and those pollutants, which have significant emissions sources at Stansted Airport.

The pollutants monitored are described in the following section.

2.1.1 Oxides of Nitrogen

Combustion processes emit a mixture of oxides of nitrogen, primarily nitric oxide (NO) and nitrogen dioxide (NO₂), collectively termed NO_x. Major outdoor sources of NO_x in urban areas are fuel combustion in motor vehicles, power generation, heating plant and industrial processes. Based on 2006 National Atmospheric Emission Inventory (NAEI) data, in the UK, civil aircraft are estimated to contribute only approximately 0.55% of total UK emissions¹⁰ of NO_x. However, such emission inventories only consider emissions up to a height of 1000m. There will be emissions from aircraft above this height, but under most weather conditions they are unlikely to affect ground level concentrations. On and close to airports the contribution from aircraft and other airport-related sources is likely to be much more significant.

(i) NO

NO is described as a primary pollutant, being directly emitted from a range of mobile and stationary sources. Though NO is not known to have any harmful effects on human health at ambient concentrations, it undergoes oxidation in the atmosphere to form the secondary pollutant NO₂.

(ii) NO₂

NO₂ is a respiratory irritant and is toxic at high concentrations. It is also involved in the formation of photochemical smog and acid rain and may cause damage to crops and vegetation. Concentrations of NO₂ in the UK are regulated by the first European Community Directive on Ambient Air Quality and Cleaner Air for Europe². The UK Department for Environment, Food and Rural Affairs (Defra) has set air pollution bands for NO₂, which are used to describe air pollution in Air Pollution Bulletins issued to the public. The Air Quality Strategy¹ sets out Objectives for NO₂ concentrations - an hourly mean concentration of 200 µgm⁻³ not to be exceeded more than 18 times and an annual mean of 40 µgm⁻³.

2.1.2 PM₁₀ Particulate Matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. PM₁₀ particles (the fraction of particulates in air of very small size (<10µm)) are of major current concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs. Larger particles meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation. The principal source of airborne PM₁₀ matter in European cities is road traffic emissions, particularly from diesel vehicles. Based on 2006 data, less than 0.1% of UK total PM₁₀ emissions are believed to originate from aircraft¹⁰.

The Air Quality Strategy sets objectives based on 24-hour and annual mean gravimetric equivalent PM₁₀ concentrations. The 24-hour mean objective is 50 µgm⁻³, not to be exceeded more than 35 times per year, and the annual mean concentration is 40 µgm⁻³.

Defra has also set air pollution bands for PM₁₀ to describe air pollution in Air Pollution Bulletins issued to the public. These are included in Appendix 1.

2.1.3 Hydrocarbons

There are many sources of hydrocarbon emissions. Methane, for example, is a naturally occurring gas, while xylene compounds are synthetic and used in many applications, for example as a solvent in paint. A range of hydrocarbons is found in vehicle fuel, and occurs in vehicle emissions. In most urban areas, vehicle emissions would constitute the major source of hydrocarbons, in particular benzene. Also, there is the potential that they may be released to the air from facilities where fuels are stored or handled (such as petrol stations).

A wide range of hydrocarbons is emitted from both fuel storage and handling, and from fuel combustion in vehicles. It is not easy to measure all of these hydrocarbon species (particularly the most volatile) without expensive continuous monitoring systems. However, there are four moderately volatile species, all of which may be associated with fuels and vehicle emissions, which are easy to monitor using passive samplers. These are benzene, toluene, ethyl benzene and xylene. They are not the largest constituents of petrol emissions, but due to their moderate volatility they can be monitored using simple diffusive samplers. Diffusion tubes are available for monitoring this group of organic compounds, and are known as “BTEX” tubes.

(i) Benzene

Of the organic compounds measured in this study, benzene is the one of most concern, as it is a known human carcinogen; long-term exposure can cause leukaemia. Benzene is well known as one of the harmful compounds found in cigarette smoke, but it is also found in petrol and other liquid fuels, in small concentrations. In urban areas, the major source of benzene in ambient air is vehicle emissions.

(ii) Toluene

Toluene is also found in petrol in small concentrations. Its primary use is as a solvent in paints and inks; it is also a constituent of tobacco smoke. It has been found to adversely affect human health. Typical ambient concentrations range from trace to 3.8 $\mu\text{g m}^{-3}$ in rural areas, up to 204 $\mu\text{g m}^{-3}$ in urban areas, and higher near industrial sources. There are no recommended limits for ambient toluene concentrations, although there are occupational limits for workplace exposure.

(iii) Ethyl benzene

Again, there are no limits for ambient concentration of ethyl benzene, and although there are occupational limits relating to workplace exposure, they are several orders of magnitude higher than typical outdoor ambient concentrations.

(iv) Xylene

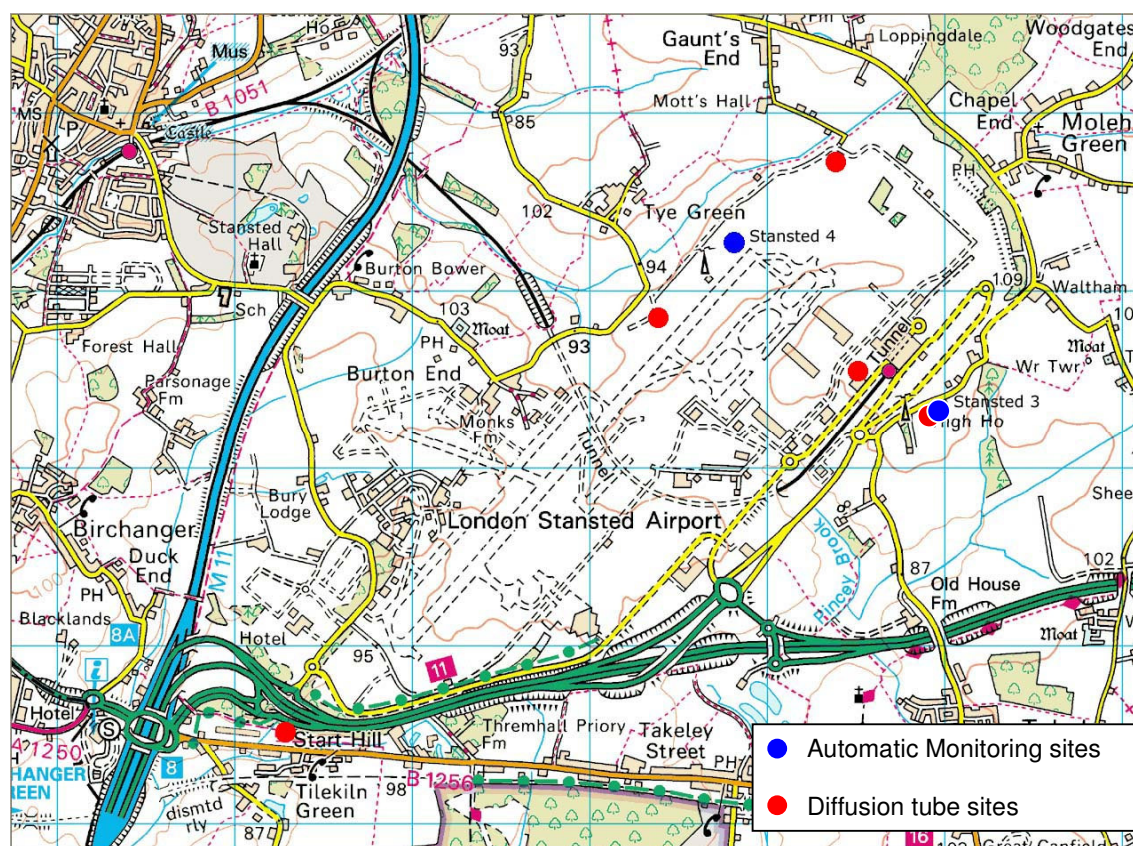
Xylene exists in ortho (o), para (p) and meta (m) isomers. There are no limits for ambient concentration of xylenes, although (as in the case of toluene and ethyl benzene) there are occupational limits relating to workplace exposure. Xylene, like toluene, can cause odour nuisance near processes (such as vehicle paint spraying), which emit it.

2.2 LOCATION OF THE MONITORING SITES

Two automatic monitoring sites, referred to as Stansted 3 and Stansted 4, were in use during 2009. The numbering of the sites follows on the sequence used for previous short-term sites in earlier monitoring studies. Diffusion tubes were used to monitor NO₂ on a monthly basis at five sites; the Stansted 3 automatic site and four sites to the north, east, south and west of the airport site. In addition, “BTEX” diffusion tubes were used to monitor benzene, toluene, ethylbenzene and xylenes at the same five sites. BTEX sampling commenced in August 2007, so 2009 is the second full year of BTEX monitoring. Table 1 shows the locations of all monitoring sites used in this study, continuous sites in blue, diffusive samplers in red. The site locations are shown on the map in Figure 1.

Table 1 Air Quality Monitoring at Stansted: Locations of Monitoring Sites

Site Name	Description	Parameters monitored	Grid reference
Stansted 3	East of High House	Automatic monitoring of NO _x , CO, PM ₁₀ Diffusion tube monitoring of NO ₂ and BTEX hydrocarbons, monthly (co-located).	TL 558 233
Stansted 4	Grass area near runway	Automatic monitoring of NO _x , also wind speed, wind direction.	TL 548 243
Stansted North	North Lights, north end of runway	Diffusion tube monitoring of NO ₂ and BTEX hydrocarbons, monthly	TL 555 248
Stansted East	Enterprise House offices	Diffusion tube monitoring of NO ₂ and BTEX hydrocarbons, monthly	TL 555 234
Stansted South	Balancing Pond south of site	Diffusion tube monitoring of NO ₂ and BTEX hydrocarbons, monthly	TL 522 215
Stansted West	Radar tower, Burton End	Diffusion tube monitoring of NO ₂ and BTEX hydrocarbons, monthly	TL 536 235

**Figure 1 Location of the Stansted Airport Monitoring Sites**

The location of the automatic monitoring site at High House (Stansted 3) was agreed with Stansted Airport, Uttlesford District Council and AEA. It is located just outside the eastern perimeter of the airport. It is considered to be close enough to the airport to detect effects relating to airport emissions. It is also close to vulnerable receptors, being located in a nursery school car park. The A120 main road runs approximately 1.5km to the south of the site. The monitoring apparatus is housed in a purpose-built enclosure. Figure 2 shows a photograph of the Stansted 3 site.



Figure 2 Stansted 3 Air Quality Monitoring Site at High House

The second site (Stansted 4) is located at the north-eastern end of the main runway, within the airport perimeter. It is intended to monitor any effects on air quality related to airport emissions. The location of Stansted 4 is also shown on the map in Figure 1, and a photo is provided in Figure 3.

Both sites fall into the category "other" as defined by the Defra Technical Guidance on air quality monitoring (LAQM.TG(09)¹¹), i.e. "any special source-oriented or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels."



Figure 3 Stansted 4 Air Quality Monitoring Site

2.3 AUTOMATIC MONITORING TECHNIQUES

Continuous automatic analysers for monitoring NO_x and PM₁₀ were selected, in order to provide real-time data. The analysers use the operating principles listed below: these represent the current state-of-the-art techniques for ambient monitoring of these species. Further information is provided in Appendix 2.

- PM₁₀ tapered element oscillating microbalance (TEOM)
- NO, NO₂ chemiluminescence with ozone

Each analyser provides a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15-minute average values by internal data loggers. The analysers are connected to a modem and interrogated via a GPRS internet device to download the data to AEA. Data are downloaded hourly.

The data are converted to concentration units at AEA and averaged to hourly mean concentrations.

The TEOM monitoring method uses a 50°C heated sample inlet in order to prevent moisture from contaminating the filter. Many studies have shown that this elevated temperature results in the loss of volatile and semi-volatile components of PM₁₀. Secondary particles such as ammonium nitrate for example, are known to evaporate below 50°C. Until recently, Government advice was that TEOM results could be converted to gravimetric equivalent measurements by applying a factor of 1.3.

However, the conclusion of equivalence trials published by Bureau Veritas in 2006¹² was that the TEOM did *not* meet the equivalence criteria, even with correction factors applied.

It is possible to upgrade TEOM analysers, or indeed replace them with instruments that do meet the equivalence criteria. However, the advice of Defra and the Devolved Administrations was that where the particulate concentration is not close to the AQS Objective, it is still acceptable to use TEOM data corrected by application of the “x 1.3” correction factor as an *indicative* measurement. As previous data from these sites have shown that PM₁₀ concentrations at Stansted 3 were well within the AQS Objective, this was the approach taken in previous recent reports.

However, there is now an alternative to correction using the 1.3 factor. King’s College London (KCL) have developed a Volatile Correction Model¹³, which allows TEOM PM₁₀ data to be corrected for the volatile components lost as a result of the TEOM’s heated inlet. The model is available at <http://www.volatile-correction-model.info/Default.aspx>. It uses data from nearby particulate analysers of the FDMS TEOM type, which measure the volatile component of the PM₁₀. This volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. **KCL state on the VCM website home page that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.**

This is now the preferred method of dealing with TEOM data when comparing them to air quality limit values and objectives, and has been used for this purpose in the present report. Where the VCM has been used to correct PM₁₀ data in this report, this is clearly indicated. However, in some cases, where investigating diurnal patterns and relationship between pollutant concentrations and wind direction, the VCM has not been applied and this too is clearly indicated.

2.4 DIFFUSIVE SAMPLERS

Diffusion tubes were used for monitoring of NO₂ and BTEX. These are “passive” samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply.

Diffusion tubes for NO₂ consist of a small plastic tube, approximately 7 cm long. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case NO₂. The tube is mounted vertically with the open end at the bottom. Ambient NO₂ diffuses up the tube during exposure, and is absorbed as nitrite. The average ambient pollutant concentration for the exposure period is calculated from the amount of pollutant absorbed.

BTEX diffusion tubes are longer, thinner, and made of metal rather than plastic. These tubes are fitted at both ends with brass Swagelok fittings. A separate “diffusion cap” is supplied. Immediately before exposure, the Swagelok end fitting is replaced with the diffusion cap. The cap is removed after exposure, and is replaced with the Swagelok fitting. BTEX diffusion tubes are very sensitive to interference by solvents.

Diffusion tubes were prepared by a commercial laboratory (Gradko International Ltd throughout 2008). The tubes were supplied in sealed condition prior to exposure. The tubes were exposed at the sites for a period of time. After exposure, the tubes were again sealed and returned to the laboratory for analysis. The exposure periods used approximated to calendar months.

The diffusion tube methodologies provide data that are accurate to $\pm 25\%$ for NO₂ and $\pm 20\%$ for BTEX. The limits of detection vary from month to month, but are typically $0.4 \mu\text{g m}^{-3}$ for NO₂ and $0.2 \mu\text{g m}^{-3}$ for BTEX. It should be noted that tube results that are less than 10 x the limit of detection will have a higher level of uncertainty associated with them.

NO₂ diffusion tube monitoring was carried out throughout the year. 2009 was the second full year of BTEX diffusion tube monitoring at Stansted.

3 Quality Assurance and Data Capture

3.1 QUALITY ASSURANCE AND QUALITY CONTROL

In line with current operational procedures within the Defra Automatic Urban Monitoring Network, full intercalibration audits of the Stansted air quality monitoring sites normally take place at six monthly intervals. Full details of these UKAS accredited calibrations, together with our data validation and ratification procedures are given in Appendix 3. In addition to instrument and calibration standard checking, the air intake sampling system was cleaned and all other aspects of site infrastructure were checked.

Following the instrument and calibration gas checking, and the subsequent scaling and ratification of the data, the overall accuracy and precision figures for the pollutants monitored at Stansted can be summarised as in Table 2.

Table 2 Estimated Accuracy and Precision of the Data Presented

Pollutant	Precision	Accuracy %
NO	±2.5	±15%
NO ₂	±6.9	±15%
PM ₁₀	±4	*

*accuracy of particle measurements with a TEOM instrument cannot be reliably assessed.

The Local Air Quality Management Technical Guidance LAQM.TG(09)¹¹ states that when using diffusion tubes for indicative NO₂ monitoring, correction should be made where applicable for any systematic bias (i.e. over-read or under-read compared to the automatic chemiluminescent technique, which is the reference method for NO₂). Throughout this study, diffusion tubes have been exposed alongside the automatic NO_x analyser at Stansted 3. These co-located measurements have been used to correct for diffusion tube bias where required. Where the resulting “bias adjustment factor” – i.e. the ratio of the automatic measurement to the diffusion tube measurement - has been used, this is indicated. The NO₂ diffusion tube results in this report are uncorrected except where clearly specified.

3.2 DATA CAPTURE

Overall data capture statistics for the two monitoring sites are given in Table 3. A data capture rate of 90% or greater for ratified data is recommended in the Defra Technical Guidance LAQM (TG(09))¹¹.

Table 3 Data Capture Statistics 2009

Site	NO _x	NO ₂	PM ₁₀
Stansted 3	98.6 %	98.6 %	97.8 %
Stansted 4	99.2 %	99.2 %	-

Data capture of at least 90% was achieved for NO₂ and PM₁₀ at Stansted 3 and Stansted 4. However, the following significant gaps in data capture occurred during the year:

Table 4 Significant Data Gaps 2009

Site	Pollutant	Period	No. of Days	Reason
Stansted 3	NO _x	6-7 May 09	1	Service
	PM ₁₀	24-25 Mar 09 22-23 Jun 09	1 1	Telemetry fault with TEOM Power cut
Stansted 4	NO _x	7 May 09	1	Service
		2 Dec 09	1	Service
		3 Dec 09	1	Telemetry Fault

4 Results and Discussion

4.1 PRESENTATION OF THE RESULTS

The summary statistics for calendar year 2009 are given in Table 5, and the time series of data for the full year, as measured by the automatic monitoring sites, are shown in Figures 4 and 5. Table 6 shows a summary of the NO₂ diffusion tube data.

Measured concentrations of the oxides of nitrogen NO and NO₂ are reported in micrograms per cubic metre (µg m⁻³). Conversion factors to other common units for air pollution concentrations parts per million (ppm) and parts per billion (ppb) are given in Appendix 1.

PM₁₀ is conventionally reported in units of µg m⁻³, micrograms per cubic metre. In this report PM₁₀ measured using the TEOM instrument are converted to gravimetric equivalent using the King's College London Volatile Correction Model¹³ where appropriate, or otherwise to "indicative gravimetric equivalent" by application of a correction factor. See section 2.3 above for an explanation of this.

Table 5 Air Pollution Statistics for Stansted 3 and 4, 1st January to 31st December 2009

Stansted 3	NO (µg m⁻³)	NO₂ (µg m⁻³)	NO_x (µg m⁻³)	PM₁₀[*] (µg m⁻³)	PM₁₀ VCM corrected (µg m⁻³)
Maximum 15-minute mean	406	149	764	551	-
Maximum hourly mean	256	120	499	325	259
Maximum running 8-hour mean	99	87	216	99	85
Maximum running 24-hour mean	74	67	165	53	62
Maximum daily mean	73	63	164	523	62
Average	8	24	36	20	19
Data capture	98.6 %	98.6 %	98.6 %	97.8 %	97.5%
Stansted 4	NO (µg m⁻³)	NO₂ (µg m⁻³)	NO_x (µg m⁻³)	PM₁₀^{*,†} (µg m⁻³)	PM₁₀ VCM corrected (µg m⁻³)
Maximum 15-minute mean	1155	762	2365		
Maximum hourly mean	910	667	2057		
Maximum running 8-hour mean	598	426	1340		
Maximum running 24-hour mean	328	235	736		
Maximum daily mean	187	152	438		
Average	8	21	33		
Data capture	99.2 %	99.2 %	99.2 %		

All mass units are at 20 Celsius and 101.3 kPa.

*PM₁₀ is Indicative Gravimetric Equivalent (TEOM x1.3).

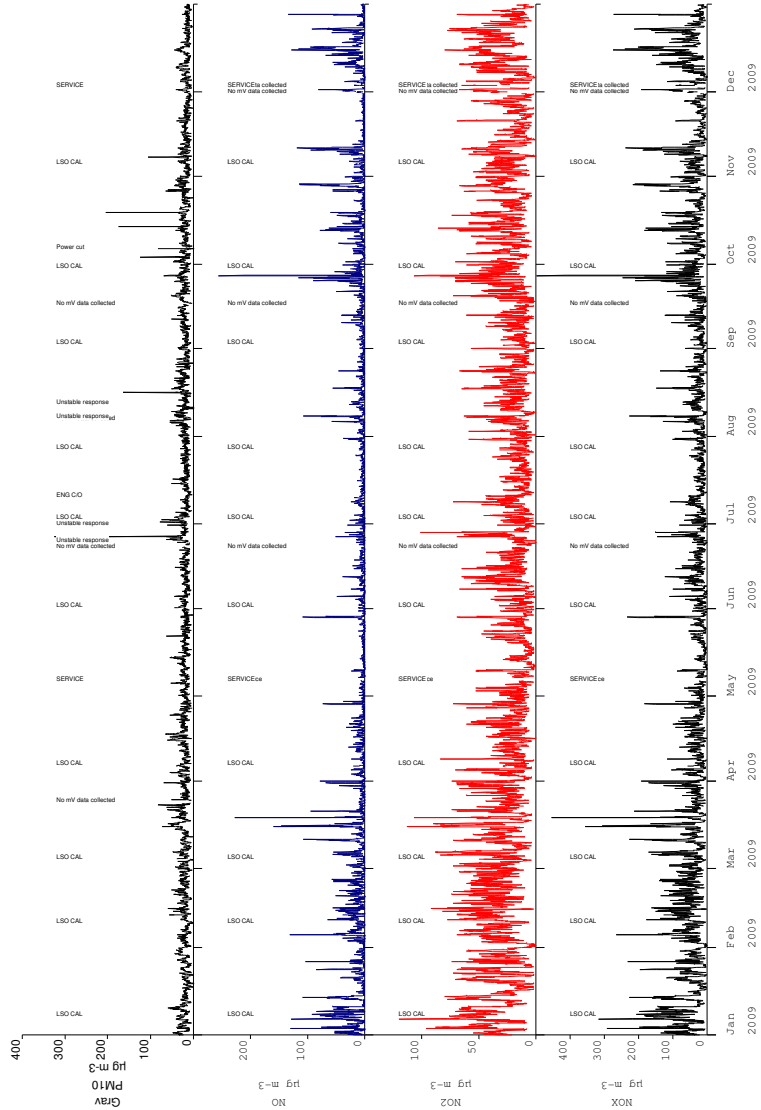


Figure 4 Time Series of Hourly Averaged Concentrations at Stansted 3 – 2009

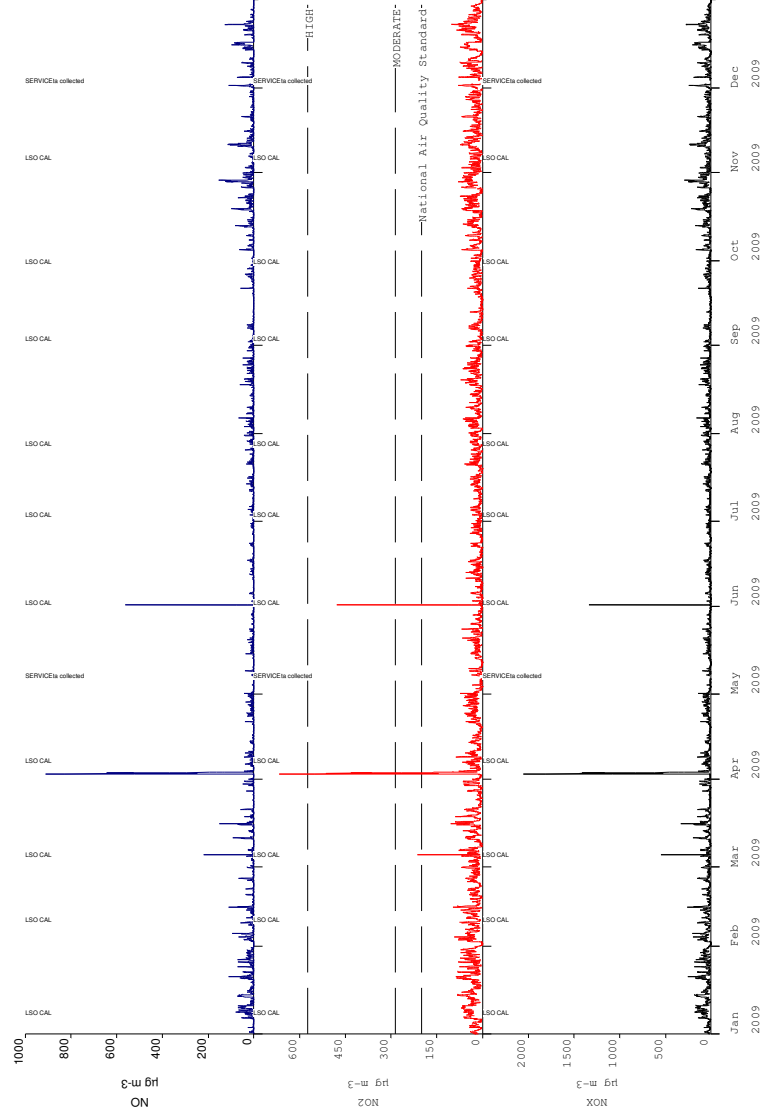


Figure 5 Time Series of Hourly Averaged Concentrations at Stansted 4 – 2009

Table 6 shows the NO₂ diffusion tube results for 2009. There are two months with no data from the Stansted South site. These tubes went missing. A new location resolved this issue.

Annual mean NO₂ concentrations measured with diffusion tubes ranged from 21 µg m⁻³ to 34 µg m⁻³ at the five sites. The annual mean concentration measured at Stansted 3 using diffusion tubes was 25 µg m⁻³ – very slightly higher than the value of 24 µg m⁻³ obtained using the reference technique (the chemiluminescence analyser).

Diffusion tubes are affected by several artefacts, which can cause them to under-read or (more commonly) over-read with respect to the reference technique. It has therefore become common practice to calculate and apply a “bias adjustment factor”, based on co-located diffusion tube and automatic analyser measurements, to annual mean NO₂ concentrations measured by diffusion tubes. This “bias adjustment factor” is calculated as the ratio of the automatic analyser result to the diffusion tube result. This factor can then be used to correct the annual means measured at the other non-co-located sites.

The annual mean concentration measured at Stansted 3 using diffusion tubes was 25 µg m⁻³, and the annual mean obtained using the chemiluminescence analyser was 24 µg m⁻³. This gives a “bias adjustment factor” of 0.96. (This is the same as the bias adjustment factor calculated for 2008). Table 6 includes annual means at the other sites, corrected by application of this bias adjustment factor.

It should be noted that

- (i) only the annual mean concentration should be adjusted in this way, as diffusion tube “bias” can vary considerably from month to month due to meteorological and other factors.
- (ii) even after application of a bias adjustment factor, diffusion tube measurements remain indicative only.

Table 6 Diffusion Tube Results for Nitrogen Dioxide 2009 µg m⁻³

Start date	Stansted North	Stansted East	Stansted South	Stansted West	Stansted 3	Stansted 3 (automatic)
07/01/2009	34	51	-	41	34	32
09/02/2009	11	28	-	10	26	37
04/03/2009	23	40	33	22	26	29
06/04/2009	21	35	26	25	24	21
29/04/2009	18	31	17	17	19	14
01/06/2009	10	23	24	14	19	18
02/07/2009	26	32	24	17	18	15
27/07/2009	18	26	20	18	18	18
02/09/2009	16	30	29	14	24	20
29/09/2009	27	40	32	27	30	26
05/11/2009	36	36	30	27	26	21
02/12/2009	28	37	33	24	31	31
Mean	22	34	27	21	25	24
Mean (bias adjusted)	21	33	26	20	24	
2008 Mean (bias adjusted)	24	35	31	20	25	

Tubes are exposed in triplicate at all sites. The results shown are the mean of these replicate measurements. The full dataset is shown in Appendix 4.

Mean concentrations of BTEX hydrocarbons, as measured using diffusion tubes during 2009, are shown in Table 7. For information, 2008 benzene results are included in brackets. The full dataset is provided in Appendix 5.

Table 7 Annual Mean Concentrations of Hydrocarbon Species ($\mu\text{g m}^{-3}$) at Stansted, 2009

	Benzene	Toluene	Ethyl benzene	m+p - xylenes	o-xylene
Stansted North	0.70 (0.80)	0.94	0.42	0.77	0.26
Stansted East	0.84 (0.92)	1.61	0.58	1.16	0.45
Stansted South	0.72 (0.85)	1.28	0.45	0.98	0.41
Stansted West	0.64 (0.69)	1.12	0.40	0.59	0.21
Stansted 3	0.77 (0.76)	1.21	0.43	0.66	0.30

4.2 COMPARISON WITH AIR QUALITY STANDARDS AND GUIDELINES

In January 2000, the UK Government published the current Air Quality Strategy containing air quality objectives for a range of air pollutants. Three of these (carbon monoxide, nitrogen dioxide and PM₁₀ particulate matter) are measured at Stansted. Revised air quality objectives were issued in the Air Quality (Amendment) Regulations 2002. The objectives are based on the first and second EC Daughter Directive and/or the recommendations made by the UK independent Expert Panel on Air Quality Standards (EPAQS). The objectives provide policy targets by outlining what the Government considers current measures should deliver.

In addition, Defra has defined Air Pollution Bands for NO₂, CO and PM₁₀. NO is not thought to be harmful to health at concentrations experienced in the ambient environment and there are no air quality standards or guidelines for this compound. Defra air pollution bands for NO₂, CO and PM₁₀ assign data to the categories LOW, MODERATE, HIGH, or VERY HIGH, depending on the magnitude of concentrations over a specified averaging period. These descriptors are used for pollutant concentrations measured at National Monitoring Network sites throughout the UK, when presented on the World Wide Web, TELETEXT or the Air Quality Information Line service.

Full details of the air quality standards and objectives used for analysis of Stansted Airport monitoring data are summarised in Appendix 1.

Table 8 presents a comparison of the automatic monitoring data with Air Quality Strategy Objectives for the protection of human health.

Table 8 Comparison of Automatic Monitoring Data with AQS Objectives for the protection of human health.

Pollutant	AQS Objective	Threshold	Result for STAL	Objective met?
Stansted 3				
NO ₂	1-hr mean not to be exceeded more than 18 times a year	200 µg m ⁻³	0 exceedences	Yes
NO ₂	Annual mean	40 µg m ⁻³	24 µg m ⁻³	Yes
PM ₁₀ *	24-hr mean not to be exceeded more than 35 times a year	50 µg m ⁻³	2 exceedences	Yes
PM ₁₀ *	Annual mean	40 µg m ⁻³	19 µg m ⁻³	Yes
Stansted 4				
NO ₂	1-hr mean not to be exceeded more than 18 times a year	200 µg m ⁻³	13 exceedences	Yes
NO ₂	Annual mean	40 µg m ⁻³	24 µg m ⁻³	Yes

* VCM corrected PM₁₀ data.

Stansted 3 did not record any 1-hour means above 200 µg m⁻³. Stansted 4 recorded thirteen 1-hour means above this value. Therefore, both sites met the AQS Objective for hourly mean NO₂. The NO₂ episodes at Stansted 4 are discussed further in Section 4.5. Similarly, the bias-adjusted annual means from the NO₂ diffusion tubes ranged from 21 µg m⁻³ to 33 µg m⁻³. All of the sites were therefore below the annual mean objective concentration.

Stansted 3 recorded two daily means above $50 \mu\text{g m}^{-3}$, and therefore met the AQS Objective for hourly mean PM_{10} . The annual mean VCM-corrected PM_{10} concentration at Stansted 3 was $19 \mu\text{g m}^{-3}$ which was well within the AQS Objective.

The AQS Objectives for benzene are:

- $16.25 \mu\text{g m}^{-3}$ as a running annual mean, to be achieved by December 31st 2003.
- $5 \mu\text{g m}^{-3}$ annual average to be achieved by 31 December 2010

The indicative annual mean benzene concentrations at the four BTEX diffusion tube sites ranged from $0.64 \mu\text{g m}^{-3}$ to $0.84 \mu\text{g m}^{-3}$. These averages from 2009 are well below the current and 2010 AQS objective.

4.3 TEMPORAL VARIATION IN POLLUTANT CONCENTRATIONS

4.3.1 Seasonal Variation

Figures 6 and 7 show the variation of monthly averaged pollutant concentrations during 2009 at Stansted 3 and Stansted 4 respectively. Because there is a slight possibility of very local emissions influencing the measurements at Stansted, **the PM_{10} data shown here have *not* been corrected using the VCM.** Instead they are expressed as “indicative gravimetric equivalent”, i.e. TEOM measured value x 1.3.

As with previous years both sites recorded highest concentrations of NO and NO_2 during the winter months. This pattern is typical of urban monitoring sites; highest levels of primary pollutants tend to occur in the winter months, when emissions may be higher, and periods of cold, still weather reduce pollutant dispersion.

By contrast, PM_{10} concentrations at Stansted 3 showed a less clear seasonal pattern, with highest concentrations in March, August and October. Monthly mean concentrations differed by only by $7 \mu\text{g m}^{-3}$ throughout the year. PM_{10} concentrations at this site have not exhibited a consistent seasonal pattern, and in recent years the highest concentrations have often occurred in the summer months. It is likely that secondary material makes up a substantial component of the particulate matter at this site: for secondary pollutants, high concentrations can also often occur during summer months when chemical reactions in the atmosphere are promoted by high temperatures and strong sunlight. This observation is consistent with other PM measurements made in the south of England.

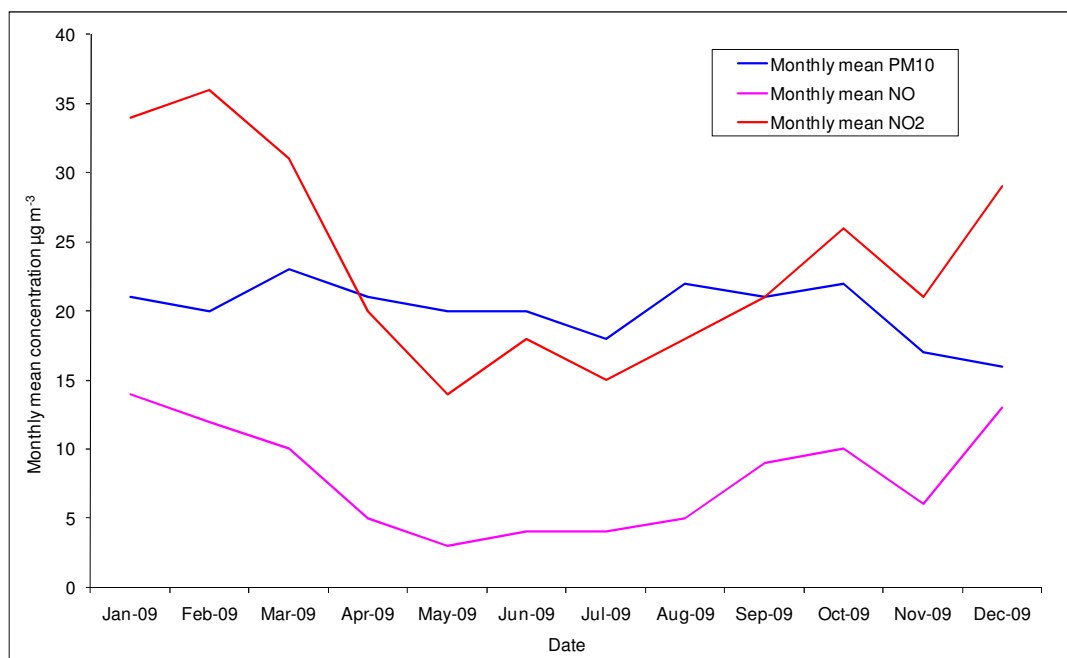


Figure 6 Seasonal variation of pollutant concentrations at Stansted 3, 2009



Figure 7 Seasonal variation of pollutant concentrations at Stansted 4, 2009

4.3.2 Diurnal Variation

Figures 8 and 9 show diurnal variation in pollutant concentrations, as measured at Stansted 3 and Stansted 4 respectively.

Both sites show clear peaks for NO and NO₂ in the morning, corresponding to rush hour traffic at around 6am and 7am. Concentrations decrease during the middle of the day, with a much broader

evening rush-hour peak building up from early afternoon. For NO_2 , which has a secondary component, the afternoon peak is higher than the morning peak. For NO , the opposite is true. This is because in the afternoon, concentrations of oxidising agents, particularly ozone, in the atmosphere tend to increase, leading to enhanced oxidation of NO to NO_2 . This is a typical pattern for oxides of nitrogen in urban areas.

For PM_{10} at Stansted 3, the diurnal pattern is less pronounced. PM_{10} concentrations do not decrease substantially during the middle of the day: rather, there is a steady increase through the afternoon. For PM_{10} , emissions of sulphur dioxide and NO_x can react with other chemicals in the atmosphere to form secondary sulphate and nitrate particles, which can result in elevated levels of PM_{10} . In addition, the diurnal PM_{10} profile may be affected by the pattern of use of light and heavy-duty vehicles throughout the day.

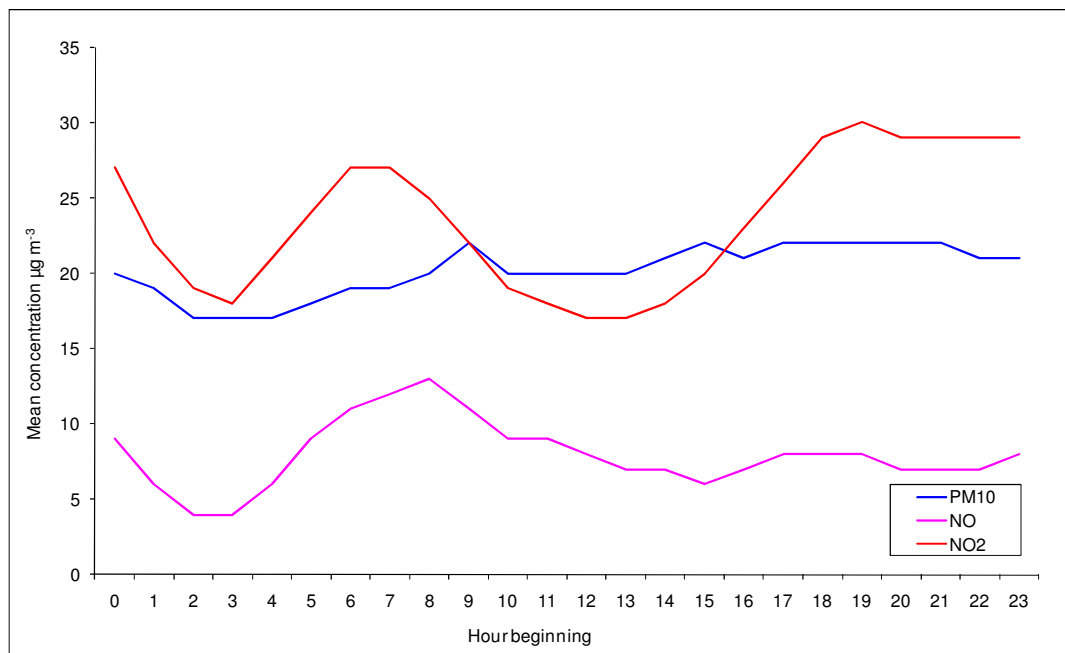


Figure 8 Diurnal variation of pollutant concentrations at Stansted 3, 2009

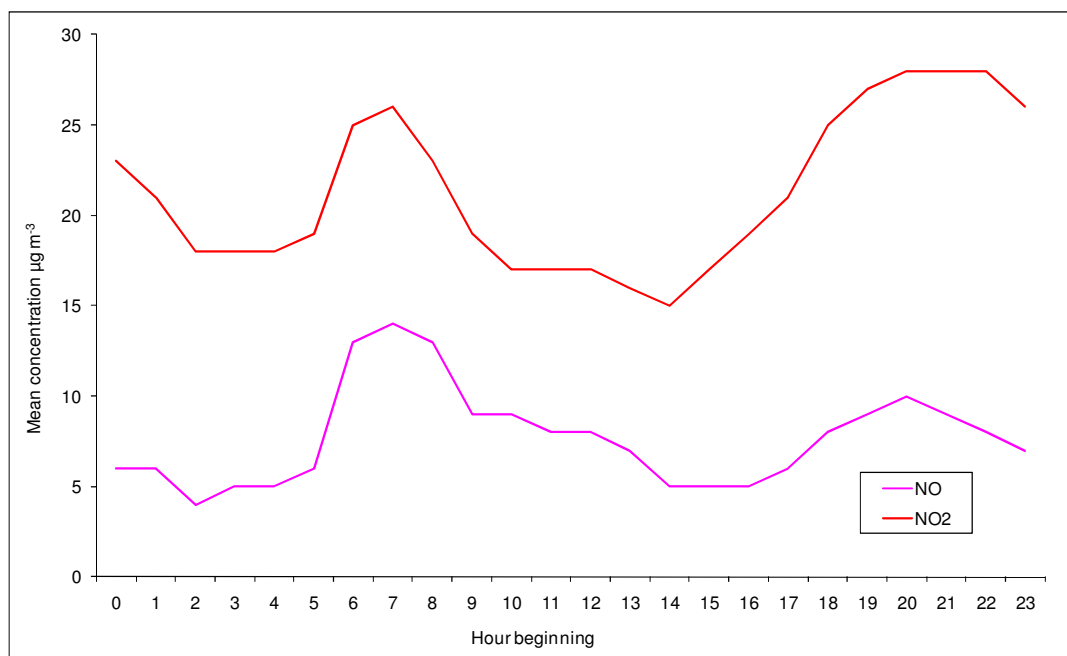


Figure 9 Diurnal variation of pollutant concentrations at Stansted 4, 2009

4.4 SOURCE APPORTIONMENT

In order to investigate the possible sources of air pollution that are being monitored at Stansted airport, meteorological data was used to add a directional component to the air pollutant concentrations. No data were available from the airport itself but some wind speed and wind direction data were sourced from St Albans Fleetville monitoring station. Although this is not ideal due to the site being approximately 40 km from Stansted, the site is not restricted by any close buildings and as such the wind direction and wind speed data will be broadly representative of the area. Figure 10 shows the wind speed and direction data from the St Albans site. The meteorological data are summarised by direction and by different wind speed categories. Wind speeds are split into 2 ms^{-1} intervals as shown by the scale bar in the plot. The grey circles indicate the percentage of time over the period that the wind is measured from each direction, e.g. Figure 10 shows that the wind direction was from a south westerly direction for over 20% of the year, and that this was the prevalent wind direction. It also shows that for the majority of the time wind speeds were less than 6 ms^{-1} .

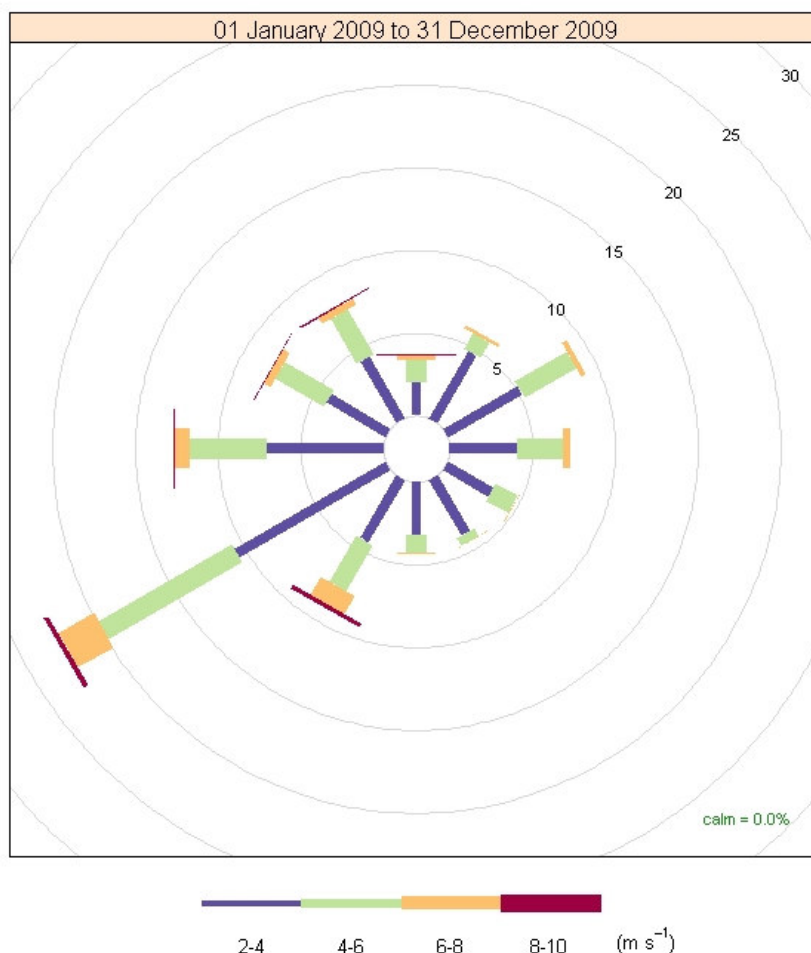


Figure 10 Wind rose showing the wind speed and direction in 2009 from St Albans, Fleetville monitoring site.

Figure 11 shows plots of hourly pollutant concentrations against the corresponding wind speed and wind direction. The further the data point is plotted from the central position on the plot the higher the wind speed. These plots do not allow a derivation of any specific values or exceedences but provide a visual indication as to the direction of possible sources of pollution that are being measured at the site. The plots are best interpreted with reference to the map in Figure 1.

The NO₂ plots show clearly the contribution from sources within the airport boundary with elevated concentrations recorded from the North and the North West quadrant of the plot for Stansted 3 and from a southerly direction at Stansted 4. The plot for Stansted 3 suggests a source to the south which is possibly a signature from the A120. The NO₂ plot from Stansted 4 also highlights a significant point source of the north east which is corroborated by the NO data. This is the location of an emergency generator.

In contrast, the PM₁₀ plot shows that there are some emissions originating from the airport but that the most significant source can be seen from the North West as indicated by the high concentrations recorded at the site at higher wind speeds than seen for NO₂. Looking at Figure 1 it is likely that the dominant source in this plot is the M11 motorway. The PM₁₀ plot also shows a contribution from the south east similar to that seen for NO₂. Again this is possibly a signature from the A120.

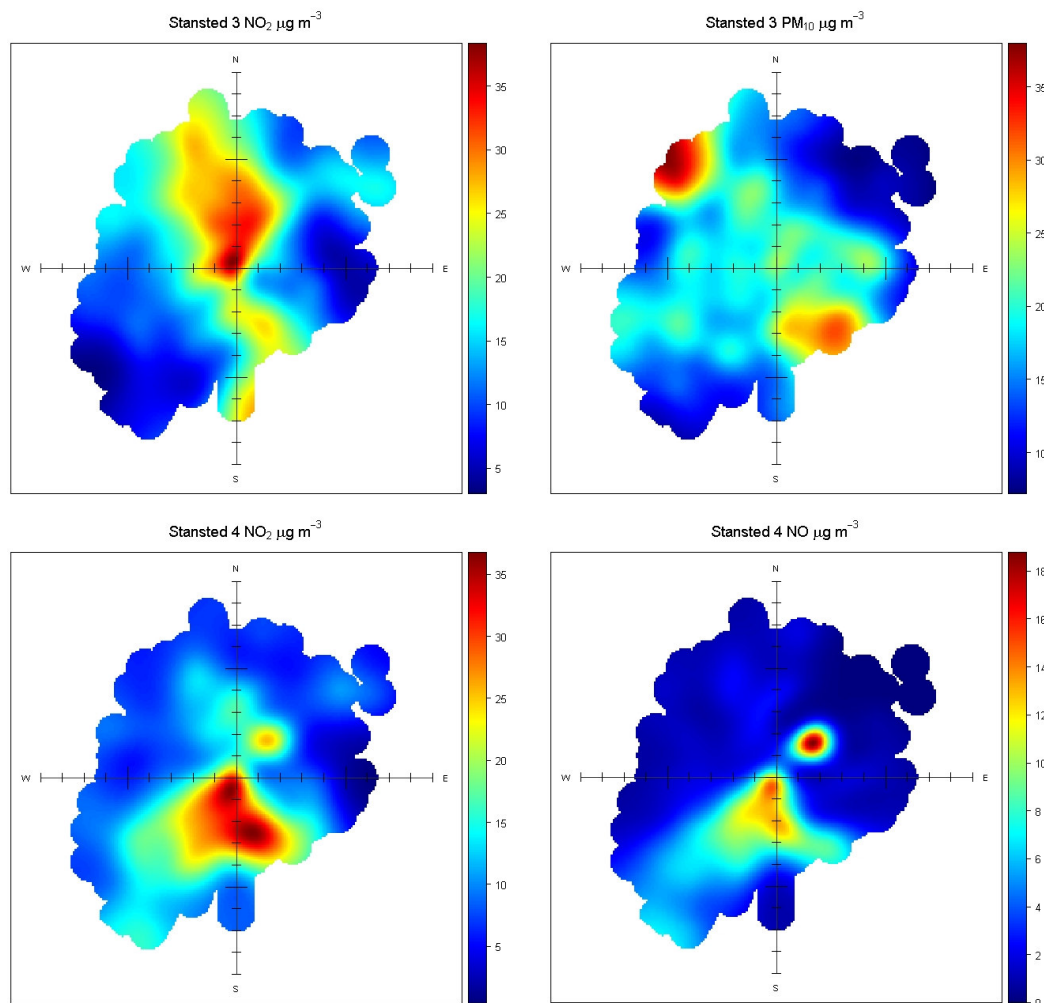


Figure 11 Bivariate plots showing pollutant concentrations as a function of both wind direction and wind speed (increment on the axes represent 1 metre per second).

The fact that the airport is a major source of oxides of nitrogen and, to a lesser degree, a source of PM_{10} , it would be expected that there would be some correlation between airport activity and pollutant concentrations.

Figure 12 shows monthly statistics for the number of passengers and air traffic movements (ATM's) during 2009. The distinct seasonal pattern indicating high 'activity' in the summer months (July and August) and lower in the winter is clearly seen. Figure 6 and Figure 7 show the corresponding monthly air pollutant concentrations. As discussed in 4.3 above, these also show a seasonal distribution, predominantly for oxides of nitrogen, but in this case, the peak is in the winter months rather than the summer. This is a typical profile whereby summer concentrations are lower due to increased photochemical activity in the presence of UV light which drives the formation of ozone from pollutants such as NO_2 .

Although the emissions from the airport are a significant contributor to the ambient pollutant concentrations, as is illustrated in particular for NO and NO_2 in Figure 11, it is clear from this simplistic analysis of air and passenger movements, that the profile of air pollutant concentrations (i.e. the periods of high and low concentration) measured at Stansted throughout the year is influenced greatly by general meteorological factors.

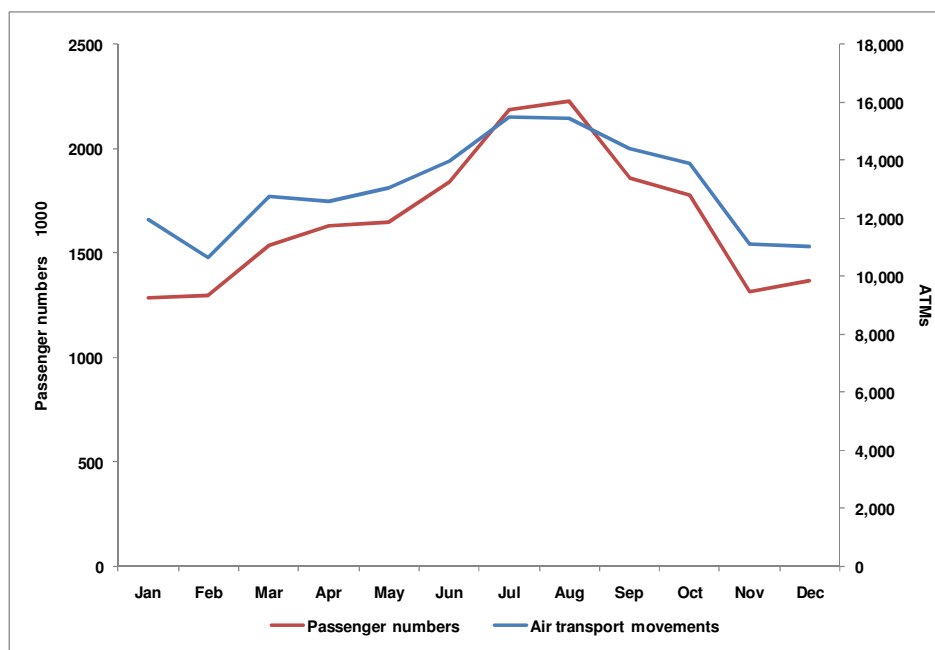


Figure 12 Monthly variation of Stansted airport activity 2009.

4.5 PERIODS OF ELEVATED POLLUTANT CONCENTRATIONS

In this section, the most significant periods of high air pollution concentrations for the whole year are briefly reviewed, using the fully validated data set.

It is important to stress, however, that despite there being some periods of high pollutant concentration, both sites met the applicable Air Quality Objectives, and remained within the Defra “Low” air quality band throughout most of the year.

The PM₁₀ data shown here have not been corrected using the VCM. Instead they are expressed as “indicative gravimetric equivalent” i.e. TEOM measured value x 1.3.

4.5.1 Nitrogen Dioxide

As discussed in Section 4.2, Stansted 4 recorded thirteen exceedences of the NO₂ 1-hour mean Objective. Details of these hourly mean exceedences, the peak concentrations and the Defra air pollution bands which were reached on these days are detailed in Table 9. This shows that the Moderate band was breached on two days during the year and the High band was breached once. There were no other breaches of the air quality bands recorded at either monitoring site during 2009.

Table 9 Details of the Nitrogen Dioxide Exceedences at Stansted 4

Date of exceedence	Number of hours >200 µg m ⁻³	Maximum hourly mean µg m ⁻³	Maximum 15 minute mean µg m ⁻³	Defra air pollution band reached
5 th March 2009	1	214	762	Low
2 nd April 2009	5	667	737	High
3 rd April 2009	6	514	684	Moderate
1 st June 2009	1	478	609	Moderate

All of these exceedences of the NO₂ Objective look to be associated with the diesel-powered emergency generator located nearby. They all occur without any corresponding increase in concentrations at Stansted 3 and are therefore highly localised events. They also all coincide with wind directions from the north to west quadrant.

4.5.2 Particulates

PM₁₀ concentrations at Stansted 3 were within the Defra “Low” band throughout 2009. However, Figure 5 shows that there are a number of “spikes” in PM₁₀ concentration at Stansted 3. The dates on which these occurred and the peak concentrations are listed below:

- 26th June – 325 µg m⁻³
- 16th August – 164 µg m⁻³
- 3rd October – 125 µg m⁻³
- 6th October – 83 µg m⁻³
- 14th October – 174 µg m⁻³
- 19th October – 205 µg m⁻³

These peaks are all short term periods of elevated concentration of only one or two hours duration and all look to be driven by a local emissions source. In addition there is a peak of 105 µg m⁻³ measured on 7th November. This episode coincided with the Saturday after Bonfire night. Similar elevated concentrations are seen at other national network sites across the UK.

4.6 COMPARISON WITH OTHER SITES

Figure 13 and Figure 14 provides a comparison between annual mean pollutant levels at the Stansted sites, and corresponding measurements made at several AURN monitoring stations in the region. These sites are listed below:

- Northampton – an urban background site in the grounds of a college in Northampton, approximately 45m from the nearest major road.
- Thurrock – an urban background site in the town of Thurrock, Essex, approximately 35m from the kerb of a busy road.
- Cambridge Roadside – roadside site in the city of Cambridge, where vehicle emissions are the major pollution source.
- Southend-on-Sea – an urban background site situated in an urban public park in a residential area.
- BIA – an airside apron location at Birmingham Airport, approximately halfway down the runway and 900 metres north east of the terminal complex
- LHR2 – long-term airside monitoring station at Heathrow. 180 metres north of runway 27R and north east of the Central Terminal Area.
- London Harlington – a background monitoring station approximately 1km north east of the Heathrow perimeter.
- Gatwick LGW3 – long-term monitoring station at Gatwick, directly under the runway approach, 250 metres from the threshold of runway 26L and 25 metres from the A23.

Annual mean concentrations of NO₂ at Stansted 4 have been consistently comparable with the urban background concentrations measured at Southend-on-Sea and Northampton. Concentrations at Stansted 3 have historically been slightly higher than these urban background concentrations and very much mirror the concentrations recorded at Birmingham Airport. However, Figure 13 shows that concentrations of NO₂ at this site, and also Birmingham Airport, have been reducing since 2004 and the 2008 and 2009 annual mean concentrations have been more in line with the urban background concentrations. Concentrations of NO₂ at background sites within London see higher concentrations than other background sites in the region.

Cambridge Roadside site, which is located at the kerb of a busy road in the nearby city of Cambridge, is included for comparison. This site (like many other urban roadside sites in the UK) has consistently recorded annual mean NO₂ concentration in excess of 40µg m⁻³, and substantially higher concentrations than either of the Stansted sites.

Concentrations of PM₁₀ at Stansted 3 have historically been higher than local urban background sites, both in London and regionally. Unlike with NO₂, concentrations of PM₁₀ at Stansted 3 are more comparable to the Heathrow monitoring site. As discussed in Section 4.4 the PM₁₀ concentrations measured at the site are heavily influenced by sources other than the airport. This will be contributing to the elevated concentrations seen at the site. Since 2006 the annual mean concentrations of PM₁₀ at Stansted 3 have reduced by 4 µg/m³.

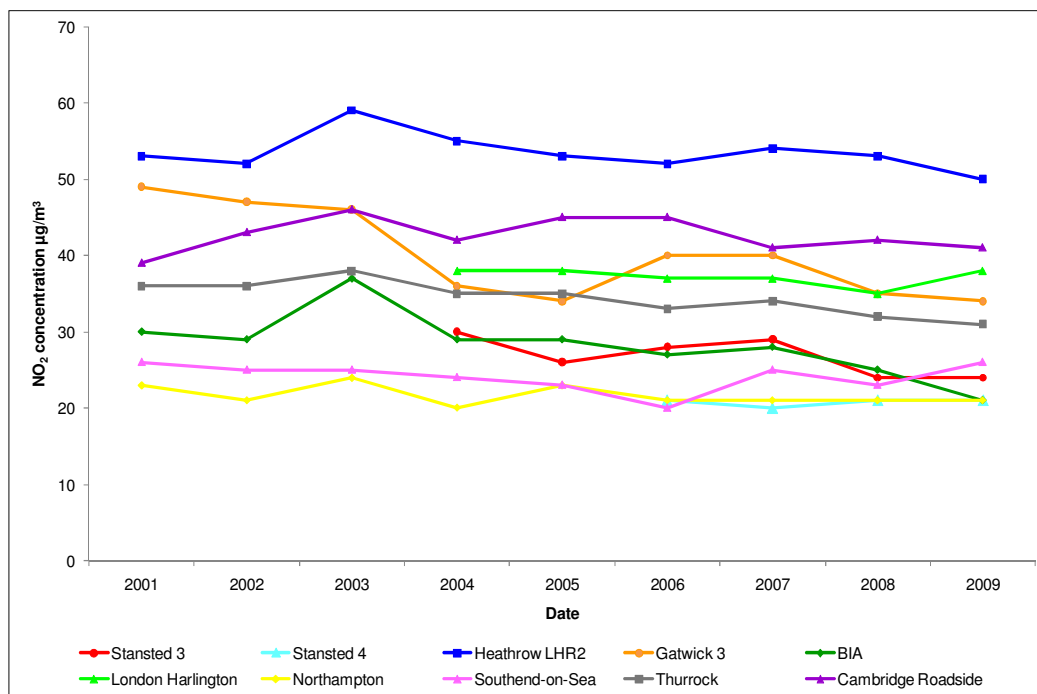


Figure 13 Annual mean trend NO₂ concentrations at Stansted 3, Stansted 4 and other regional monitoring sites.

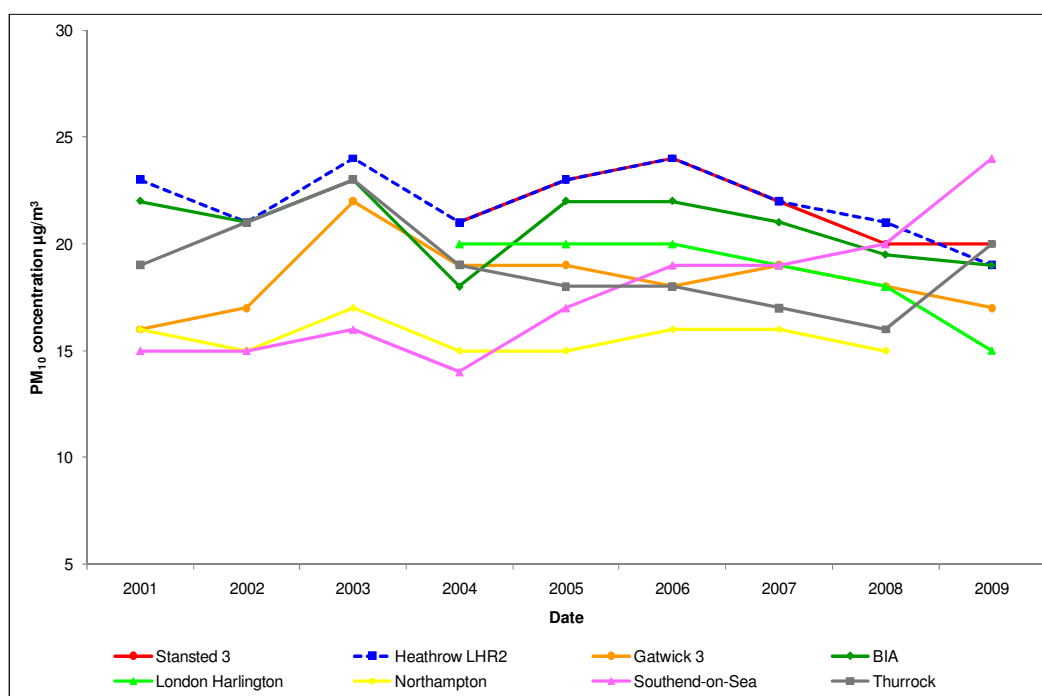


Figure 14 Annual mean trend PM₁₀ concentrations at Stansted 3 and other regional monitoring sites.

5 Conclusions

This report describes results from the ongoing air pollution monitoring programme undertaken at Stansted Airport during calendar year 2009. This was the fourth year in which ongoing continuous monitoring (as opposed to a series of short-term monitoring programmes) has been undertaken. Oxides of nitrogen, PM₁₀ and a range of hydrocarbon species were measured using automatic techniques at two sites and diffusive samplers at four other sites.

The following conclusions have been drawn from the 2000 dataset:

1. The data capture target of least 90% was achieved for all pollutants measured at both sites.
2. Both automatic monitoring sites (Stansted 3 and 4) met the AQS Objectives for hourly mean NO₂ and also for annual mean NO₂. Stansted 4 saw 13 exceedences of the hourly Objective which is within the allowable limit of 18 exceedences.
3. All of the exceedences of the NO₂ Objective at Stansted 4 look to be associated with the diesel-powered emergency generator located nearby. They all occur without any corresponding increase in concentrations at Stansted 3 and are therefore highly localised events. They also all coincide with wind directions from the north to west quadrant which is from the direction of the generator.
4. All five NO₂ diffusion tube sites met the AQS Objective for annual mean NO₂. The Stansted East site, at Enterprise House (which was “borderline” last year with respect to the Objective) was well within the Objective in 2008.
5. PM₁₀ was measured at Stansted 3: this site met the AQS Objectives for daily mean and annual mean PM₁₀ concentration.
6. NO and NO₂ concentrations were higher during the winter months: this is a fairly typical pattern for urban sites. There were no clear patterns in seasonal PM₁₀ concentrations.
7. “BTEX” diffusion tubes were deployed at five sites on a monthly basis, measuring benzene, toluene, ethylbenzene and xylenes. Benzene concentrations at all five sites were less than 1 µg m⁻³, and well within the AQS Objective for the running annual mean for benzene, to be achieved by 2010.
8. The diurnal variation of NO and NO₂ concentrations showed a pattern similar to that observed at other urban monitoring sites with the peak concentrations coinciding with the morning and evening rush hour period. By contrast, levels of PM₁₀ showed a much less pronounced diurnal pattern.
9. An investigation into the source of pollutants found that NO₂ concentrations measured at Stansted 3 and Stansted 4 originated mainly for emissions from the airports whilst elevated PM₁₀ concentrations were caused by emissions from predominantly non-airport sources.
10. Annual mean concentrations of NO₂ at Stansted 4 have been consistently comparable with the urban background concentrations measured at Southend-on-Sea and Northampton. Concentrations at Stansted 3 have historically been slightly higher than these urban background concentrations but these have been reducing and the 2008 and 2009 annual mean concentrations have been more in line with the urban background concentrations.

6 Recommendations

The following recommendations will improve the future quality of data and data analysis at Stansted airport:

1. Investigate the relocation of the Stansted 4 monitoring site to avoid the high NO_x peaks recorded at this site due to emissions from the diesel generator. Relocation of Stansted 4 outside of the airport security perimeter would also enhance access to the site for routine and, more crucially, non-routine site visits. If movement of the site is not possible then keeping a log of the use of the generator will ensure we can say with 100% confidence that the peaks are associated with the generator use.
2. Keep a database of the hourly wind direction and wind speed data recorded at Stansted. This will enhance the accuracy of the directional analysis for future years.
3. AEA understand that there is interest in undertaking an assessment of the impact of the airport on the nearby Hatfield Forest. This could be undertaken using a transect of NO₂ diffusion tubes sites in a southerly direction away from the airport.
4. An upgrade of the power supply to Stansted 3 would improve the data capture rates for this site. We understand work on this is underway or has been completed.

AEA will continue to keep a watching brief on any developments in air quality monitoring techniques and policy guidance and will update Stansted Airport Ltd of any relevant changes.

7 Acknowledgements

AEA would like to thank Stansted Airport Ltd, and in particular Andy Jefferson, for assistance with this monitoring study.

8 References

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Appendices

Appendix 1: Air Quality Standards and Objectives

Appendix 2: Monitoring Apparatus and Techniques

Appendix 3: Quality Assurance and Quality Control

Appendix 4: NO₂ Diffusion Tubes – Full Dataset

Appendix 4: BTEX Diffusion Tubes – Full Dataset

Appendix 1

Air Quality Standards and Objectives

Table A1.1 UK Air Quality Objectives for protection of human health, July 2007. New objectives (added in 2007) highlighted in shading.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene			
All authorities	16.25 $\mu\text{g m}^{-3}$	Running annual mean	31.12.2003
England and Wales only	5.00 $\mu\text{g m}^{-3}$	Annual mean	31.12.2010
Scotland and Northern Ireland	3.25 $\mu\text{g m}^{-3}$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu\text{g m}^{-3}$	Running annual mean	31.12.2003
Carbon monoxide			
England, Wales & N. Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31.12.2003
Scotland only	10.0 mg m^{-3}	Running 8-hour mean	31.12.2003
Lead			
	0.5 $\mu\text{g m}^{-3}$	Annual mean	31.12.2004
	0.25 $\mu\text{g m}^{-3}$	Annual mean	31.12.2008
Nitrogen dioxide			
	200 $\mu\text{g m}^{-3}$ not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 $\mu\text{g m}^{-3}$	Annual mean	31.12.2005
Particles (gravimetric) (PM₁₀)			
All authorities	50 $\mu\text{g m}^{-3}$, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 $\mu\text{g m}^{-3}$	Annual mean	31.12.2004
Scotland only	50 $\mu\text{g m}^{-3}$, not to be exceeded more than 7 times a year	24-hour mean	31.12.2010
	18 $\mu\text{g m}^{-3}$	Annual mean	31.12.2010
Particles (gravimetric) * (PM_{2.5})			
All authorities	25 $\mu\text{g m}^{-3}$ (target)	Annual mean	2020
	15% cut in urban background exposure	Annual mean	2010 - 2020
Scotland only	12 $\mu\text{g m}^{-3}$ (limit)	Annual mean	2010
Sulphur dioxide			
	350 $\mu\text{g m}^{-3}$, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 $\mu\text{g m}^{-3}$, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 $\mu\text{g m}^{-3}$, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005
PAH *	0.25 ng m^{-3}	Annual mean	31.12.2010
Ozone *	100 $\mu\text{g m}^{-3}$ not to be exceeded more than 10 times a year	Daily maximum of running 8-hour mean	31.12.2005

* not included in regulations at present.

Table A1.2 UK air quality objectives for protection of vegetation and ecosystems, July 2007.
New objectives highlighted in shading

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen dioxide (for protection of vegetation & ecosystems) *	30 $\mu\text{g m}^{-3}$	Annual mean	31.12.2000
Sulphur dioxide (for protection of vegetation & ecosystems) *	20 $\mu\text{g m}^{-3}$	Annual mean	31.12.2000
	20 $\mu\text{g m}^{-3}$	Winter average (Oct-Mar)	31.12.2000
Ozone *	18 mg m^{-3}	AOT40 ⁺ , calculated from 1h values May-July. Mean of 5 years, starting 2010	01.01.2010

* Not included in regulations at present

⁺ AOT 40 is the sum of the differences between hourly concentrations greater than 80 $\mu\text{g m}^{-3}$ (=40ppb) and 80 $\mu\text{g m}^{-3}$, over a given period using only the 1-hour averages measured between 0800 and 2000.

Conversion factors from volumetric to mass concentration measurement for gaseous pollutants are provided below:

NO 1 ppb = 1.25 $\mu\text{g m}^{-3}$
 NO₂ 1 ppb = 1.91 $\mu\text{g m}^{-3}$
 O₃ 1 ppb = 2.00 $\mu\text{g m}^{-3}$
 C₆H₆ (benzene) 1 ppb = 3.25 $\mu\text{g m}^{-3}$
 C₇H₈ (toluene) 1 ppb = 3.83 $\mu\text{g m}^{-3}$
 C₈H₁₀ (xylene) 1 ppb = 4.41 $\mu\text{g m}^{-3}$
 PM₁₀ indicative gravimetric equivalent = PM₁₀ as measured by TEOM x1.3 (at 20°C and 1atmosphere (101.3 kPa) pressure).

In this report, the mass concentration of NO_x has been calculated as follows:

$$\text{NO}_x \mu\text{g m}^{-3} = (\text{NO ppb} + \text{NO}_2 \text{ ppb}) * 1.91.$$

This conforms with the requirements of the Ambient Air Quality Directive² and is also the convention generally adopted in air quality modelling.

Table A1.3 Defra Air Pollution Bands and Index Values

Air Quality Bands and Index Values for NO ₂		
Band	Index	Nitrogen Dioxide µg m ⁻³
Low	1	0-95
	2	96-190
	3	191-286
Moderate	4	287-381
	5	382-477
	6	478-572
High	7	573-635
	8	636-700
	9	701-763
Very High	10	764 or more

Air Quality Bands and Index Values for PM ₁₀ (Gravimetric equivalent)		
Band	Index	PM ₁₀ µg m ⁻³ (Gravimetric equivalent)
Low	1	0-21
	2	22-42
	3	43-64
Moderate	4	65-74
	5	75-86
	6	87-96
High	7	97-107
	8	108-118
	9	119-129
Very High	10	130 or more

Air Quality Bands and Index Values for PM ₁₀ (Reference equivalent)		
Band	Index	PM ₁₀ µg m ⁻³ (Reference equivalent)
Low	1	0-19
	2	20-40
	3	41-62
Moderate	4	63-72
	5	73-84
	6	85-94
High	7	95-105
	8	106-116
	9	117-127
Very High	10	128 or more

Appendix 2

Monitoring Apparatus and Techniques

Monitoring Equipment

Continuous automatic analysers for monitoring NO, NO₂ and PM₁₀ were selected, in order to provide real-time data. The analysers use the operating principles listed below: these represent the current state-of-the-art techniques for ambient monitoring of these species.

NO, NO₂: chemiluminescence with ozone

PM₁₀: tapered element oscillating microbalance

Each analyser provides a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15 minute average values by the on-site data logger. This logger is connected to a modem and interrogated twice daily, by telephone, to download the data to AEA. The data are then converted to concentration units and averaged to hourly mean concentrations.

Each gas analyser is equipped with an automatic calibration system, which is triggered daily under the control of the data logger. Fully certificated calibration gas cylinders are also used at each site for manual calibration.

The PM₁₀ TEOM analyser cannot be calibrated in the same way as the gas analysers and these data are scaled using the results of 6-monthly checks. In these checks, the flow rate through the analyser is measured and the mass determination checked with pre-weighed filters.

The TEOM monitoring method uses a 50°C heated sample inlet in order to prevent moisture from contaminating the filter. Many studies have shown that this elevated temperature results in the loss of volatile and semi-volatile components of PM₁₀. Secondary particles such as ammonium nitrate for example, are known to evaporate below 50°C. Until recently, Government advice was that TEOM results could be converted to indicative gravimetric equivalent measurements by applying a factor of 1.3.

However, the conclusion of equivalence trials published in 2006 was that the TEOM did not meet the equivalence criteria, even with correction factors applied. (See "UK Particulate Monitoring Equipment Study" report by Bureau Veritas, at http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf).

To solve this problem, King's College London (KCL) have developed a Volatile Correction Model, which allows TEOM PM₁₀ data to be corrected for the volatile components lost as a result of the TEOM's heated inlet. The model is available at <http://www.volatile-correction-model.info/Default.aspx>. It uses data from nearby particulate analysers of the FDMS TEOM type, which measure the volatile component of the PM₁₀. This volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. **KCL state on the VCM website home page that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.** This is the preferred method of dealing with TEOM data when comparing them to air quality limit values and objectives, and has been used for this purpose in the present report.

All of the air monitoring equipment at both sites is housed in purpose-built enclosures.

Appendix 3

Quality Assurance and Quality Control

Quality Assurance and Quality Control

AEA operates air quality monitoring stations within a tightly controlled and documented quality assurance and quality control (QA/QC) system. Elements covered within this system include; definition of monitoring objectives, equipment selection, site selection, protocols for instrument operation calibration, service and maintenance, integrity of calibration gas standards, data review, scrutiny and validation.

All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards at the Gas Standards Calibration Laboratory at AEA. The calibration laboratory operates within a specific and documented quality system and has UKAS accreditation for calibration of the gas standards used in this survey.

An important aspect of QA/QC procedures is the regular 6-monthly intercalibration and audit check undertaken at every monitoring site. This audit has two principle functions, firstly to check the instruments and the site infrastructure, and secondly to recalibrate the transfer gas standards routinely used on-site, using standards recently checked in the calibration laboratory. AEA's audit calibration procedures are UKAS accredited to ISO 17025.

In line with current operational procedures within the Defra Automatic Urban and Rural Network (AURN), full intercalibration audits take place at the end of winter and summer. At these visits, the essential functional parameters of the monitors, such as noise, linearity and, for the NO_x monitor, the efficiency of the NO₂ to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked.

All air pollution measurements are reviewed on a daily basis, at AEA, by experienced staff. Data are compared with corresponding results from AURN monitoring stations and with expected air pollutant concentrations under the prevailing meteorological conditions. This review process rapidly highlights any unusual or unexpected measurements, which may require further investigation. When such data are identified, attempts are made to reconcile the data against known or possible local air pollution sources or local meteorology, and to confirm the correct operation of all monitors. In addition to checking the data, the results of the daily automatic instrument calibrations (see Appendix 2) are examined to identify any possible instrument faults. Should any faults be identified or suspected, arrangements are made for AEA personnel or equipment service contractors to visit the site, as soon as possible.

At the end of every quarter, the data for that period are reviewed to check for any spurious values and to apply the best daily zero and sensitivity factors, and to account for information which only became available after the initial daily processing. At this time, any data gaps are filled with data from the data logger back-up memory, or occasionally the chart recorder record, to produce as complete as possible a data record.

Finally, the data are re-examined on an annual basis, when information from the 6-monthly intercalibration audits can be incorporated. After completion of this process, the data are fully validated and finalised, for compilation in the annual report.

Following these 3-stage data checking and review procedures allows the overall accuracy and precision of the data to be calculated. The accuracy and precision figures for the pollutants monitored at Stansted are summarised below.

Estimated Accuracy and Precision of the Data Presented

	Precision	Accuracy
Nitric Oxide (NO)	$\pm 2.5 \mu\text{g m}^{-3}$	$\pm 15\%$
Nitrogen Dioxide (NO ₂)	$\pm 6.9 \mu\text{g m}^{-3}$	$\pm 15\%$
Particles (PM ₁₀)	$\pm 4 \mu\text{g m}^{-3}$ *	

* accuracy of particle measurements cannot currently be assessed.

Appendix 4

NO₂ Diffusion Tubes – full dataset

Results are quoted here to 1 decimal place as quoted by the analyst. However, given the uncertainty of diffusion tube measurements, they are rounded to the nearest integer in the main part of the report.

Table A4.1 Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted North (Runway lights, 23 Approach) ($\mu\text{g m}^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
07/01/2009	30.3	34.3	39.3	34.4	Tube 3 rejected - high outlier
09/02/2009	1.3	12.2	20.7	11.4	Large spread in results
04/03/2009	21.0	23.4	25.2	23.2	
06/04/2009	20.5	23.1	20.4	21.3	
29/04/2009	18.6	17.1	18.0	17.9	
01/06/2009	9.7	10.1	10.2	10.0	
02/07/2009	24.7	25.8	26.2	25.6	
27/07/2009	17.9	17.8	18.2	18.0	
02/09/2009	14.8	16.6	16.3	15.9	
29/09/2009	25.3	25.1	29.0	26.5	
05/11/2009	33.2	36.5	37.6	35.7	
02/12/2009	25.1	27.6	30.5	27.8	
Mean	20.2	22.5	24.3	22.3	

Table A4.2 Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted East (Enterprise House) ($\mu\text{g m}^{-3}$)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
07/01/2009	29.4	50.6	51.8	51.2	Tube 1 rejected - low outlier
09/02/2009	28.0	27.6	28.7	28.1	
04/03/2009	38.6	41.7	40.9	40.4	
06/04/2009	37.1	33.1	34.6	34.9	
29/04/2009	31.8	29.4	30.9	30.7	
01/06/2009	23.4	23.2	23.2	23.3	
02/07/2009	28.9	-	34.4	31.6	Missing tube
27/07/2009	25.9	25.5	26.9	26.1	
02/09/2009	30.4	27.2	31.0	29.5	
29/09/2009	38.8	37.7	43.8	40.1	
05/11/2009	33.4	38.2	36.6	36.1	
02/12/2009	34.4	40.2	35.8	36.8	
Mean	31.9	34.0	34.9	33.5	

Table A4.3 Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted South (Balancing Pond “B”) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
07/01/2009	-	-	-	-	Tubes missing
09/02/2009	-	-	-	-	Tubes missing
04/03/2009	32.5	33.5	32.9	32.9	
06/04/2009	23.9	26.0	26.5	25.5	
29/04/2009	16.5	17.6	17.3	17.1	
01/06/2009	23.7	24.2	23.9	23.9	
02/07/2009	24.6	24.3	22.9	23.9	
27/07/2009	19.0	20.2	20.3	19.8	
02/09/2009	30.2	29.5	27.9	29.2	
29/09/2009	29.4	34.6	32.5	32.2	
05/11/2009	30.4	31.7	28.4	30.1	
02/12/2009	32.3	34.1	32.9	33.1	
Mean	26.3	27.6	26.6	26.8	

Table A4.4 Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted West (Ground Radar Tower) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
07/01/2009	44.6	39.9	37.6	40.7	
09/02/2009	8.7	17.9	10.6	9.7	Tube 2 rejected – high outlier
04/03/2009	-	21.0	22.3	21.7	Missing tube
06/04/2009	26.4	23.0	24.4	24.6	
29/04/2009	18.1	16.5	15.2	16.6	
01/06/2009	14.5	14.4	13.0	14.0	
02/07/2009	15.2	17.8	17.9	17.0	
27/07/2009	17.2	17.7	17.7	17.5	
02/09/2009	12.8	15.2	13.0	13.6	
29/09/2009	28.2	27.1	26.2	27.2	
05/11/2009	29.6	26.8	23.4	26.6	
02/12/2009	25.9	22.7	24.7	24.4	
Mean	20.8	21.5	20.1	20.5	

Table A4.5 Monthly mean NO₂ concentrations as measured by diffusion tubes, Stansted 3 (High House) (µg m⁻³)

Start date	Tube 1	Tube 2	Tube 3	Mean	Comments
07/01/2009	34.9	37.2	30.7	34.2	
09/02/2009	27.0	23.8	28.0	26.3	
04/03/2009	32.8	25.9	26.2	26.1	Tube 1 rejected – high outlier
06/04/2009	25.9	23.3	24.0	24.4	
29/04/2009	18.3	18.0	19.2	18.5	
01/06/2009	18.8	18.7	18.4	18.6	
02/07/2009	20.1	16.7	18.5	18.4	
27/07/2009	18.0	17.6	19.3	18.3	
02/09/2009	23.0	23.8	25.3	24.1	
29/09/2009	30.6	28.7	30.7	30.0	
05/11/2009	26.3	26.3	25.0	25.9	
02/12/2009	30.1	23.4	31.1	30.6	Tube 2 rejected – low outlier
Mean	24.8	23.6	24.7	24.6	

Appendix 5

BTEX Diffusion Tubes – full dataset

Table A5.1 Monthly Hydrocarbon concentrations at Stansted North – 23 Approach
($\mu\text{g m}^{-3}$)

Period Sampled		Pollutant/ Concentration $\mu\text{g m}^{-3}$				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
07/01/2009	09/02/2009	1.09	1.21	0.25	0.76	0.28
09/02/2009	04/03/2009	0.28	0.56	0.13	0.31	0.08
04/03/2009	06/04/2009	0.84	0.97	0.39	0.62	0.17
06/04/2009	29/04/2009	0.72	0.74	0.35	0.44	0.05
29/04/2009	01/06/2009	0.60	0.66	0.47	0.51	0.09
01/06/2009	02/07/2009	0.55	0.49	0.35	0.36	0.08
02/07/2009	27/07/2009	0.45	0.73	0.36	0.59	0.19
27/07/2009	02/09/2009	0.58	0.99	0.50	0.91	0.38
02/09/2009	29/09/2009	0.48	0.59	0.34	0.56	0.30
29/09/2009	05/11/2009	0.58	1.22	0.32	0.82	0.40
05/11/2009	02/12/2009	1.53	2.09	1.37	3.00	0.90
02/12/2009	19/01/2010	0.65	1.02	0.24	0.42	0.17
Annual Mean		0.70	0.94	0.42	0.78	0.26

Table A5.2 Monthly Hydrocarbon concentrations at Stansted East – Enterprise House
($\mu\text{g m}^{-3}$)

Period Sampled		Pollutant/ Concentration $\mu\text{g m}^{-3}$				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
07/01/2009	09/02/2009	1.31	1.92	0.55	1.38	0.54
09/02/2009	04/03/2009	1.00	1.32	0.42	1.08	0.42
04/03/2009	06/04/2009	0.99	3.77	1.79	2.84	1.01
06/04/2009	29/04/2009	0.58	1.50	0.40	0.85	0.35
29/04/2009	01/06/2009	0.53	1.34	0.37	0.83	0.25
01/06/2009	02/07/2009	0.55	1.00	0.40	0.76	0.26
02/07/2009	27/07/2009	0.83	1.35	0.63	1.29	0.50
27/07/2009	02/09/2009	0.71	1.27	0.47	0.93	0.43
02/09/2009	29/09/2009	0.87	1.22	0.54	0.95	0.33
29/09/2009	05/11/2009	0.58	1.56	0.42	1.12	0.36
05/11/2009	02/12/2009	0.85	1.52	0.63	1.10	0.52
02/12/2009	19/01/2010	1.22	1.54	0.40	0.84	0.43
Annual Mean		0.84	1.61	0.59	1.16	0.45

Table A5.3 Monthly Hydrocarbon concentrations at Stansted South – Pond B
($\mu\text{g m}^{-3}$)

Period Sampled		Pollutant/ Concentration $\mu\text{g m}^{-3}$				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
07/01/2009	09/02/2009	1.14	1.42	0.34	0.82	0.38
09/02/2009	04/03/2009	0.31	0.06	0.10	<L.O.D.	<L.O.D.
04/03/2009	06/04/2009	0.84	1.96	0.45	0.88	0.29
06/04/2009	29/04/2009					
29/04/2009	01/06/2009					
01/06/2009	02/07/2009	0.36	1.11	0.49	2.00	0.87
02/07/2009	27/07/2009	0.73	1.32	0.49	0.43	0.19
27/07/2009	02/09/2009	0.38	0.87	0.29	0.60	0.29
02/09/2009	29/09/2009	0.82	2.48	1.01	1.44	0.65
29/09/2009	05/11/2009	0.60	1.39	0.31	0.96	0.38
05/11/2009	02/12/2009	1.50	1.98	0.72	1.15	0.41
02/12/2009	19/01/2010	0.52	1.42	0.33	0.48	0.25
Annual Mean		0.72	1.28	0.45	0.97	0.41

<L.O.D. – below the Limit of Detection

BTEX tubes for periods beginning 06/04/2009 and 29/04/2009 (April and May) were found upside down so the results have been rejected.

Table A5.4 Monthly Hydrocarbon concentrations at Stansted West – Ground Radar
($\mu\text{g m}^{-3}$)

Period Sampled		Pollutant/ Concentration $\mu\text{g m}^{-3}$				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
07/01/2009	09/02/2009	0.14	<L.O.D.	0.04	<L.O.D.	<L.O.D.
09/02/2009	04/03/2009	0.83	0.76	0.23	0.53	0.22
04/03/2009	06/04/2009	0.89	0.83	0.46	0.58	0.13
06/04/2009	29/04/2009	0.71	1.49	0.31	0.27	<L.O.D.
29/04/2009	01/06/2009	0.46	0.67	0.27	0.38	0.06
01/06/2009	02/07/2009	0.44	1.09	0.38	0.47	0.04
02/07/2009	27/07/2009	0.52	0.60	0.42	0.51	0.14
27/07/2009	02/09/2009	0.58	0.72	0.35	0.55	0.26
02/09/2009	29/09/2009	0.56	1.00	0.68	0.98	0.43
29/09/2009	05/11/2009	0.60	1.22	0.32	0.82	0.37
05/11/2009	02/12/2009	1.58	2.86	1.14	1.09	0.29
02/12/2009	19/01/2010	0.37	1.12	0.22	0.29	0.10
Annual Mean		0.64	1.12	0.40	0.59	0.20

<L.O.D. – below the Limit of Detection

Table A5.5 Monthly Hydrocarbon concentrations at Stansted 3 – High House ($\mu\text{g m}^{-3}$)

Period Sampled		Pollutant/ Concentration $\mu\text{g m}^{-3}$				
Date on	Date off	Benzene	Toluene	Ethyl Benzene	m, p-Xylene	o-Xylene
07/01/2009	09/02/2009	1.23	2.07	0.46	0.92	0.35
09/02/2009	04/03/2009	1.26	1.26	0.58	0.89	0.47
04/03/2009	06/04/2009	0.87	1.20	0.39	0.82	0.21
06/04/2009	29/04/2009	0.91	0.95	0.50	0.60	0.26
29/04/2009	01/06/2009	0.44	0.92	0.28	0.35	0.12
01/06/2009	02/07/2009	0.53	0.86	0.42	0.60	0.12
02/07/2009	27/07/2009	0.82	2.69	0.66	0.73	0.45
27/07/2009	02/09/2009	0.56	0.97	0.47	0.83	0.30
02/09/2009	29/09/2009	0.77	0.96	0.50	0.79	0.28
29/09/2009	05/11/2009	0.62	1.39	0.30	0.91	0.39
05/11/2009	02/12/2009	0.23	0.17	0.40	0.12	0.38
02/12/2009	19/01/2010	0.99	1.09	0.20	0.37	0.24
Annual Mean		0.77	1.21	0.43	0.66	0.30



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