

Air Quality Annual Review 2008



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Summary

The City of London Corporation monitors air quality throughout the year at thirteen separate locations. The City has a statutory duty to monitor air quality and compare the levels of pollution to health based standards that have been prescribed in regulations. This report presents the data that was collected in 2008 and compares it to previous years in order to assess long term trends.

In February 2008, the first phase of the London Low Emission Zone was introduced. All Lorries over 12 tonnes in London are required to meet a standard of Euro III for particulate matter. From July 2008, a standard of Euro III for particulate matter for Lorries between 3.5 and 12 tonnes, and buses and coaches over 5 tonnes, was introduced. It is too early to assess the effect that this action has had on particulate levels in the City.

Being situated at the heart of London, the City experiences some of the worst air quality in the Country. The whole of the City was declared an Air Quality Management Area in 2001 as a result of the ongoing problems with fine particles (PM₁₀) and nitrogen dioxide. Concentrations of these two pollutants are affected by the weather. The unsettled weather patterns that existed in the UK in both 2007 and 2008, with higher than average rainfall, gave rise to lower levels of pollution than would be expected. However, nitrogen dioxide levels were still high, exceeding the air quality objective at almost all locations. Concentrations of fine particles were the lowest they have been since monitoring began in 1999, but continue to exceed the 24-hour objective at busy roadside locations.

The main findings for 2008 are summarised below:

- The annual average government air quality objective for nitrogen dioxide was exceeded at all five of the City's continuous monitoring sites. Both background and roadside concentrations were higher than for 2007. The hourly average government objective was exceeded by a large margin at the roadside locations of Beech Street and Walbrook Wharf. Nitrogen dioxide was also monitored using diffusion tubes. These are less accurate than continuous analysers. Four of the five sites had concentrations that exceeded the annual average air quality objective. For the first time since 2002, concentrations of nitrogen dioxide at the Barbican were just below the air quality objective.
- Particulate matter was monitored at Beech Street, Upper Thames Street and Sir John Cass School. All three sites complied with the annual average objective. However, the 24-hour average PM₁₀ air quality objective was exceeded at Upper Thames Street.
- The running 8-hour average ozone standard was exceeded just 9 times during 2008, with an annual average concentration of 32.9 µg m⁻³.
- Concentrations of carbon monoxide and sulphur dioxide were low throughout the year, and complied with government air quality objectives. Carbon monoxide concentrations were slightly higher than in 2007. The overall trend however, is a continuous decline. Similarly, since monitoring began in 1968, sulphur dioxide concentrations have been decreasing year on year and continue to be very low.
- Benzene was monitored at Mansion House and Upper Thames Street. Concentrations of the hydrocarbon continue to be well below the government air quality objectives and the overall trend is a continuous decline.

1. Introduction

1.1 Air Quality in the City

The City of London experiences some of the worst air quality in the UK. This is primarily due to the density of development and its geographical location. Road traffic is the main source of pollution, supplemented by commercial and domestic heating. Pollutants generated by traffic largely consist of hydrocarbons, nitrogen oxides, particulates and carbon monoxide. There are no industrial sources of pollution in the City. Being located at the heart of London, the City is heavily influenced by pollution generated in neighbouring authorities and across London as a whole. The South-East of England is also affected by pollutants, particularly fine particles, which originate in continental Europe.

1.2 Air Quality Management

In 1997 the Government published a National Air Quality Strategy for the UK. The aim of the strategy was to create a more strategic and integrated approach to air quality management. The Strategy was updated in 2007 and can be found on the following web site www.defra.gov.uk/environment/airquality/strategy

The 2007 Air Quality Strategy includes a new standard for PM_{2.5} (very fine particles considered most hazardous to health). It is anticipated that objectives for this pollutant will be transposed into regulations some time during 2009.

Under Part IV of the Environment Act 1995, local authorities are required to assess air quality, and to identify areas where air quality is unlikely to meet objectives prescribed in the Air Quality (England) Regulations 2000. Objectives have been set for seven pollutants: carbon monoxide (CO), benzene, 1, 3-butadiene, nitrogen dioxide (NO₂), lead, sulphur dioxide (SO₂) and PM₁₀ (fine particles ≤10 µm in diameter). The objectives are outlined in Appendix 1. If the objectives are not achieved, local authorities must declare Air Quality Management Areas and produce action plans indicating the action they propose to take in pursuit of better air quality.

The City 'Stage 1 and 2 Air Quality Review and Assessment' was published in September 1998. The review identified three pollutants with potential to result in an exceedence of the air quality objectives: nitrogen dioxide, fine particles and sulphur dioxide. Further work for Stage 3 of the Review and Assessment process concluded that just nitrogen dioxide and fine particles were likely to exceed the objectives. Consequently, the whole of the City was declared an Air Quality Management Area in January 2001 for these two pollutants. The need for an Air Quality Management Area was confirmed in the Stage 4 Review and Assessment published in June 2002. The City subsequently published an Air Quality Action Plan in 2003 with a view to improving air quality in the City. All documents can be viewed on the City web site: www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Pollution/air+quality.htm.

The Mayor of London has also produced an Air Quality Strategy with a view to improving air quality across the whole of London. A copy of the strategy can be found on the GLA web site at www.london.gov.uk/mayor/environment/air_quality/index.jsp. The Strategy is being updated and the first draft is expected summer 2009.

1.3 Health Effects of Air Pollution

Exposure to air pollution can have both acute (short-term) and chronic (long-term) impacts on human health. Some people are more susceptible to the effects of air pollution than others, particularly those with pre-existing heart or lung disease, young children and the elderly. The City operates a free pollution alert service called airTEXT. The airTEXT service alerts people to pollution and gives health advice so that they may take steps to reduce the likelihood of any impacts. More information and registration details can be viewed on the website: www.airtext.info

Healthy people are unlikely to show symptoms, even at the high pollution levels that are sometimes experienced in London. The general health impacts of major forms of air pollution are outlined in Appendix 2.

2. Air Quality Monitoring in the City

2.1 Background to Monitoring in the City

The City of London has been monitoring air quality in the City since the late 1960's. Monitoring initially focussed on sulphur dioxide and black smoke in response to the introduction of the Clean Air Acts. As the main source of pollution changed from industry and coal burning to road vehicles, the type of air quality monitoring undertaken has altered to reflect this.

As the City is an Air Quality Management Area for nitrogen dioxide and fine particles, air quality monitoring in the City focuses on these pollutants. However, other pollutants such as carbon monoxide, sulphur dioxide and benzene are monitored to ensure continuing compliance with the respective objectives. The monitoring requirements of the City are regularly reviewed.

All monitoring is subject to quality assurance and quality control procedures. Details of these procedures can be found in the Review and Assessment reports undertaken as part of the air quality management process. All documents are available on the City of London web site.

2.2. Air Quality Monitoring in 2008

Table 2.2.1 gives a summary of the monitoring that was undertaken in the City during 2008 using continuous analysers. All data from the continuous analysers has been ratified and data capture information is provided for each site and each pollutant.

TABLE 2.2.1: AIR QUALITY MONITORING USING CONTINUOUS ANALYSERS

Monitoring Site	Site Classification	Nitrogen Dioxide	Fine Particles (PM ₁₀)	Carbon Monoxide	Sulphur Dioxide	Ozone
Beech Street	Roadside (1m from kerb)	✓	✓			
Walbrook Wharf	Roadside (2m from kerb)	✓		✓		
Senator House	Urban background	✓			✓	✓
Walbrook Rooftop	Urban Background	✓				
Sir John Cass School	Urban Background	✓	✓			
Upper Thames Street	Roadside (2m from kerb)		✓			

Footnote

- Kerbside A site sampling within 1 metre of the edge of a busy road
- Roadside A site sampling within 1 and 5 meters of the edge of a busy road
- Urban Background An urban location distanced from sources, therefore broadly representative of citywide background conditions e.g. elevated locations, parks and residential areas
- Urban Centre A non-kerbside site in an area representative of typical population exposure, e.g. pedestrian precinct, shopping centre

Data from three of the monitoring sites in the City (Senator House on Queen Victoria Street, Walbrook Wharf Foyer and Sir John Cass School) form part of the London Air Quality Network (LAQN). The LAQN was formed in 1993 to co-ordinate and improve air pollution monitoring in London. The LAQN is operated and managed by the [Environmental Research Group \(ERG\) at King's College London](#). Data from the particulate monitor in Upper Thames Street will be added to the LAQN in 2009.

Nitrogen dioxide and benzene are monitored using diffusion tubes. When compared to continuous analysers, diffusion tubes are not a very accurate way of monitoring air quality, and can only be used to provide an estimate of annual average concentrations. Nitrogen dioxide tubes are exposed for a month, and benzene for two weeks in each month. The tubes are collected and sent away to a laboratory for analysis.

The nitrogen dioxide tubes are prepared using 50% TEA v/v in acetone and are analysed by the UKAS accredited laboratory Gradko International Ltd who fully ratify the data. The nitrogen dioxide diffusion tube data for 2008 has also been adjusted for laboratory bias using a factor of 0.93 (provided by Bureau Veritas).

The diffusion tube sites are presented in table 2.2.2. The number of nitrogen dioxide and benzene diffusion tubes was scaled down in April 2007. Diffusion tube sites that are no longer active are indicated with a (*) symbol.

Table 2.2.2: Diffusion Tube Sites in the City

Location	Nitrogen Dioxide	Benzene, Toluene and Xylene	Site classification
London Bridge	✓*	✓	Roadside
St Andrews by the Wardrobe, Queen Victoria Street	✓	✓*	Roadside
St Dunstons, Fleet Street	✓	✓*	Roadside
Amen Corner	✓*		Roadside
St Paul's Churchyard	✓*	✓*	Urban centre
St Bartholomew's Hospital	✓	✓*	Urban centre
Goswell Road	✓*	✓*	Roadside
Silk Street	✓*		Roadside
Speed House, Barbican	✓		Urban background
Pleach Walk, Barbican	✓*	✓*	Urban background
Harrow Place	✓*	✓*	Roadside
Finsbury Circus		✓*	Urban centre
Mansion House	✓*	✓	Kerbside
Mansell Street	✓		Roadside

Figure 2.2.1 shows the locations of the current monitoring in the City

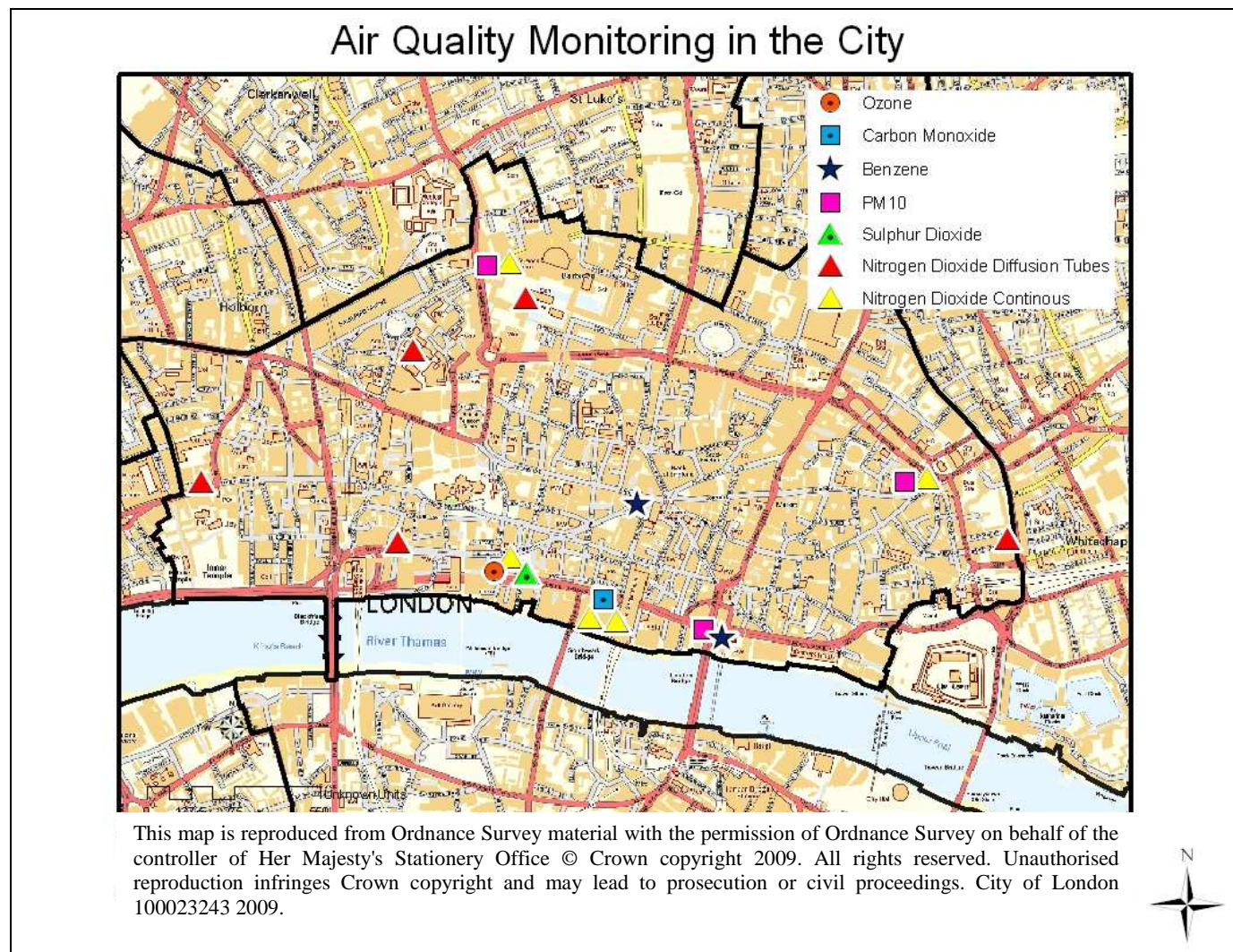


Figure 2.2.1

3. Air Quality Results

3.1 Seasonal Variation

There are general seasonal trends in air quality related to weather conditions. The air quality in summer and winter tends to be slightly worse than in autumn and spring. This is generally due to the following conditions:

- **Summer:** In summer, sunlight reacts with pollution from vehicles, petrol and other industrial sources, and fuel used for heating and cooling. The action of sunlight on these pollutants produces low-level ozone and increased levels of nitrogen dioxide and fine particles.
- **Winter:** In winter, pollution from vehicles and fuel from heating build up at ground level and can become trapped when the air above the city is warmer than the air at ground level. This action effectively forms a lid that prevents the pollution from dispersing and is known as a temperature inversion. They are particularly prevalent on cold, calm days, often after a clear, cloudless night and an early morning frost.

Figures 3.1.1 and 3.1.2 show the meteorological trends in the City during 2008. The readings were taken from a meteorological station located on the roof of Walbrook Wharf. The overall weather pattern in 2008 was relatively unsettled which led to a good dispersal of pollutants. There was higher than average rainfall during the summer and this is likely to be why concentrations of fine particles (PM10) were lower than expected in 2008.

The average temperature in the City during 2008 was 11.77 deg C. The average wind speed was 1.12 m sec⁻¹, and the average wind direction was from South-South-East, which is typical for the City.

Figure 3.1.1: Daily Average Temperature and Wind Speed in the City during 2008

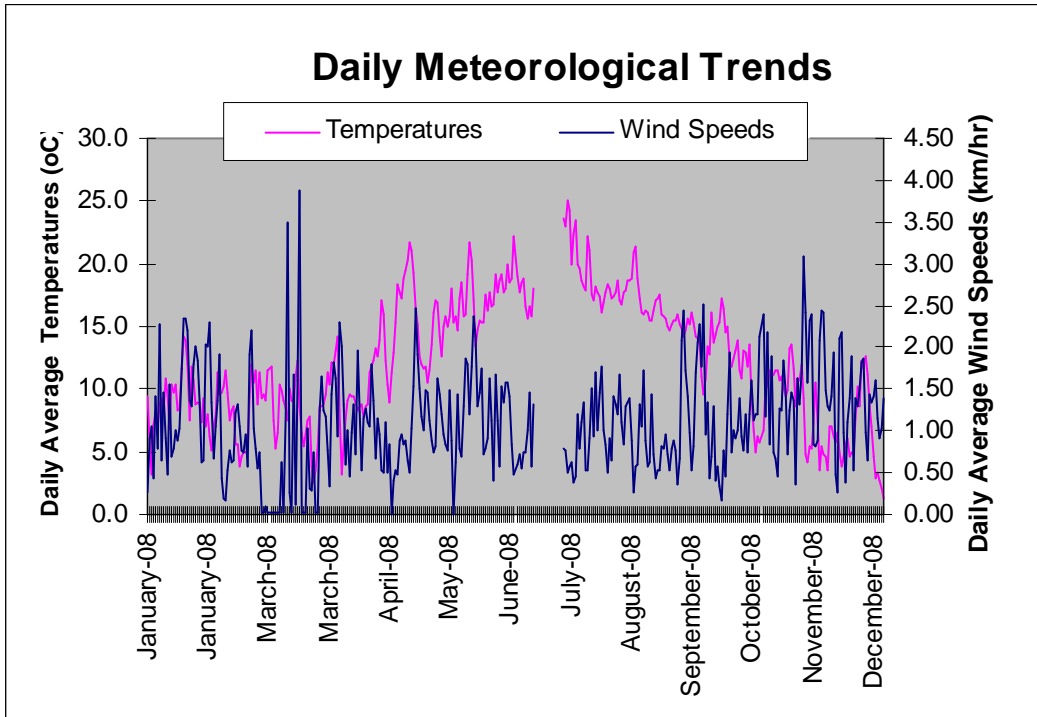
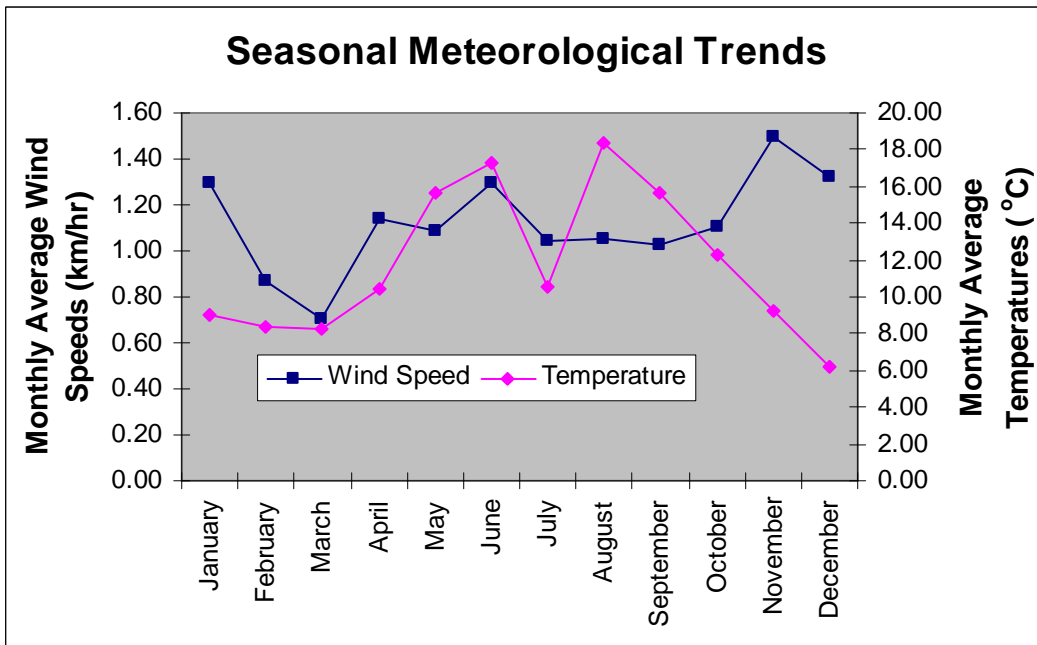


Figure 3.1.2: Monthly Average Temperature and Wind Speed in the City during 2008



3.2 Carbon Monoxide (CO)

Air Quality Objective	Measurement	Date to be achieved by	Objective Achieved in 2008
10 mg m ⁻³ (8.6 ppm)	Running 8-hour average	31.12.2003	Yes

Carbon Monoxide (CO) is a tasteless, colourless, odourless gas. In the City, CO is predominantly produced by the incomplete combustion of fuel in road vehicles, so concentrations are greatest closer to major roads. Carbon Monoxide in the atmosphere is eventually oxidised to carbon dioxide (CO₂). Concentrations of carbon monoxide are determined by emission rates and dispersion, they are therefore highest during winter months when atmospheric dispersion is weakest. This is evident in figure 3.2.1.

During 2008, CO was monitored using a continuous analyser at Walbrook Wharf, Upper Thames Street. This road has one of the highest traffic flow rates in the City. The air quality objective was not exceeded at this monitoring site.

Since 1999, when monitoring began, the carbon monoxide air quality objective has not been exceeded. Table 3.2.1 shows that there has been an overall downward trend in concentrations. Figure 3.2.1 shows the concentration of carbon monoxide remains low throughout the year. The 2008 annual average was 0.7 mg m⁻³.

Table 3.2.1: Annual Average CO Concentrations and Air Quality Objective Exceedences 1999 - 2008

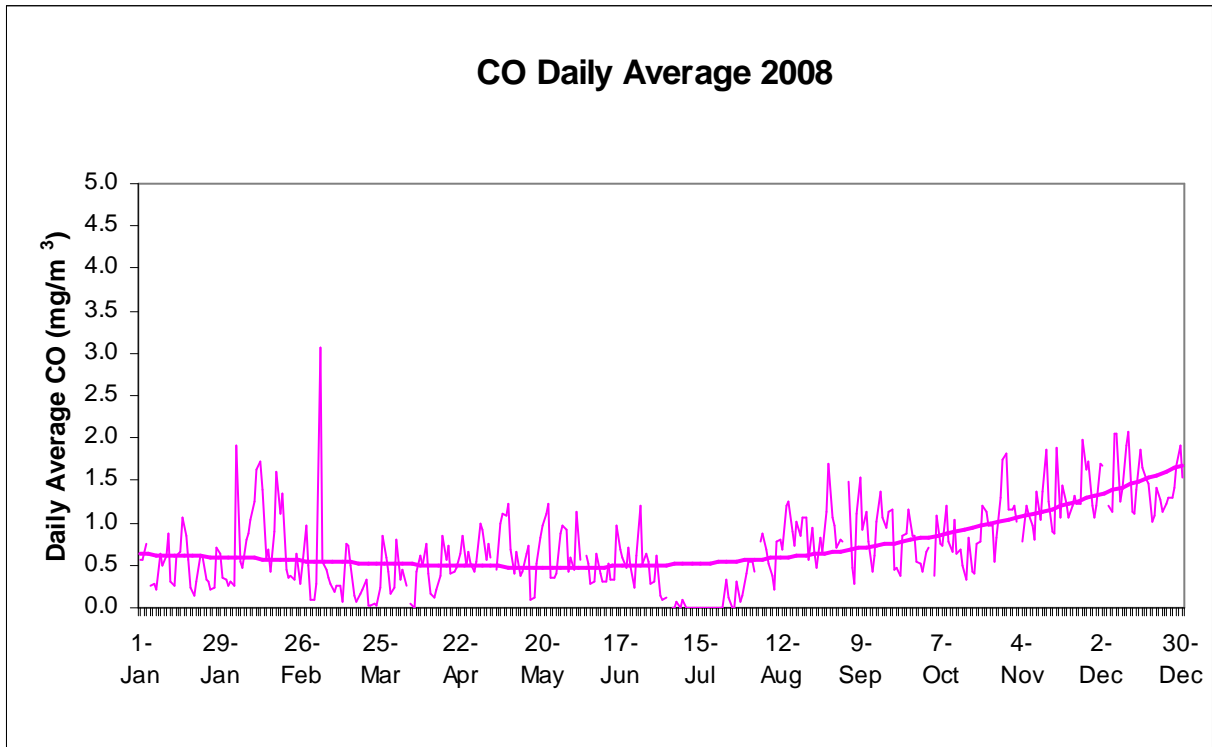
Site	Year	Annual Average CO Conc. (mg m ⁻³)	No. of Times Objective Exceeded
Beech Street	1999	1.6	0
	2000	1.7	0
	2001	1.7	0
	2002	1.3	0
Walbrook Wharf	1999	2.6	0
	2000	2.2	0
	2001	2.1	0
	2002	1.4	0
	2003	1.0	0
	2004*	0.7	0
	2005**	0.5	0
	2006	0.4	0
	2007❖	0.4	0
2008	0.7	0	

* Analyser only operational until mid-September

** Analyser moved from Walbrook Wharf to Upper Thames Street, operational from April 2005

❖ 66 % Data capture (analyser moved from Upper Thames Street to Walbrook Wharf – 2007 data starts from May 2007).

Figure 3.2.1: Daily Average CO Concentration, 2008.



3.3 Nitrogen Dioxide (NO₂)

Air Quality Objective	Measurement	Date to be achieved by	Objective achieved in 2008
200 µg m ⁻³ (105 ppb) not to be exceeded more than 18 times per year	1-hour average	31.12.2005	Senator House – Yes Sir John Cass School – Yes Walbrook Rooftop – Yes Beech Street - No Walbrook Wharf – Yes
40 µg m ⁻³ (21 ppb)	Annual average	31.12.2005	Senator House – No Sir John Cass School – No Walbrook Wharf – No Walbrook Rooftop – No Beech Street - No

Nitrogen dioxide (NO₂) is largely a secondary pollutant formed by the oxidation of nitric oxide (NO). In the City, the primary source of nitric oxide is road vehicles, although the relative contribution from heating and cooling buildings in the City is increasing. Like carbon monoxide, concentrations tend to be greatest during the winter months when dispersion is poor. This is particularly true at background sites.

In the City, nitrogen dioxide is continuously monitored at two roadside/kerbside sites (Beech Street, and Walbrook Wharf) and at three background locations (Senator House, Sir John Cass School and Walbrook Rooftop) (Figure 2.2.1). Nitrogen dioxide is also monitored using diffusion tubes at a variety of sites across the City (Figure 2.2.1). The tubes are exposed for a month, providing an indication of annual average background concentrations. The results in this report have been adjusted according to how the tubes compared with continuous analysers in 2008. The results have been multiplied by a factor of 0.93 in accordance with advice on the following web site www.uwe.ac.uk/aqm/review with the factor supplied by Bureau Veritas. Bureau Veritas run the London wide diffusion tube network.

Figure 3.3.1 and Table 3.3.1 show long-term trends in annual average NO₂ concentrations at the different monitoring sites. During 2008, the annual average air quality objective of 40 µg m⁻³ was exceeded at all of the continuously monitored sites and all but one of the diffusion tube locations. This is typical for the City. Concentrations at four of the five continuous monitoring sites were significantly higher than in 2007.

Table 3.3.1: Annual Average NO₂ Concentrations (1999 – 2008) using continuous analysers

Site	Site Classification	Year	Annual Average $\mu\text{g m}^{-3}$	No of hours > 200 $\mu\text{g m}^{-3}$
Walbrook Wharf	Roadside	2000	86	>200
		2001	118	>200
		2002	107	297
		2003	106	284
		2004	101	149
		2005	126	318
		2006	139	*
		2007	96	*
		2008	126	810
Beech Street	Roadside	1999	89	27
		2000	88	111
		2001	85	189
		2002	86	135
		2003	91	213
		2004	84	244
		2005	95	212
		2006	97	420
		2007	93	302
		2008	85	106
Senator House	Urban Background	1999	58	0
		2000	60	0
		2001	57	0
		2002	51	0
		2003	55	0
		2004	49	0
		2005	43	0
		2006	48	0
		2007	43	0
		2008	49	0
Sir John Cass School	Urban Centre	2002	55	0
		2003	64	0
		2004	47	0
		2005	51	0
		2006	56	*
		2007	52	0
		2008	55	0
Walbrook Roof	Urban Background	2007	76	*
		2008	93	13

* not applicable since < 90% data capture

Table 3.3.2: Data Capture for NO₂ (2008)

Site	Data Capture (%)
Walbrook Wharf	99
Beech Street	99
Senator House	93
Sir John Cass School	98
Walbrook Rooftop	90

Figure 3.3.1: Annual Average NO₂ Concentrations

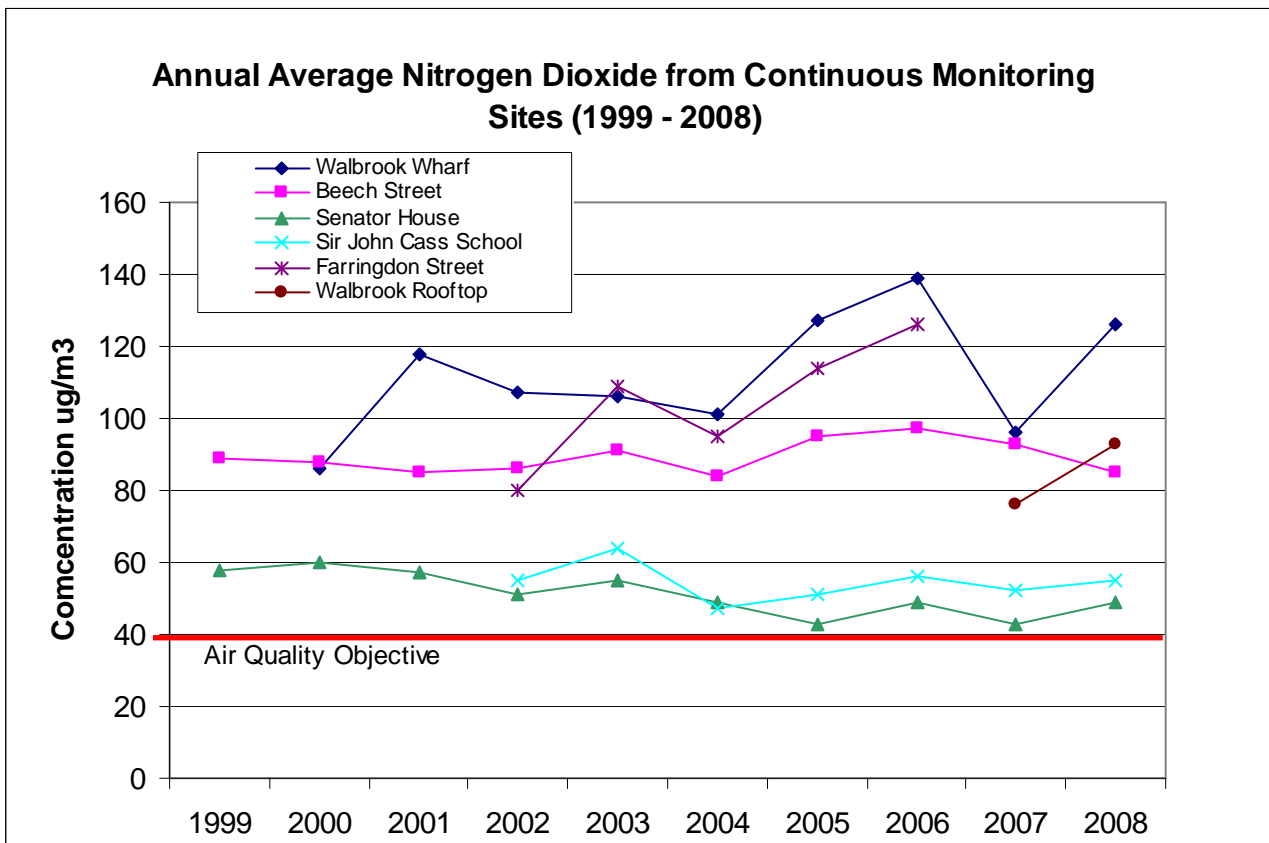


Figure 3.3.2 displays daily average NO₂ concentrations at the five continuously monitored sites. The highest concentrations were seen in May 2008.

Figure 3.3.2: Daily Average NO₂ Concentrations during 2008

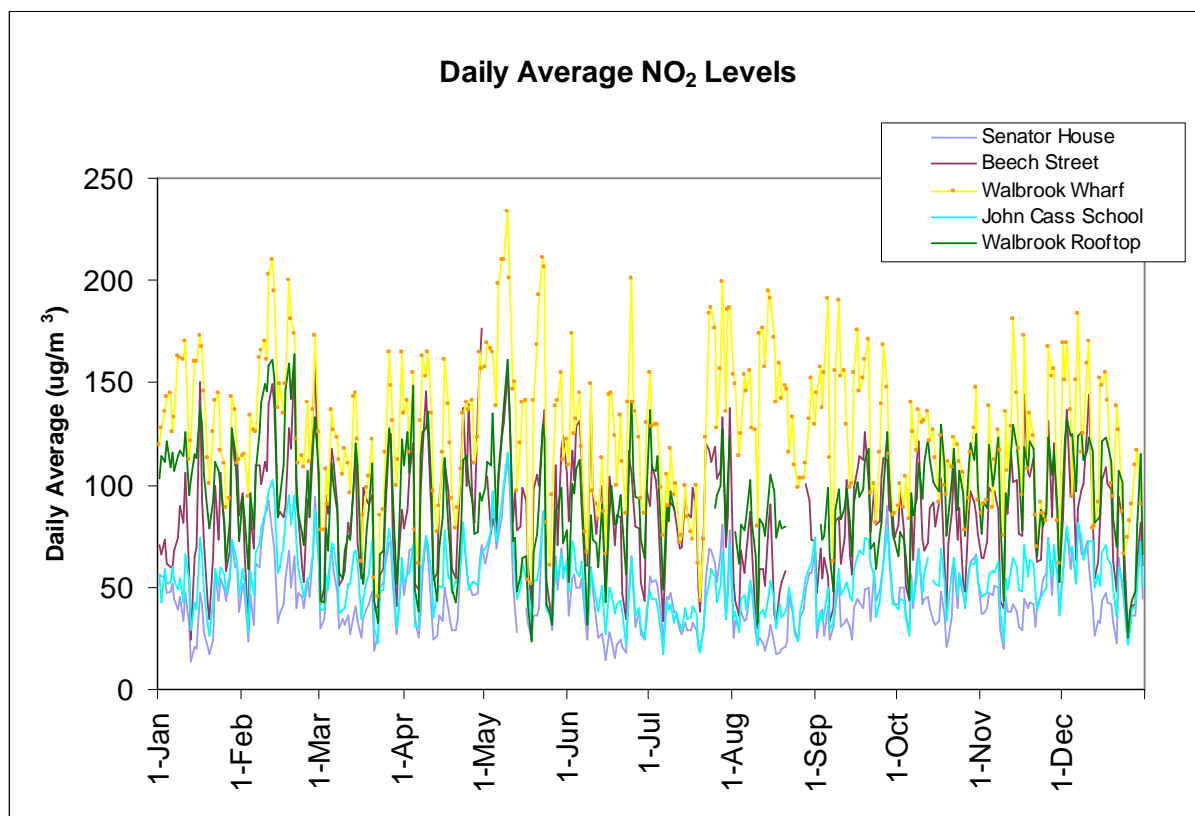
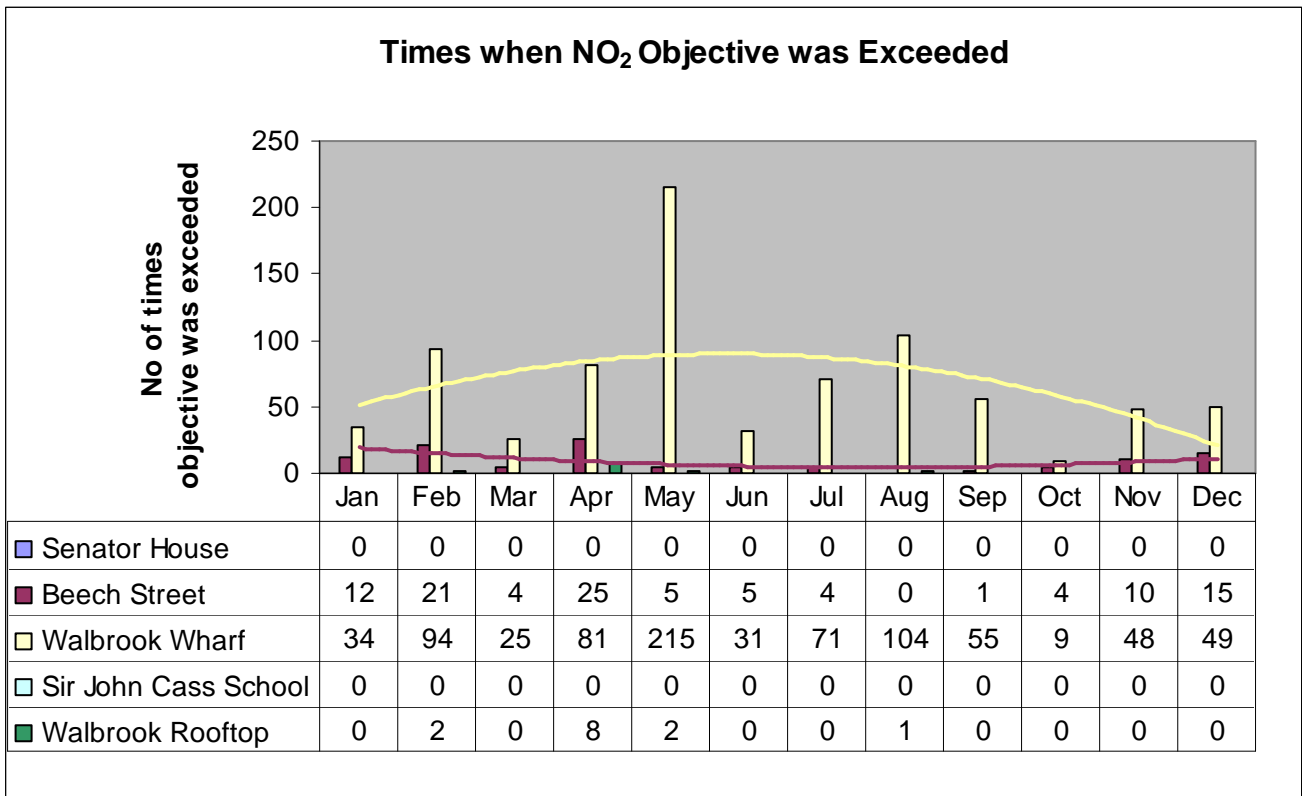


Figure 3.3.3 displays the number of times the 200 µg m⁻³ (1-hour average) NO₂ air quality objective was exceeded at each of the five continuously monitored sites over the year. Throughout the year, the objective was not exceeded at Senator House or Sir John Cass School. However, the objective was exceeded many times at Beech Street and Walbrook Wharf, with most exceedences occurring at Walbrook Wharf during May. The hourly objective was almost exceeded at the Walbrook Rooftop site, which is unusual as it represents background conditions. The concentrations recorded at roof level, whilst lower than those recorded at Walbrook Wharf at ground level, indicate that even at this height pollutants have not been adequately dispersed to reach a safe level. Despite the analyser been located on the roof, it is sited along Upper Thames Street, which experiences very heavy traffic levels, and therefore high concentrations of both NO_x and PM₁₀.

Figure 3.3.3: Number of times the 1-hour NO₂ air quality objective was exceeded, 2008



Diffusion Tubes

Nitrogen dioxide is monitored using diffusion tubes at 5 locations in the City. Annual average NO₂ concentrations in 2008 were generally above the air quality objective of 40µg m⁻³, with the exception of the Barbican, which was just below the objective for the first time since 2002.

Figure 3.3.6 displays a trend of annual average NO₂ concentrations (corrected by bias factor) at each of the diffusion tube monitoring locations from 1993 to 2008. Before 2002, although NO₂ concentrations were above the air quality objective of 40 µg m⁻³, concentrations of the gas remained relatively stable at each site and showed a general decrease in concentrations. Concentrations increased dramatically from 2002 to a peak in 2005 and are now displaying a downward trend.

Figure 3.3.5: Annual Average NO₂ Concentrations using Diffusion Tubes, 2008

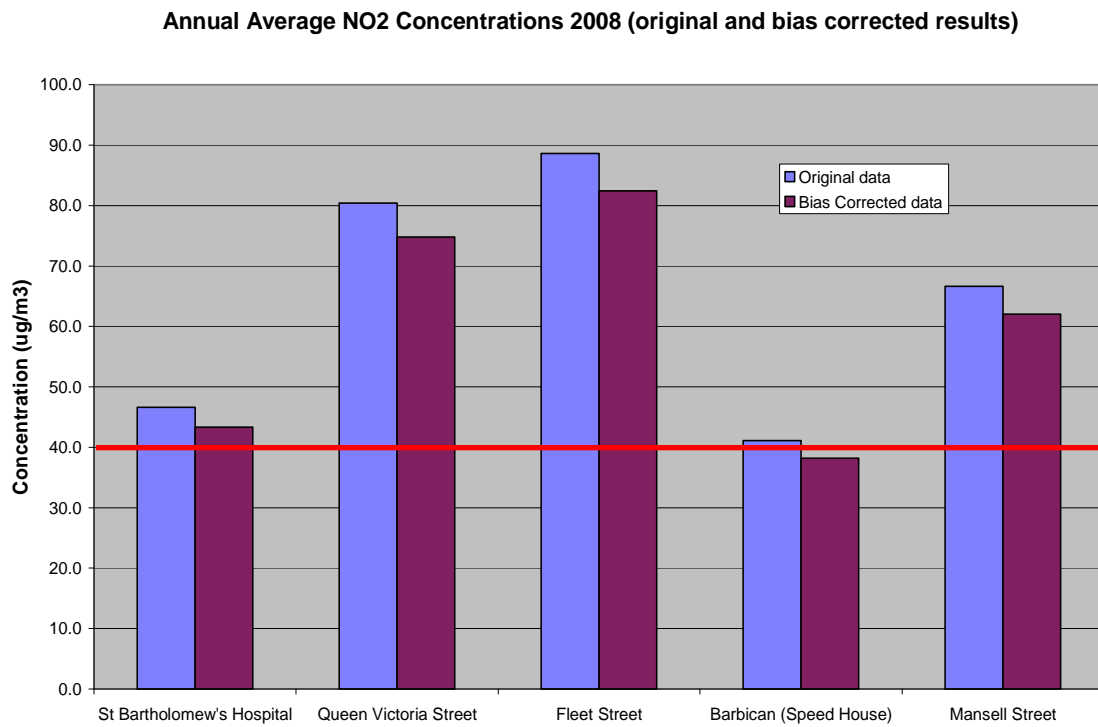
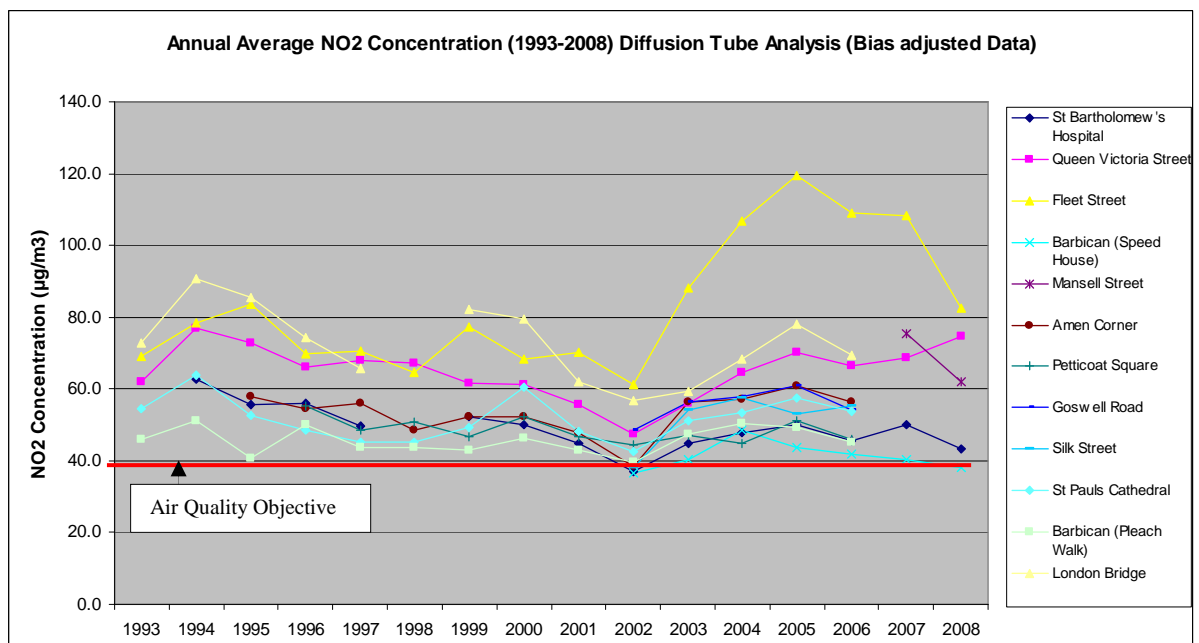


Figure 3.3.6: Annual Average NO₂ Concentrations (1993 - 2008) using diffusion tubes



3.4 Sulphur Dioxide (SO₂)

Air Quality Objective	Measurement	Date to be achieved by	Objective achieved in 2008?
125 µg m ⁻³ (47 ppb) not to be exceeded more than 3 times per year	24-hour average	31.12.2004	Yes
350 µg m ⁻³ (132 ppb) not to be exceeded more than 24 times per year	1-hour average	31.12.2004	Yes
266 µg m ⁻³ (100 ppb) not to be exceeded more than 35 times per year	15-minute average	31.12.2004	Yes

Sulphur dioxide (SO₂) is a colourless gas, which at high concentrations exhibits a taste and odour. The City has very low levels of sulphur dioxide. Local concentrations are predominantly influenced by distant industrial point sources. Easterly winds occasionally elevate the low background levels by bringing sulphur dioxide from power stations along the Thames corridor. However, even with this contribution, concentrations still remain very low.

Sulphur dioxide concentrations have generally fallen across London and the rest of the UK as a result of a combination of government policy, for example the 1956 and 1968 Clean Air Acts, and technological advances, such as the use of low-sulphur coal and the introduction of flue gas de-sulphurisation processes at coal-fired power plants.

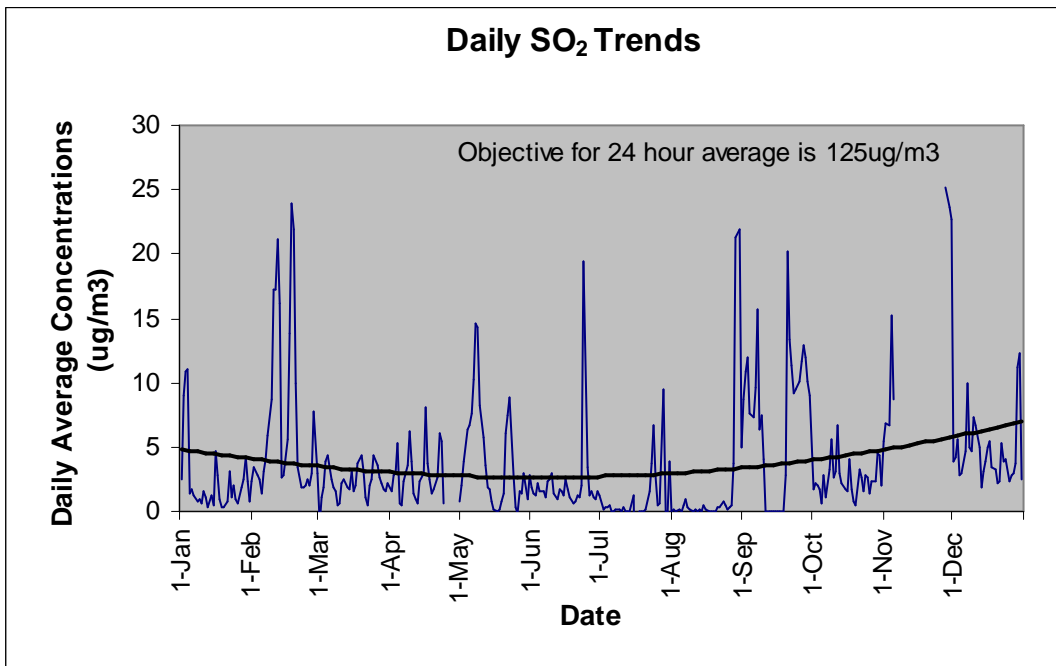
Sulphur dioxide is also monitored in the City at Senator House (Figure 2.2.1). This site provides an indication of background concentrations of the gas and data from Senator House forms part of the London Air Quality Network operated by the Environment Research Group at Kings College, London.

During 2008, all three SO₂ air quality objectives were met. Figure 3.4.1 displays daily average SO₂ concentrations at the Senator House site. It is clear that, although concentrations fluctuate throughout the year, they are well below the 24-hour average air quality objective of 125 µg m⁻³. Table 3.4.1 provides a summary of annual average SO₂ concentrations at Senator House between 2002 and 2008, along with the number of times the various air quality objectives have been exceeded.

Table 3.4.1 Annual average SO₂ concentration at Senator House, and objective exceedences

Year	Annual average SO ₂ concentration (µg m ⁻³)	Number of times 24-hour objective exceeded	Number of times 1-hour objective exceeded	Number of times 15-min objective exceeded
2002	5	0	0	0
2003	2	0	0	0
2004	2	0	0	0
2005	4.5	0	0	0
2006	1	0	0	0
2007	3	0	0	0
2008	4	0	0	0

Figure 3.4.1: Daily Average SO₂ Concentration, 2008



The 1-hour average, 15-minute average and 24-hour average concentrations were well below the 24-hour objective level throughout the entire year. The highest levels of SO₂ were recorded in the winter months, with the highest monthly average recorded at the end of November and in February.

3.5 Ozone (O₃)

Air Quality Standard	Measured As	Date to be achieved by
100µg/m ³ (50ppb), not to be exceeded more than 10 times per year	Running 8-hour average	Not applicable as it is a national standard rather than a local objective

Ozone (O₃) is a highly reactive gas that is formed in the atmosphere by chemical reaction between oxygen atoms and oxygen molecules in the presence of sunlight. Levels can be increased as a result of the presence of other pollutants produced from the chemical reaction between nitrogen oxides and hydrocarbons in the presence of sunlight. As such, it is a secondary pollutant, i.e. it is not emitted directly, and therefore the effectiveness of managing ozone on a local level is limited.

Local objectives for improving ground level ozone are not included in the Air Quality Regulations 2000. However the UK Air Quality Strategy suggests a running 8-hour average of 50ppb (100µg/m³) should not be exceeded more than 10 times per year. Ozone produced at one site may be carried for considerable distances so maximum concentrations usually occur away from the source of primary pollutants. In urban areas nitric oxide can also react with ozone to form nitrogen dioxide thus actually reducing ground level concentrations (while at the same time increasing concentrations of nitrogen dioxide). This explains why ozone levels are higher in rural than urban areas. High ozone levels are of concern because it can impair lung function and cause irritation to the respiratory tract. Asthmatics can be particularly susceptible to high levels.

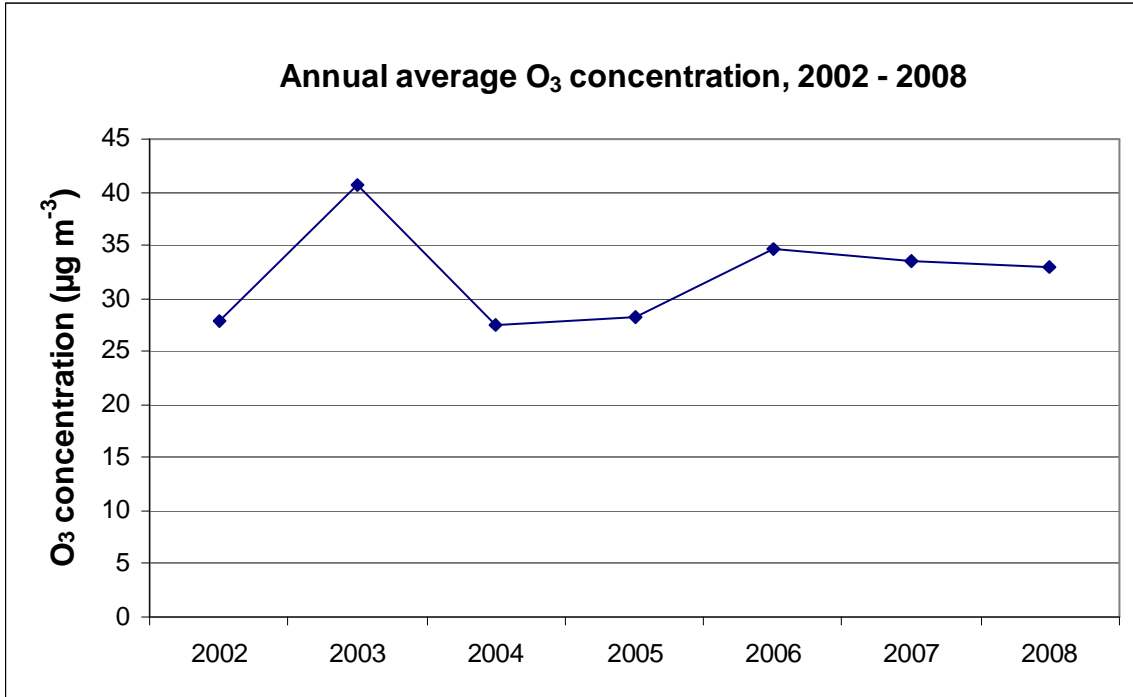
Elevated levels of ozone are often experienced in the summer months due the increased amount of sunlight as well as the movement of air masses from Central Europe. In 2008 there were only 9 days where the rolling 8 hour mean was greater than 100µg/m³. This is lower than average due to the unsettled summer weather.

Table 3.5.1 and Figure 3.5.1 display the trend in annual average O₃ concentrations between 2002 and 2008. The annual average ozone concentration for 2008 was 32.9 µg/m³, which was slightly lower than in 2007.

Table 3.5.1: Annual Average O₃ concentration at Senator House, 2002- 2008

Year	Annual average O3 Concentration
2002	27.8
2003	40.7
2004	27.5
2005	28.2
2006	34.6
2007	33.5
2008	32.9

Figure 3.5.1: Annual Average Ozone Concentration 2002 - 2008



3.6 Fine Particulate Matter (PM₁₀)

Air Quality Objective	Measurement	Date to be achieved by	Objective Achieved in 2008
50 µg m ⁻³ (gravimetric) not be exceeded more than 35 times per year	24-hour average	31.12.2004	Beech Street – Yes Upper Thames Street – No Sir John Cass School - Yes
40 µg m ⁻³ (gravimetric)	Annual average	31.12.2004	Beech Street – Yes Upper Thames Street – Yes Sir John Cass School - Yes

PM₁₀ is comprised of primary (directly emitted), secondary (chemically and/or physically altered in the atmosphere) and coarse particles, some of which are emitted locally, and some of which originate from more distant sources. Episodes of significant atmospheric pollution in London are often attributed to air masses travelling to the UK from Central Europe. A source apportionment study undertaken for the City of London determined that approximately 85% of PM₁₀ is emitted outside of the City boundary. Approximately 10% originates from road vehicles travelling within the City, with the remaining 5% from other local sources, such as construction works, domestic heaters and industrial boilers.

PM₁₀ is monitored in the City at Beech Street and Upper Thames Street using Tapered Element Oscillating Microbalance (TEOM) analysers, and at the Sir John Cass School using a Beta Attenuation Monitor (BAM) (Figure 2.2.1). The TEOM is widely used in the UK for monitoring PM₁₀. However, investigations have shown that the instrument under-reads when compared to conventional gravimetric samplers. The data has been corrected for the loss of volatile components of particulate matter that occur due to the high sampling temperature using data from the following web site www.volatile-correction-model.info. The Beta Attenuation Monitor over reads when compared to conventional gravimetric samplers and consequently the BAM data has been divided by 1.2.

In January 2001, following various stages of review and assessment against Government air quality objectives, the City designated the entire City as an Air Quality Management Area for PM₁₀. However, as the apportionment study reveals, the vast majority of PM₁₀ in the City actually originates from fugitive, distant sources, and is therefore very difficult to manage at a local level.

The deadline for achieving the Government's air quality objectives for PM₁₀ was the end of 2004. Table 3.6.1 shows the annual average concentrations from 1999 to 2008. Figure 3.6.1 shows that, unlike previous years, the annual average objective was not exceeded in 2008.

Table 3.6.1: Annual average PM₁₀ concentrations (µg m⁻³), 1999 – 2008

Year	Beech Street	Sir John Cass School	Upper Thames Street
1999	30.6	-	-
2000	36.7	-	-
2001	38.9	27.3	-
2002	30.2	32.6	-
2003	40.7	38.3	-
2004	32.0	32.0	-
2005	31.3	34	-
2006	35.4	*27.7	-
2007	34.3	30.4	**41.2
2008	26	26	34

* Analyser not operational from end July until beginning September

** Analyser not operational until May 2007

Table 3.6.2: Data Capture 2008

	Beech Street	Sir John Cass School	Upper Thames Street
Data Capture (%)	98	92	90

Figure 3.6.2 displays 24-hour average PM₁₀ concentrations during 2008 at the three monitoring locations. The main exceedences of the objective were during February and May. There were hardly any exceedences over the summer due to the high level of rainfall.

Figure 3.6.1: Annual average PM₁₀ concentrations 1999 to 2008

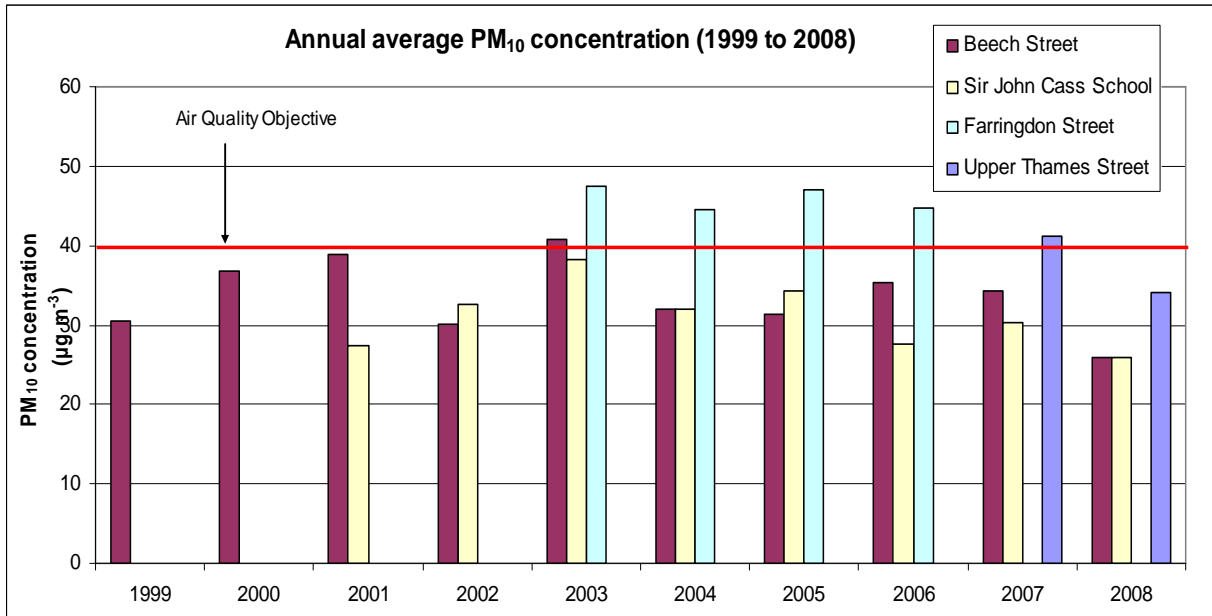


Figure 3.6.2: 24-hour Average PM₁₀ Concentrations, 2008

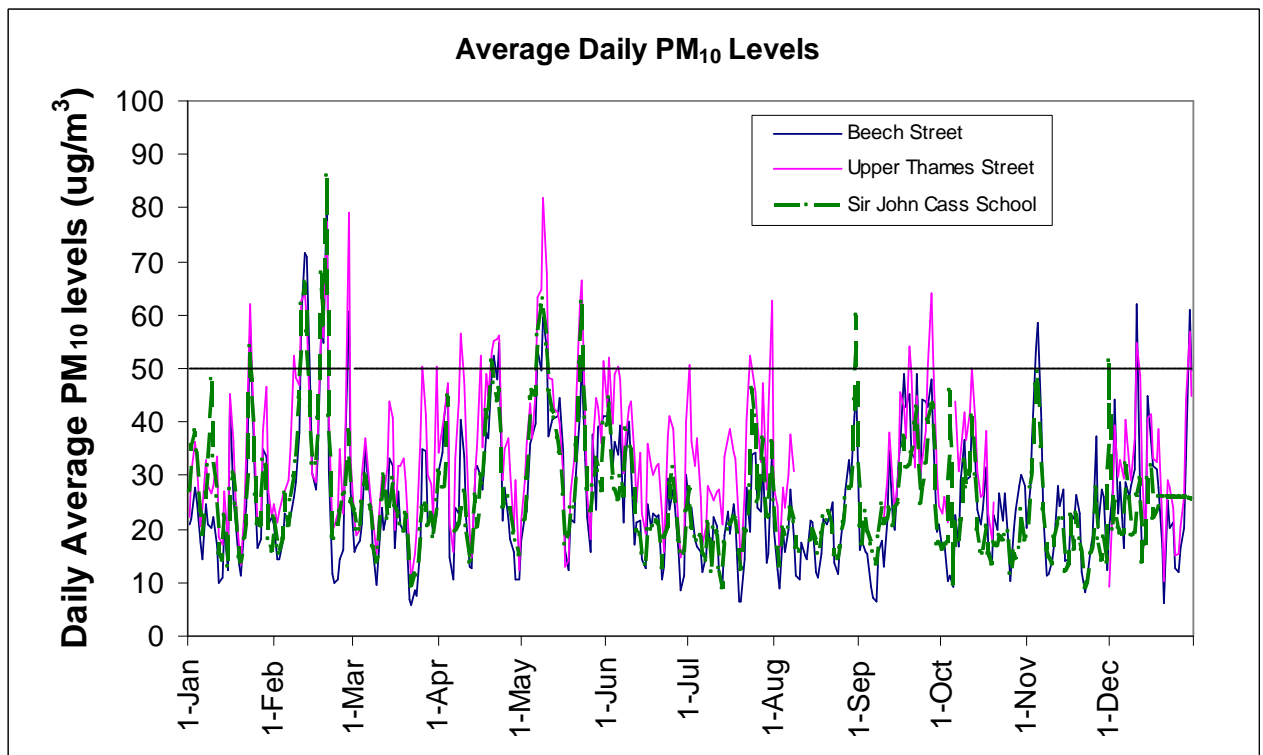
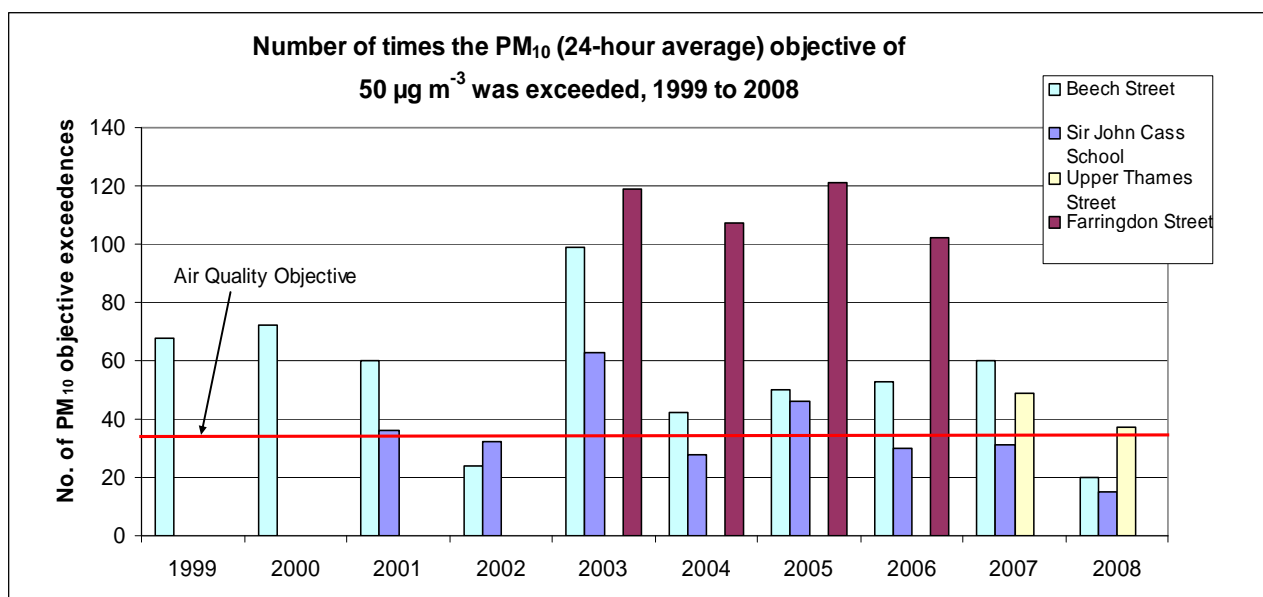


Figure 3.6.3 shows the number of times the 24-hour average $50 \mu\text{g m}^{-3}$ objective has been exceeded at each site from 1999 to 2008. The $50 \mu\text{g m}^{-3}$ objective was exceeded at Upper Thames Street but not at Sir John Cass School or Beech Street. Concentrations of PM_{10} were lower than normal in the City due to the unsettled wet weather in 2008.

Figure 3.6.3: Number of Times the 24-hour PM_{10} Air Quality Objective was exceeded, 1999-2008



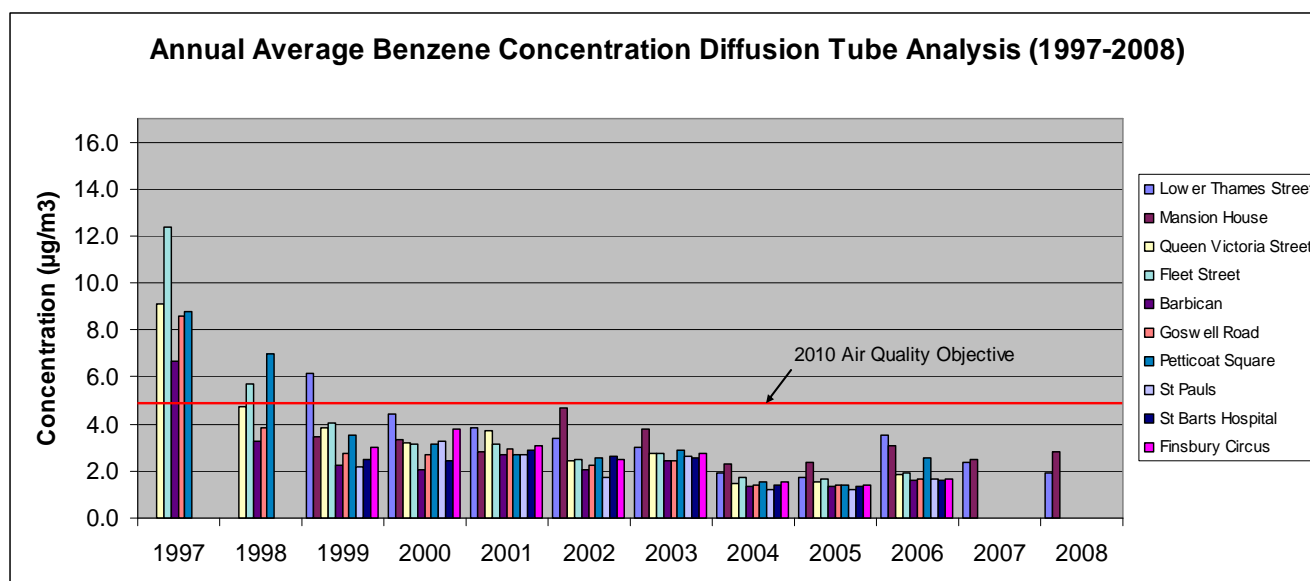
3.7 Benzene

Air Quality Objective	Measurement	Date to be achieved by	Objective Achieved in 2008
16.25 $\mu\text{g m}^{-3}$ (5ppb)	Running annual average	31.12.2003	Yes
5 $\mu\text{g m}^{-3}$	Running annual average	31.12.2010	Yes

Benzene is an aromatic hydrocarbon. In the City, the primary source of benzene is motor vehicle exhausts. As concentrations of benzene are no longer considered to be a hazard to health, monitoring has been scaled down in recent years to just two sites, Mansion House and Lower Thames Street. Benzene is monitored using diffusion tubes which are exposed for two weeks during each month of the year. This provides an estimate of annual average concentrations of the pollutant.

Benzene concentrations in the City continue to comply with both the 2003 and 2010 objectives. Figure 3.7.1 shows the long term trend in benzene concentrations in the City.

Figure 3.7.1: Annual Average Benzene Concentrations (1997 – 2008)



4. Discussion

Pollution levels in the City during 2008 were broadly equivalent to 2007. This was due to the similar weather patterns that existed during both years. Ozone episodes were low due to the absence of prolonged periods of sunny weather. Levels of fine particles were lowest they have been since monitoring began primarily due to the amount of rainfall during the summer.

The trend of an ongoing increase in roadside nitrogen dioxide, since the introduction of the congestion charge, appears to be slowing down. Walbrook Wharf continues to be subject to very high levels of nitrogen dioxide due to the high number of vehicles using Upper Thames Street, and the existence of a street canyon, which results in lower levels of dispersion. Concentrations of nitrogen dioxide are surprisingly high on Walbrook Wharf rooftop, which is not subject to the street canyon effect and is quite a distance from vehicle exhausts.

In April 2009, DEFRA submitted a report the European Commission formally requesting a time extension until 2011 for compliance with the PM₁₀ objective, see www.defra.gov.uk/environment/airquality/eu-int/eu-directives/airqual-directives/notification.htm. The European Commission will decide whether the proposals contained in the report are acceptable. If weather patterns continue to be similar to those seen in 2007 / 8, particulate levels in the City are likely to comply with the objectives by 2011. However if meteorological conditions are similar to those seen in 2003 / 4, roadside particulate levels are likely to be above the objective in 2011.

DEFRA intend to submit a similar report requesting an extension of compliance with the NO₂ objective to 2015. They must be able to convince the European Commission that every step is being taken to reduce concentrations of nitrogen dioxide to below 40µg/m³ as an annual average. This will be a significant challenge in the centre of London, especially along busy roads in the City.

The Mayor of London introduced Phase 1 and 2 of the London Low Emission Zone in 2008. All Lorries over 12 tonnes in London are now required to meet a standard of Euro III for particulate matter. From July 2008, a standard of Euro III for particulate matter for Lorries between 3.5 and 12 tonnes, and buses and coaches over 5 tonnes was introduced. It is too early to assess the effect that this action has had on particulate levels in the City. The Mayor of London has signalled his intention to suspend Phase 3 of the LEZ, which would require smaller diesel vans to be Euro III for particulates from October 2010. The Mayor is currently considering alternative options for reducing particulate emissions across London. This includes the introduction of hybrid and hydrogen fuel cell buses, smoothing traffic flows, the trial of low carbon technology for taxis and the creation of an electric vehicle partnership.

The City of London Corporation is involved in many areas of work to improve air quality. The City has been working with DEFRA and the Greater London Authority to develop a package of measures to reduce emissions in Central London. In recognition of the high priority placed on local air quality, the City has adopted NI194, which is the National Indicator for reducing emissions of air pollutants from local authority activities, into its Local Area Agreement. The City is the only authority in the Country to do so.

www.cityoflondon.gov.uk/Corporation/LGNL_Services/Community_and_living/Community_advice/Community_strategy/laa.htm

During 2008, indoor air quality monitoring began in Walbrook Wharf Phase 2 reception. This data will be used for a research project being undertaken by the Environment Research Group, Kings College London. The study is designed to assess how outdoor pollution penetrates different buildings in London.

www.londonair.org.uk/london/asp/news.asp?NewsId=NewsIndoorAQ

In 2009, an ozone analyser was installed at Walbrook Wharf roadside to monitor the effects of direct nitrogen dioxide from vehicle exhausts, which is an area that needs further research. Once sufficient data has been collected, it will be analysed by the Environment Research Group at Kings College London and be fed into national policy on direct nitrogen dioxide.

5. Further Information

This report and other reports relating to air quality in the City can be found on the City website:

www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Pollution/air+quality.htm

Anyone wishing to comment on this report or on Air Quality Management in general, can contact the Environmental Services Department on 020 7332 3630 or email des.generalenq@cityoflondon.gov.uk.

Appendix 1

Air Quality Criteria

Objectives included in the Air Quality (England) Regulations 2000 for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective	Concentration Measured as	Date to be achieved by
Benzene	16.25µg/m ³ (5ppb) 5µg/m ³	Running annual average Annual average	31.12.2003 31.12.2010
1,3 Butadiene	2.25µg/m ³ (1ppb)	Running annual average	31.12.2003
Carbon monoxide	10mg/m ³ (8.6ppm)	Running 8-hour average	31.12.2003
Lead	0.5µg/m ³ 0.25µg/m ³	Annual average Annual average	31.12.2004 31.12.2008
Nitrogen Dioxide	200µg/m ³ (105ppb) not to be exceeded more than 18 times a year 40µg/m ³ (21ppb)	1-hour average Annual average	31.12.2005 31.12.2005
Particles (PM ₁₀)	50µg/m ³ (gravimetric) not to be exceeded more than 35 times per year 40µg/m ³ (gravimetric)	24-hour average Annual average	31.12.2004 31.12.2004
Particles (PM _{2.5})	25µg/m ³ (gravimetric) 15% cut	Annual Average Urban background exposure reduction	2020 2010-2020
Sulphur dioxide	350µg/m ³ (132ppb) not to be exceeded more than 24 times per year 125µg/m ³ (47ppb) not to be exceeded more than 3 times per year 266µg/m ³ (100ppb) not to be exceeded more than 35 times per year	1-hour average 24-hour average 15-minute average	31.12.2004 31.12.2004 31.12.2005

Notes: µg/m³ - micrograms per cubic metre
mg/m³ - milligrams per cubic metre
ppb - parts per billion
ppm - parts per million

Air quality objectives represent the Government's view of achievable air quality by the prescribed dates having regard to the actual costs, benefits and feasibility. Results of air quality monitoring in the City are represented in relation to the above objectives to provide advice on the current position and assist in the development of policy and actions. Ozone is not included as an objective due to the difficulties in controlling ozone levels locally. It is however, included in the list of pollutants used by the DETR for providing public information on air quality and ozone levels monitored in the City are presented using this criterion.

The DEFRA Air Pollution Information Guidelines are used to provide public information on air quality for five pollutants (Sulphur dioxide, Ozone, Carbon monoxide, Nitrogen dioxide and Fine particles) using four bands: -

DEFRA Air Pollution Information Guidelines

Pollutant/Description	Low	Moderate	High	Very High
Sulphur dioxide ($\mu\text{g m}^{-3}$, 15 minute average)	less than 266	266 - 531	532 – 1,063	1,064 or more
Ozone ($\mu\text{g m}^{-3}$, hourly average)	less than 100 (8 hour running average)	100 - 179 (hourly average)	180 - 359 (hourly average)	360 or more (hourly average)
Carbon monoxide (mg m^{-3} , 8 hour average)	less than 11.6	11.6 – 17.3	17.4 – 23.1	23.2 or more
Nitrogen dioxide ($\mu\text{g m}^{-3}$, hourly average)	less than 287	287 - 572	573 - 763	764 or more
Fine particles ($\mu\text{g m}^{-3}$, 24 hour average)	less than 50	50 - 74	75 - 99	100 or more

These bands are health-based and the categories are detailed below:

- Low Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.
- Moderate Mild effects unlikely to require action may be noticed amongst sensitive individuals.
- High Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their “reliever” inhaler is likely to reverse the effects on the lungs.
- Very High The effects on sensitive individuals described for “High” levels of pollution may worsen.

The risk to healthy individuals is very small at all levels of air pollution likely to be experienced in the UK. However, because the “very high” band has no upper limit, it is possible that individuals not usually sensitive to pollution may notice effects, including eye irritation, coughing and pain on breathing deeply when concentrations of pollutants move into the “very high” band.

Appendix 2

Health Effects of Air Pollution

Below are brief explanations as to the health effects of major air pollutants. The levels of air pollution we usually experience in the UK are unlikely to cause serious short-term effects on people's health, however on rare occasions of high pollution, some people may feel eye irritation, others may start to cough while others may find breathing deeply hurts (see footnote).

Carbon Monoxide

Carbon monoxide is an odourless, colourless gas caused by incomplete combustion. It interferes with the take up of oxygen by red blood cells and at low levels can exhibit a slight reduction in the maximum physical performance of healthy individuals. It is toxic at high concentrations, but these levels are not experienced outdoors. The people most susceptible to carbon monoxide are those with angina and disease of the coronary arteries.

Nitrogen Dioxide

Nitrogen dioxide is an irritant gas. Exposure can bring about reversible effects on lung function and increased reactivity to natural allergens. Young children and people suffering from asthma and chronic respiratory diseases are particularly susceptible to nitrogen dioxide.

Sulphur Dioxide

Sulphur dioxide is an irritant and high concentrations may cause breathing difficulties in people exposed to it. Recent studies have shown that people suffering from asthma may be particularly susceptible. Concentrations found in pollution episodes may provoke asthma attacks.

Ozone

Ozone is an irritant and at very high concentrations can affect the eyes, nose and throat. Very high ozone levels are usually observed in rural areas. Recent research has indicated a link between high ozone levels and increased mortality.

Particulates

Particulate air pollution appears to be associated with a range of symptoms including asthma and effects on cardiovascular and respiratory system and can lead to chronic health problems. In addition, particles may carry surface absorbed carcinogenic compounds into the lungs. PM₁₀ (the fraction of particulates in air that are very small: <10 micrometers) are of major concern as they are small enough to penetrate deep into the lungs and have the potential to pose significant health risks.

Aromatic Hydrocarbons: Benzene, Toluene and Xylene

Aromatic hydrocarbons are known to be carcinogenic. They are easily ignited and produce carbon dioxide and carbon monoxide on combustion. Breathing aromatic hydrocarbons at highly elevated concentrations for extended periods has been known to cause fatigue, headache, nausea and drowsiness. Symptoms are temporary unless exposed for a long time, when permanent damage to the central nervous system can occur.

Footnote:

The information regarding the health effects of air pollution has been largely compiled from information available from the leaflet "Air Pollution- what it means for your health" produced by DEFRA. Further information can be obtained from www.airquality.co.uk or www.doh.gov.uk/hef/airpolh, or alternatively an information pack on air pollution and health can be obtained from the Department of Health Publications Centre, PO Box 410, Wetherby, LS23 7LN, fax 01937 845 381.

Appendix 3

Summary of Annual Average Pollutant Levels in 2008

Pollutant	Annual Average $\mu\text{g}/\text{m}^3$	Monitoring Site	Achieved Acceptable Level?	Comments
Nitrogen Dioxide	49	Senator House	No	The annual average objective that was to be met by the end of 2005 is 40 $\mu\text{g}/\text{m}^3$. Both roadside and background sites exceeded this objective. These results highlight the reason the City has been declared an Air Quality Management area of NO_2 .
	85	Beech Street	No	
	126	Walbrook Wharf	No	
	55	Sir John Cass School	No	
	93	Walbrook Rooftop	No	
Particulates	26	Beech Street	Yes	The annual average objective was not exceeded at any site
	34	Upper Thames Street	No	
	26	Sir John Cass School	Yes	
Sulphur Dioxide	4*	Senator House		There were no occurrences where the 15-minute, 1 hour or 24 hour averages exceeded objective levels throughout the year.
Ozone	33*	Senator House		Due to the nature and sources of ozone pollution there has been no <i>local</i> air quality objective set, however there has been 8-hour running average objective set. This objective is 100 $\mu\text{g}/\text{m}^3$, not to be exceeded more than 10 times in a year. This was exceeded just 9 times in 2008.
Carbon Monoxide	0.7*	Walbrook Wharf		Walbrook Wharf is located on one of the busiest roads in the City and should therefore represent the worst case for carbon monoxide. While there is no annual average objective set for CO, the objective for the running 8-hour average was not exceeded throughout the year

* Indicates that although the annual average has been calculated, there has been no annual average objective set, hence any comment regarding objectives does not relate to the calculated annual average.