Corporation of London

Air Quality Review

Stage 3a

April 2000

CORPORATION
OF LONDON

SUMMARY

- In order to keep abreast of developments in air quality research and changes to European Union (EU) legislation the government has committed itself to a periodic review of the National Air Quality Strategy. The amended strategy, the Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in January 2000. One of the main outcomes of the new strategy has been the change in the air quality objectives detailed in the Air Quality Regulations 1997. The new objectives have been laid down in the Air Quality (England) Regulations 2000 published on 6th April 2000.

- The Regulations have tightened the air quality objectives for benzene, 1,3 butadiene, carbon monoxide, lead and hourly average nitrogen dioxide. The 15-minute objective for sulphur dioxide and annual average nitrogen dioxide objective remain the same. The objective for PM_{10} has been replaced with the less stringent European Union limit value. Also included are a number of new objectives for sulphur dioxide, nitrogen dioxide, lead and particles to reflect the limit values agreed in the European Union Air Quality Daughter Directive. This report contains the Corporation of London Review and Assessment for the new objectives. It should be read together with the Corporation of London Air Quality Review Stage 3, which is based on the previous objectives.

- The report concludes that concentrations of benzene, 1,3 butadiene, carbon monoxide and lead are unlikely to exceed the prescribed air quality objectives detailed in the Air Quality (England) Regulations 2000.

- Air quality modelling was undertaken for sulphur dioxide, nitrogen dioxide and PM_{10} to predict the future concentrations in the City. The modelling was undertaken by Cambridge Environmental Research Consultants using the same input data as detailed in the Corporation of London Air Quality Review Stage 3.

- The air quality modelling indicates that the annual average nitrogen dioxide and 24-hour average PM_{10} in the City are likely to exceed the air quality objectives. Sulphur dioxide concentrations are predicted to be below the objective level.

- Following this assessment of air quality, the Corporation of London proposes to declare an Air Quality Management Area covering the entire City of London for PM_{10} and nitrogen dioxide.

Contents

1. Introduction

Following the Review of the United Kingdom National Air Quality Strategy and publication of the Corporation of London Air Quality Review Stage 3, the national air quality objectives have been revised. The new objectives have been laid down in the Air Quality (England) Regulations 2000.

This report contains the results of the assessments that have been carried out for the new objectives and subsequently makes proposals for an Air Quality Management Area in the City of London. It should be read together with the Stage 3 Review and Assessment, which provides full details on air quality monitoring in the City and background information on the modelling that was carried out for the assessment. Copies of the Stage 3 Air Quality Review are available from the Department of Environmental Services at the Corporation of London.

The Air Quality (England) Regulations 2000 have tightened the objectives for benzene, 1,3 butadiene, carbon monoxide, lead and hourly average nitrogen dioxide. The 15-minute objective for sulphur dioxide and annual average nitrogen dioxide objective remain the same. For particles, since the old objective was considered to be unachievable, the Government has replaced the objective with the less stringent European Union limit value. Also included are a number of new objectives for sulphur dioxide, nitrogen dioxide, lead and particles to reflect the limit values agreed in the European Union Air Quality Daughter Directive. The new objectives are given in Table 1.

Pollutant	**Air Quality Objective**		**Date to be achieved by**
	Concentration	**Measured as**	
Benzene	16.25μg/m^3 (5ppb)	Running annual average	31.12.2003
1,3 Butadiene	2.25μg/m^3 (1ppb)	Running annual average	31.12.2003
Carbon monoxide	11.6μg/m^3 (10ppb)	Running 8-hour average	31.12.2003
Lead	0.5μg/m^3 0.5μg/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
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

Table1

2. Assessment of Pollutants in the City

2.1 Benzene

Objective 16.25μg/m^3 (5ppb) or less when expressed as a running annual average.
Target date: 31 December 2003.

The benzene standard has remained the same at 5ppb (16.25μg/m^3) but the compliance date has been brought forward to the 31 December 2003.

The main source of benzene in the City of London is from vehicle exhausts. The increasing number of vehicles fitted with three way catalysts will significantly reduce emissions of benzene in future years. Recently agreed additional reductions in vehicle emissions as part of the Auto-Oil programme are expected to further reduce emissions of benzene from vehicles. The 5ppb objective is expected to be met at all locations in the UK except possibly in the vicinity of major industrial processes which handle store or emit benzene [(2)]. There are no such industrial processes within or in close proximity to the City.

Benzene is currently monitored using diffusion tubes at ten locations across the City. Further details on the site locations and monitoring technique used can be found in the Stage 3 Air Quality Review. Running annual average concentrations are already below the 2003 objective as can be seen in Table 2 and Figure 1.

Site Classification	**Site**	**Running Annual Average Concentration**					
		1997		1998		1999	
		μg/m^3	ppb	μg/m^3	ppb	μg/m^3	ppb
Roadside	Queen Victoria Street	8.27	2.6	4.25	1.3	3.60	1.1
Roadside	Fleet Street	11.09	3.4	4.6	1.4	3.86	1.2
Background	Barbican	6.84	2.1	2.14	0.7	2.24	0.7
Roadside	Goswell Road	7.72	2.4	3.08	1.0	2.69	0.8
Background	Petticoat Square	9.6	2.9	7.14	2.2	3.28	1.0
Background	St Pauls	-	-	2.27	0.7	2.07	0.6
Background	St Barts Hospital	-	-	2.27	0.7	2.37	0.7
Roadside	Lower Thames Street	-	-	6.48	2.0	5.29	1.6
Background	Finsbury Circus	-	-	2.92	0.9	2.98	0.9
Roadside	Mansion House	-	-	2.27	0.7	3.5	1.1

Table 2

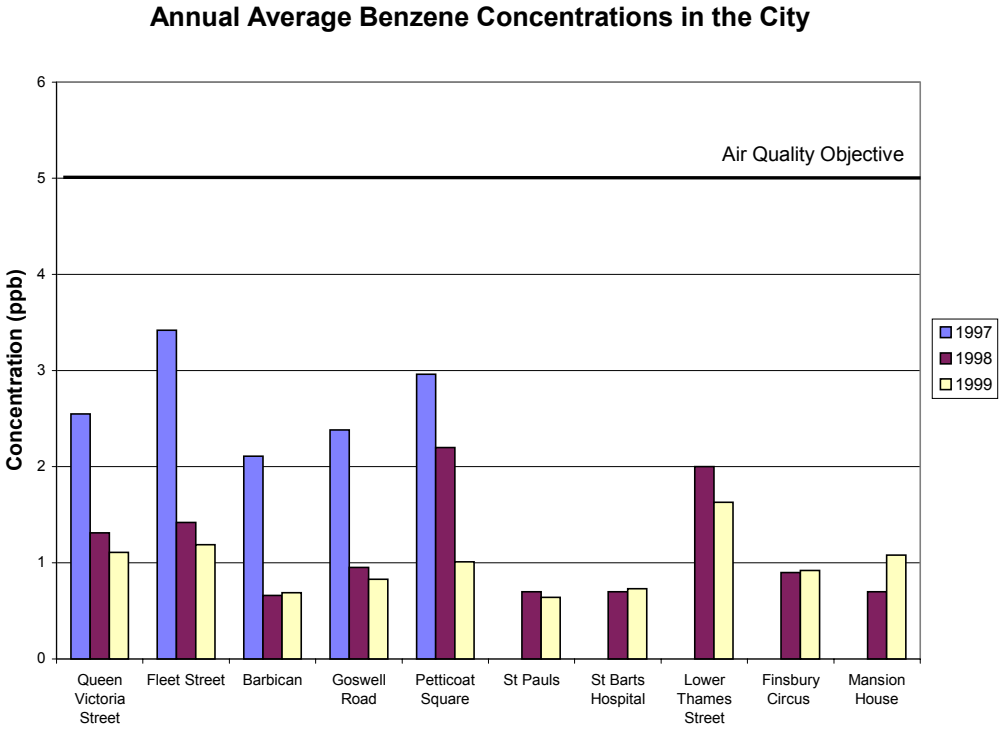

Figure 1

Concentrations of benzene in the City are expected to comply with the 5ppb objective by the end of 2003 and no further assessment of this pollutant is considered necessary. The Corporation of London will continue to monitor benzene across the City to ensure compliance with the air quality objective.

2.2. 1,3 butadiene

Objective 2.25μg/m^3 (1ppb) or less when expressed as a running annual average.
Target date: 31 December 2003.

The standard for 1,3 butadiene has remained the same at 1ppb (2.25μg/m^3) but the compliance date has been brought forward to 31 December 2003.

The main source of 1,3 butadiene in the City of London is from vehicle exhausts. The increasing number of vehicles fitted with three way catalysts will significantly reduce emissions of 1,3 butadiene in future years. As with benzene, the recently agreed additional reductions in vehicle emissions and improvements in fuel quality as part of the Auto-Oil programme are expected to further reduce emissions of 1,3 butadiene from vehicles. The 1ppb objective is expected to be met at all locations in the UK except possibly in the vicinity of major industrial processes which handle store or emit 1,3 butadiene[(2)]. There are no such industrial operations within or in close proximity to the City.

1,3 butadiene is not monitored in the City. It is however monitored at a kerbside location on Marylebone Road in the City of Westminster and at University College London in the London Borough of Camden Concentrations are given in Table 3.

Site Classification	**Site**	**Running annual average concentration**					
		1996		1997		1998	
		μg/m^3	ppb	μg/m^3	ppb	μg/m^3	ppb
Kerbside	Marylebone Road	-	-	-	-	2.49	1.1
Roadside	UCL	0.91	0.4	0.91	0.4	0.91	0.4

Table 3

Maximum running annual average concentrations are already well below the objective at these London sites, which are likely to reflect conditions in the City of London.

Concentrations of 1,3 butadiene in the City are expected to comply with the objective by the prescribed date and no further assessment for this pollutant is considered necessary.

2.3 Lead

Objective: 0.5µg/m^3 or less when expressed as an annual average.
Target date: 31 December 2004.

Additional objective: 0.25µg/m^3 or less when expressed as an annual average.
Target date: 31 December 2008.

The initial standard for lead has remained the same at 0.5µg/m^3 but the compliance date has been brought forward to the end of 2004. An additional, more stringent target of 0.25µg/m^3 has been introduced for compliance by the end of 2008.

There is no routine monitoring of lead carried out in the City of London. Figure 2 shows the annual average lead levels at a site in central London from 1976 to 1994. It is clear that there has been a steady decline and that levels have been below both the 2004 and 2008 objectives since 1989.

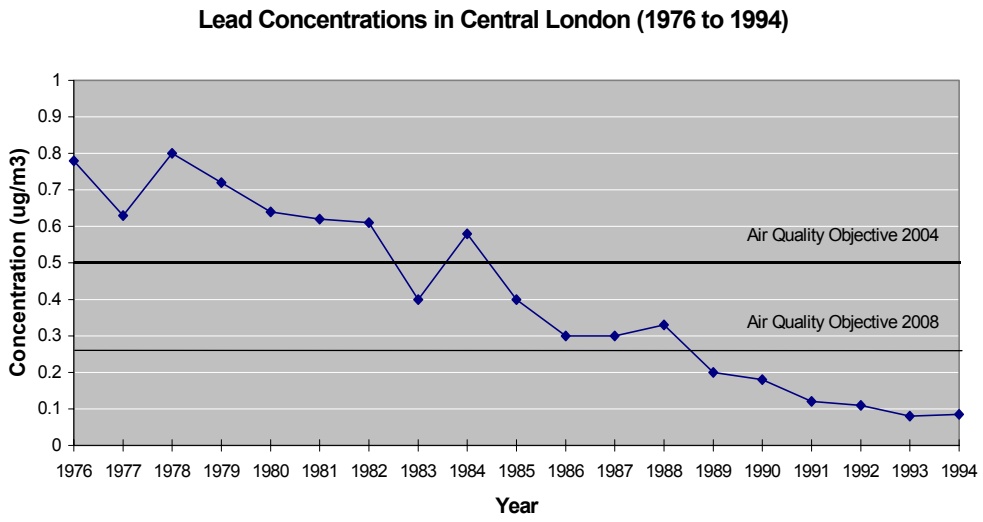

Figure 2

More recent lead concentrations monitored at Cromwell Road in the Royal Borough of Kensington and Chelsea are given in Table 4.

Annual average lead in air concentration at Cromwell Road ($\mu g/m^3$)				
1994	1995	1996	1997	1998
0.244	0.199	0.151	-	0.089

Table 4

The annual average concentrations are below both the 2004 and 2008 objective. Concentrations of lead at roadside locations are expected to decline further following the ban of the sale of leaded petrol in the UK, which came into force on 1 January 2000.

Existing national policies are expected to deliver the lead air quality objective in the City for both 2004 and 2008 and no further assessment is required for this pollutant.

2.4 Carbon Monoxide

Objective 11.6μg/m^3 (10ppm) or less when expressed as a running 8 hour average.
Target date: 31 December 2003.

The standard for carbon monoxide has remained the same at 10ppm (11.6μg/m^3) but the compliance date has been brought forward to 31December 2003.

Carbon monoxide is monitored at a variety of locations across the City of London. The results of recent monitoring are given in Table 5.

Location	Year	Annual Average (ppm)	Maximum 8-hour average (ppm)	No. of hours > objective	Data Capture
Walbrook Wharf, Upper Thames Street	1998/1999 (12 months data)	2.55	7.1	0	89 %
Fish Street Hill Lower Thames Street	1996	1.98	7.5	0	86 % from April
	1997	1.46	5.82	0	87 %
	1998	1.23	4.47	0	73%
	1999	1.35	3.6	0	100 %
Beech Street	1997	2.8	12.6	**6**	96 %
	1998	1.8	9.65	0	96 %
	1999	1.45	6.3	0	95%

Table 5

The monitoring results do not suggest that the prescribed objective is likely to be exceeded in the City, even adjacent to the most heavily trafficked roads. Beech Street tunnel is the only site to exhibit an exceedence of the 10ppm 8 hour average objective since monitoring began. The Stage 3 Air Quality Review for the Corporation of London contains further justification for not carrying out any further assessment on carbon monoxide.

The main source of carbon monoxide in the City is road traffic. Recently agreed reductions in vehicle emissions as part of the Auto Oil programme are expected to deliver the revised air quality objective by the end of 2003, even at busy roadside locations[(2)]. No further assessment is considered necessary for this pollutant, however the Corporation of London will continue to monitor carbon monoxide concentrations in the City to ensure compliance with the objective.

2.5 Nitrogen Dioxide

Objective 200μg/m^3 (105ppb) or less when expressed as a 1-hour average not to be exceeded more than 18 times per year.
Target date: 31 December 2005.

Objective 40μg/m^3 (21ppb) or less when expressed as an annual average.
Target date: 31 December 2005.

The annual average objective for nitrogen dioxide has remained the same at 21ppb (40μg/m^3) but the hourly objective has been reduced from 150ppb to 105ppb (200μg/m^3) with a maximum of 18 exceedences.

The main source of nitrogen dioxide in the City of London is road traffic. Nitrogen dioxide is monitored at a variety of locations in the City. The most widespread monitoring is carried out using diffusion tubes. The Stage 3 Air Quality Review provides further details on the monitoring locations and techniques.

Figures 3, 4 and 5 give the results of diffusion tube monitoring at sites across the City. A recent study undertaken by the Central London Air Quality Cluster Group suggests that NO_2 diffusion tubes under read when compared to continuous analysers in London by around 30%. The lines for each bar in figures 3 - 5 represent the concentration if 30% is added; this would bring the readings into line with the continuous analysers.

The sites have been divided into classes as defined in the Department of Environment Transport and the Regions (DETR) guidance LAQM TG1 (00) 'Revised Guidance Review and Assessment: Monitoring Air Quality' [(4)]:

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

Annual Average Nitrogen Dioxide at Roadside Sites in the City

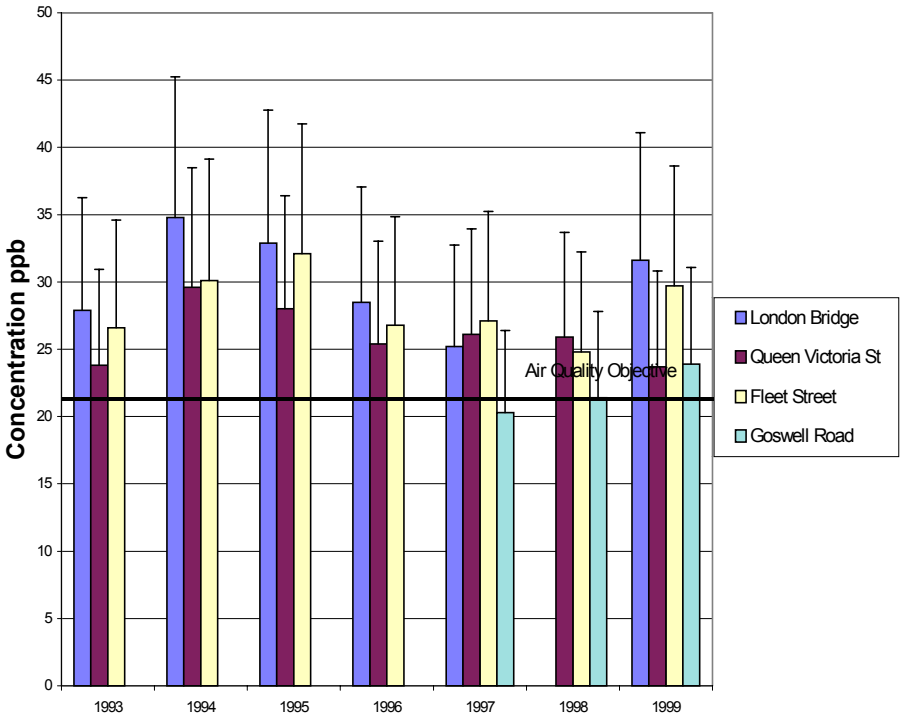

Figure 3

Annual Average Nitrogen Dioxide at Urban Centre Sites in the City

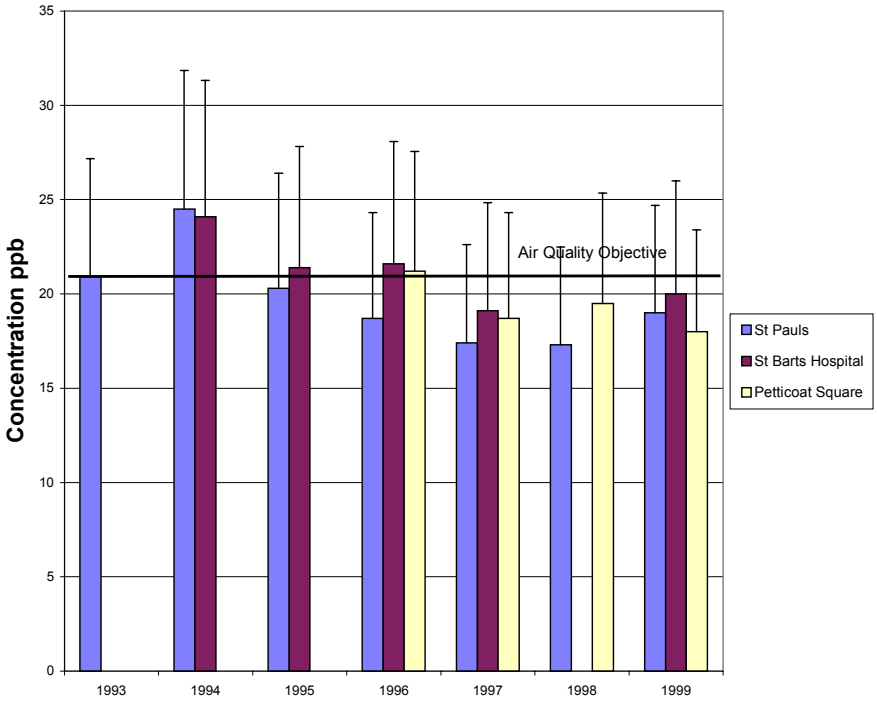

Figure 4

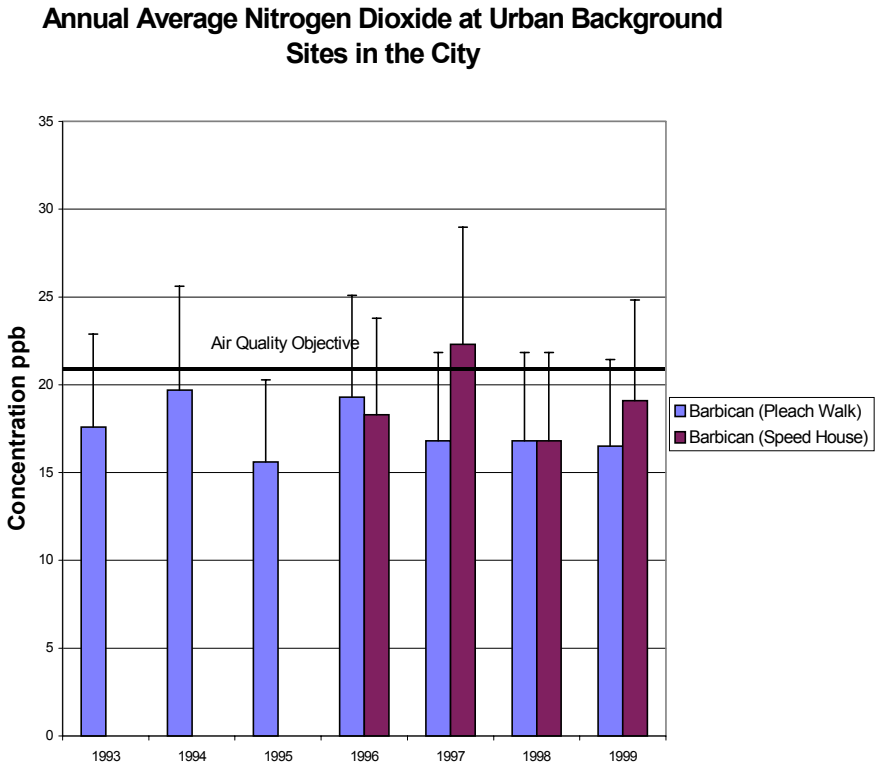

Figure 5

It is clear that the roadside sites exhibit the highest concentrations of nitrogen dioxide, this is to be expected, as vehicle emissions are the main source of nitrogen dioxide in the City. With the potential 30% error added on, all sites show an exceedence of the annual average air quality objective.

Results from continuous monitoring sites in the City are given in Table 6.

Site	**Type**	**Annual average ppb**			**No of hours above 200μg/m^3**		
		1996	1997	1998	1996	1997	1998
Beech Street	Roadside	-	46	41	-	155	86
OPSIS	Urban background	32	31	34	15	20	0
Senator House	Urban background	34	32	31	41	20	4

Table 6

The results show exceedences of the annual average air quality objective at all sites, particularly at Beech Street, which is a roadside site. The hourly air quality objective, which allows 18 hours above 200μg/m^3, was exceeded by a significant margin at Beech Street in both 1997 and 1998. The OPSIS had an exceedence in 1997 and Senator House in both 1996 and 1997.

2.5.1 Nitrogen Dioxide Air Quality Modelling

As there are current exceedences of the air quality objectives for nitrogen dioxide in the City detailed air quality modelling was undertaken to assess the likely concentrations in 2005. Full details of the modelling technique and input data used is given in the CERC reports [3 and 5] and a summary provided in the Stage 3 Air Quality Review.

As air quality is very much dependant on the weather conditions modelling runs were carried out using both 1996 and 1997 meteorological data. The annual average nitrogen dioxide concentrations were worst in 1997 and the maximum concentration in 1996. Consequently these two predictions have been used for the basis of assessing the need for an air quality management area in the City. The CERC report contains the full set of contour maps.

The results of the modelling are given in Figures 6 and 7.

Figure 6 shows that the annual average NO_2 concentration of 21ppb will be exceeded in most of the western half of the City and at many roadside locations throughout the City. The highest concentrations are predicted to be around Ludgate Circus, Holborn Circus and Fleet Street west of Fetter Lane. The modelling has predicted the lowest concentrations to be around Liverpool Street and Fenchurch Street Stations.

Figure 7 shows the 99.8th percentile of the hourly average nitrogen dioxide concentration. This equates to 18 exceedences of the 105ppb objective. The modelling predicts that the objective will not be exceeded at any location in the City. The highest concentrations anticipated will be 95ppb at roadside locations. The lowest concentrations are expected to be around 71ppb in the northern sections of the City.

Predicted annual average nitrogen dioxide concentrations for 2005 using 1997 meteorological data

Air Quality Objective 40μg/m^3 (21ppb)

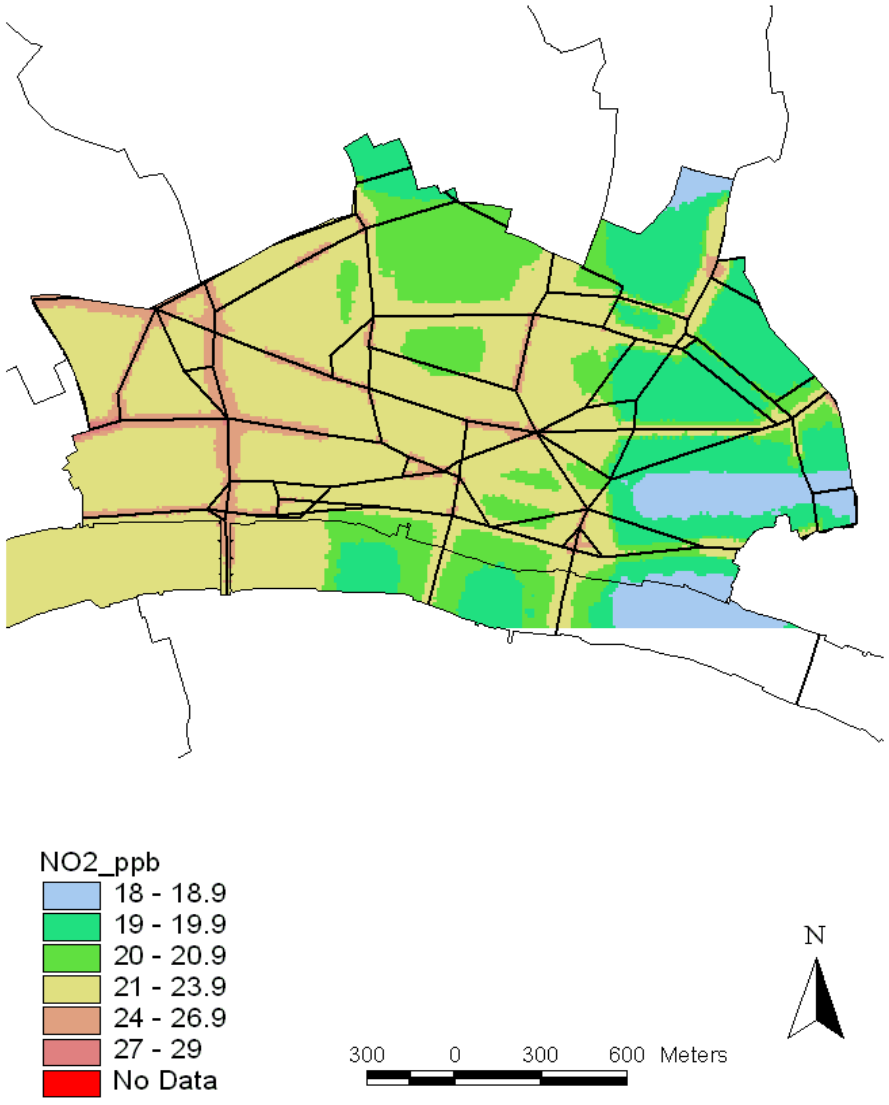

Figure 6

Predicted 99.8th percentile hourly average nitrogen dioxide concentrations for 2005 using 1996 meteorological data.

Air Quality Objective 200μg/m^3 (105**ppb) not to be exceeded more than 18 times per year (99.8th percentile)**

Figure 7

2.6 Particulates (PM_{10})

Objective 50μg/m^3 (gravimetric) or less when expressed as a 24-hour average not to be exceeded more than 35 times per year.
Target date: 31 December 2004.

Objective 40μg/m^3 (gravimetric) or less when expressed as an annual average.
Target date: 31 December 2004.

Particulate matter is composed of a wide range of materials which, for the purposes of air quality monitoring, can be grouped into three main types:

Primary: combustion sources (mainly road traffic)

Secondary: mainly sulphate and nitrate formed by chemical reactions in the atmosphere

Coarse: suspended soils and dust, sea salt, biological particles and construction work

Following the publication of the National Air Quality Strategy in 1997 further research has been carried out into the sources of PM_{10} in the UK. In any given year approximately 80% of the primary PM_{10} arises from emissions in the UK, the remainder coming from mainland Europe. The contribution of mainland Europe secondary PM_{10} is much higher at around 50%. This can be particularly significant in London due to its proximity to the continent.

Government research suggested that eliminating all urban traffic emissions of PM_{10} would not be sufficient to achieve the old objective due to the influence of particles from mainland Europe under certain weather conditions. Consequently they have decided to adopt the less stringent Air Quality Daughter Directive Stage 1 24-hour limit value of 50μg/m^3 not to be exceeded more than 35 times per year and introduce an annual average objective of 40μg/m^3.

PM_{10} concentrations are currently monitored at two locations in the City of London. A TEOM was established in Beech Street in October 1998, the site is classified as roadside. A BAM particulate monitor was established at John Cass Foundation School in December 1999, this site is an urban centre site. Further details on the monitoring techniques and locations can be found in the Stage 3 Air Quality Review.

Monitoring of PM_{10} levels across the UK has largely to date been based on the use of TEOM analysers. A principal concern with the TEOM instrument is that the filter is held at an elevated temperature (50^oC) in order to minimise errors associated with the evaporation and condensation of water vapour. This can lead to the loss of the more volatile species (some hydrocarbons, nitrates etc) and has led to the identification of differences between TEOM and gravimetric measurements. Preliminary research

suggests that the TEOM under reads when compared to the gravimetric sampler by up to 30%. Further studies have been commissioned by the Department of the Environment Transport and the Regions (DETR) to try and provide a robust relationship between the two analysers. For the purpose of this report a factor of 1.3 will be applied to all TEOM measurements to bring them in line with the gravimetric standard. This was taken into account in the modelling carried out for the revised objectives.

Concentrations of particulate matter from the TEOM for 1999 are given in Table 7. A factor of 1.3 has been applied to the measurements to bring them into line with the gravimetric samplers. The annual average was just below the 40μg/m^3 objective. The number of exceedences of the 50μg/m^3 24-hour objective was much greater than the 35 allowed in the Air Quality Regulations.

Annual average μg/m^3	**No. of exceedences of 50μg/m^3 as a 24-hour average**	**Data capture**
39	76	99%

Table 7

Results from the BAM for January and February 2000 have already given 13 exceedences of the 24-hour average air quality objective.

2.6.1 PM_{10} Air Quality Modelling

Air quality modelling was undertaken for the new annual average objective and the 24-hour average objective. Full details of the modelling technique and input data used are given in the CERC reports [3 and 5] and a summary provided in the Stage 3 Air Quality Review.

Modelling runs were undertaken using 1996 and 1997 meteorological data. The highest concentrations for both objectives were found in 1996. The results for this meteorological year are presented in Figures 8 and 9.

The annual average concentrations shown in figure 8 are predicted to be below the 40μg/m^3 objective. The concentrations range from 32 to 36μg/m^3. The highest concentrations are at roadside locations particularly in the western half of the City.

The 24-hour average objective of 50μg/m^3 not to be exceeded more than 35 times in any one year is presented in Figure 9 as the 90th percentile. The modelling predicts that the objective will be exceeded along the main road network mainly in the western half of the City. The concentrations are anticipated to be between 48 and 53μg/m^3 with most of the City within the 49 to 50μg/m^3 band.

Predicted annual average PM_{10} concentrations for 2004 using 1996 meteorological data

Air Quality Objective 40μg/m^3

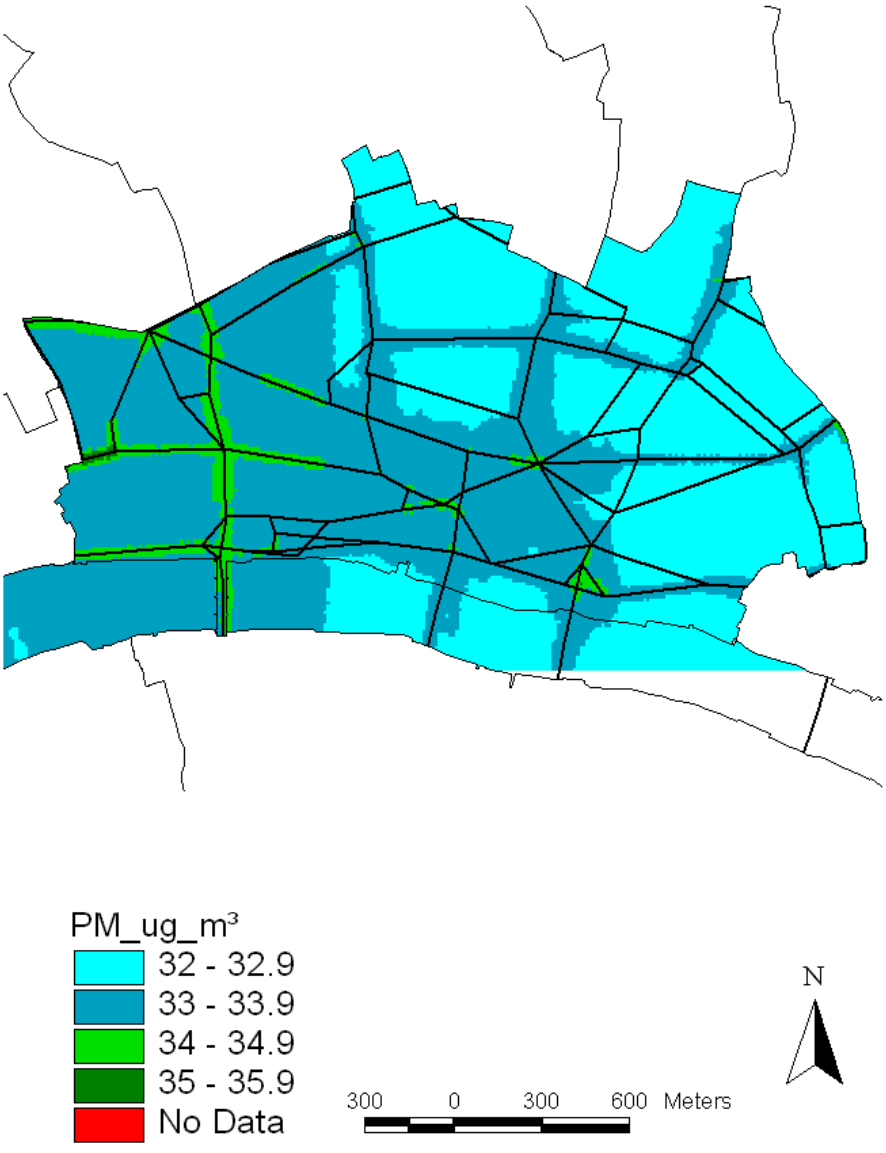

Figure 8

Predicted 90th percentile 24-hour average PM_{10} concentrations for 2004 using 1996 meteorological data

Air Quality Objective 50μg/m^3 not to be exceeded more than 35 times per year (90th percentile)

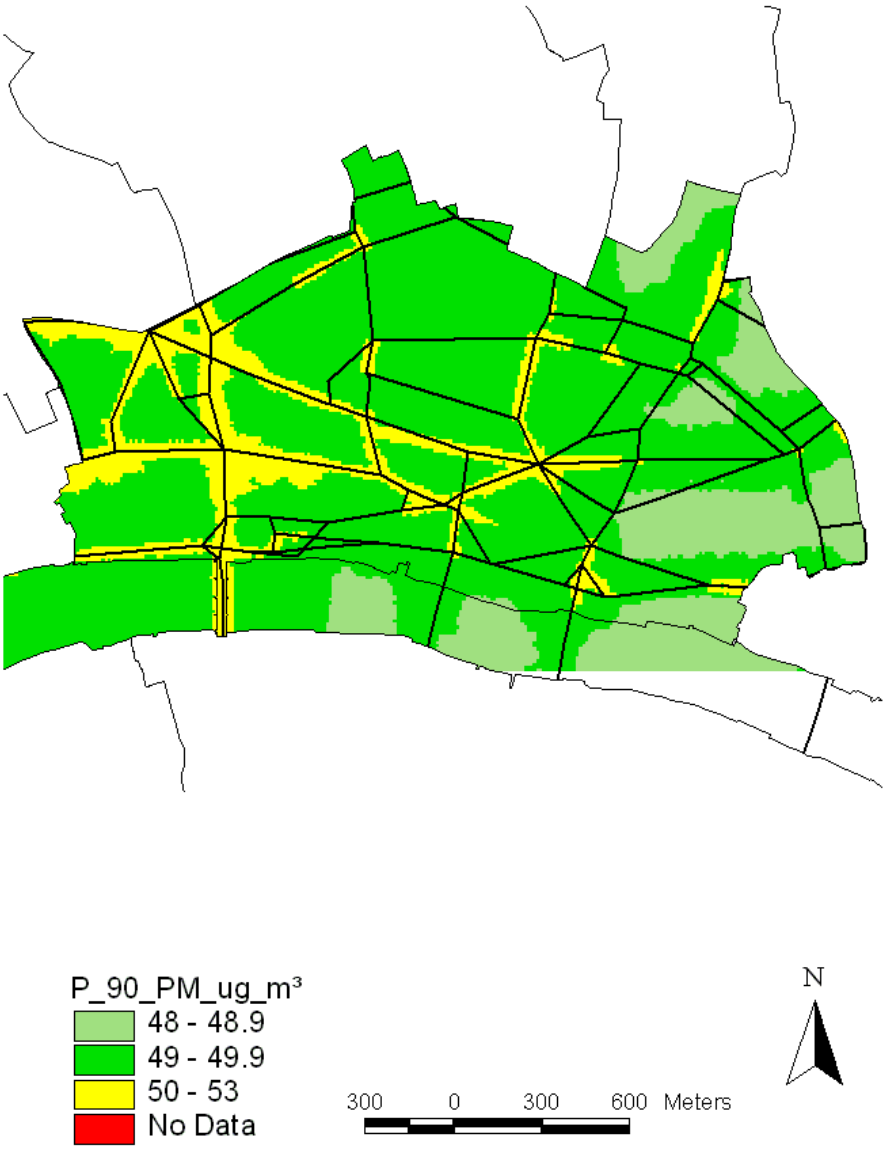

Figure 9

2.7 Sulphur dioxide

Objective 350μg/m^3 (132ppb) or less when expressed as a 1-hour average not to be exceeded more than 24 times per year.
Target date: 31 December 2004.
Objective 125μg/m^3 (47ppb) or less when expressed a 24-hour average not to be exceeded more than 3 times per year.
Target date: 31 December 2004.
Objective 266μg/m^3 (100ppb) or less when expressed as a 15-minute average not to be exceeded more than 35 times per year.
Target date: 31 December 2005.

The initial objective of 100ppb expressed as a 15-minute average not to be exceeded more than 35 times per year has been retained and two further objectives introduced in the regulations.

Road transport accounts for approximately 23% of sulphur dioxide emissions in London. One of the main sources of sulphur dioxide affecting the City of London are the power stations along the East Thames corridor. Easterly winds can bring sulphur dioxide from the power stations across the City increasing the background concentration.

Concentrations of sulphur dioxide are monitored in the City using continuous analysers. Further details of the monitoring locations and techniques used can be found in the Stage 3 Air Quality Review. Recent results have been compared to the three air quality objectives and are presented in Table 8.

Site	Year	Data capture	1-hour average (99.7%ile)	24-hour average (99%ile)	15-minute average (99.9%ile)
OPSIS	1996	92%	165μg/m^3 (62ppb)	100μg/m^3 (38ppb)	-*
	1997	69%	125μg/m^3 (47ppb)	113μg/m^3 (42ppb)	-*
	1998	75%	136μg/m^3 (51ppb)	46μg/m^3 (17ppb)	-*
Senator House	1996	76%	186μg/m^3 (70ppb)	106μg/m^3 (40ppb)	-*
	1997	84%	133μg/m^3 (50ppb)	93μg/m^3 (35ppb)	263μg/m^3 (99ppb)
	1998	45%	128μg/m^3 (48ppb)	66μg/m^3 (25ppb)	212μg/m^3 (80ppb)

* The 15-minute average was not monitored for this period

Table 8

There were no exceedences of the air quality objectives in recent years, although the 1997 15-minute average at Senator House came very close.

2.7.1 Sulphur Dioxide Air Quality Modelling

Air quality modelling was undertaken for all three objectives. Full details of the modelling technique and input data used are given in the CERC reports [3 and 5] and a summary provided in the Stage 3 Air Quality Review.

Modelling runs were undertaken using 1996 and 1997 meteorological data. The highest concentrations were found in 1997. The results for this meteorological year are presented in Figures 10, 11 and 12.

The 1-hour average objective of 350μg/m^3 (132ppb) not to be exceeded more than 24 times per year is presented in Figure 10 as the 99.7th percentile. Concentrations are predicted to be much lower than the objective ranging between 85μg/m^3 and 101μg/m^3 (32 and 38ppb). Most of the City falls within the 96μg/m^3 to 101μg/m^3 (36- 38ppb) band.

The 24-hour average objective of 125μg/m^3 (47ppb) not to be exceeded more than 3 times per year is presented in Figure 11 as the 99th percentile. Concentrations are predicted to be lower than the objective ranging for 66μg/m^3 to 72μg/m^3 (25 to 27ppb).

The 15-minute average objective of 266μg/m^3 (100ppb) not to be exceeded more than 35 times per year is presented in Figure 12 as the 99.9th percentile. Concentrations are predicted to be well below the objective ranging from 133μg/m^3 to 165μg/m^3 (50 to 62ppb).

Predicted 99.7th percentile 1-hour average sulphur dioxide concentrations for 2004 using 1997 meteorological data

Air Quality Objective 350μg/m^3 (132ppb) not to be exceeded more than 24 times per year (99.7th percentile)

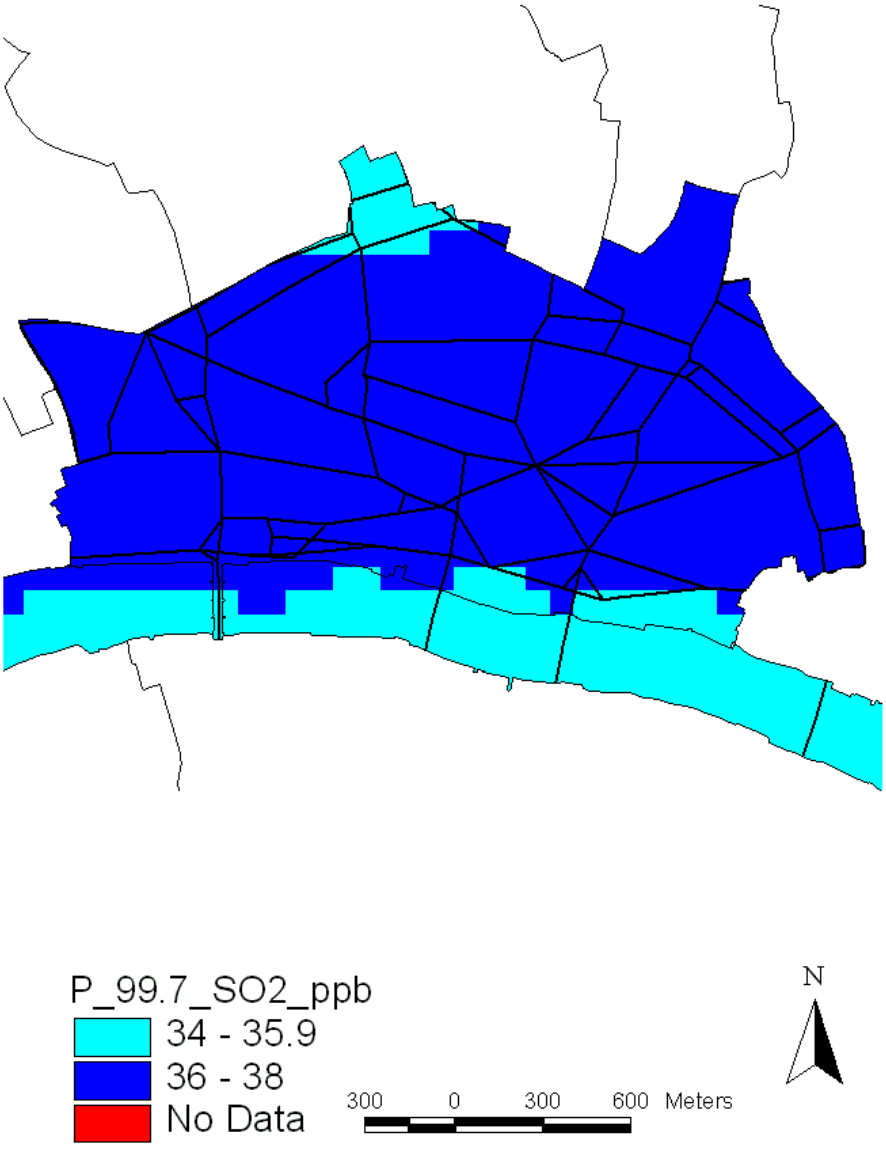

Figure 10

Predicted 99th percentile 24-hour average sulphur dioxide concentrations for 2004 using 1997 meteorological data

Air Quality Objective 125μg/m3 (47ppb) not to be exceeded more than three times per year (99th percentile)

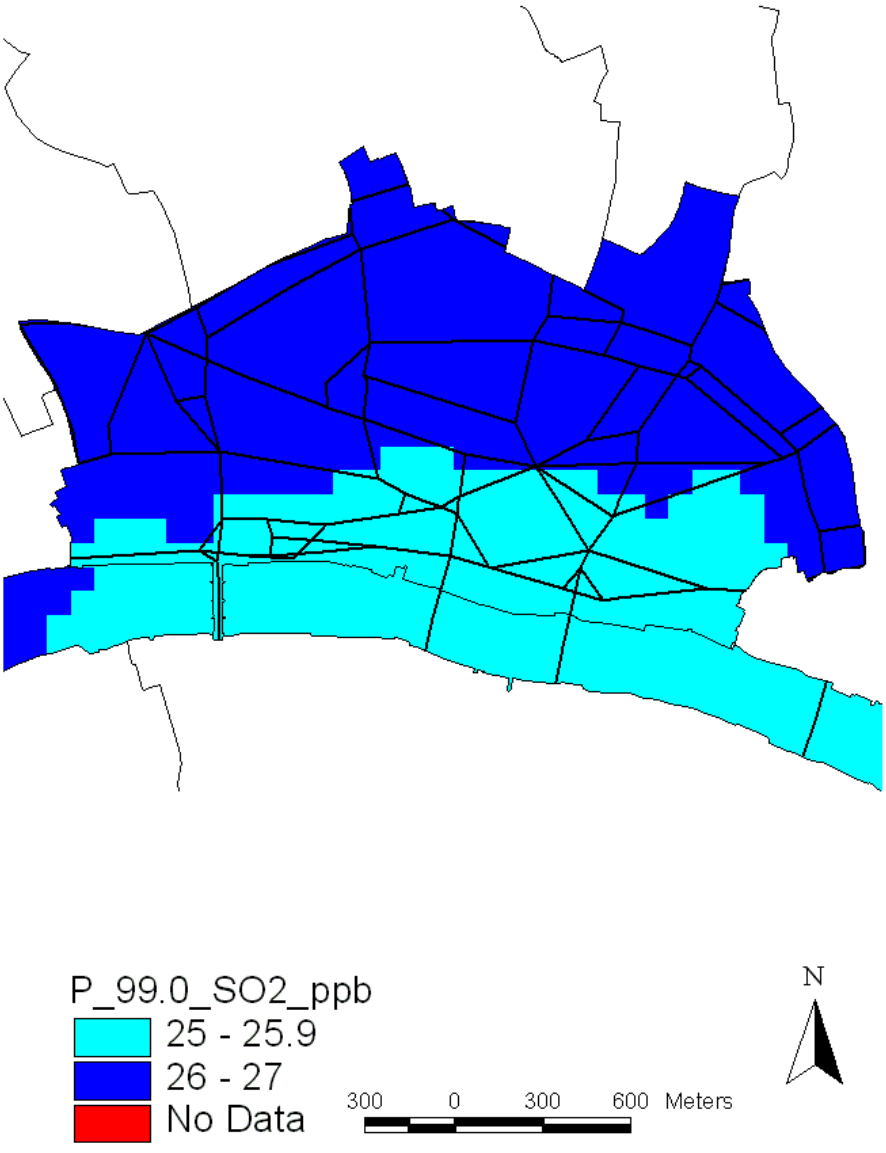

Figure 11

Predicted 99.9th percentile 15-minute average sulphur dioxide concentrations for 2005 using 1997 meteorological data

Air Quality Objective 266μg/m^3 (100ppb) not to be exceeded more than 35 times per year (99.9th percentile)

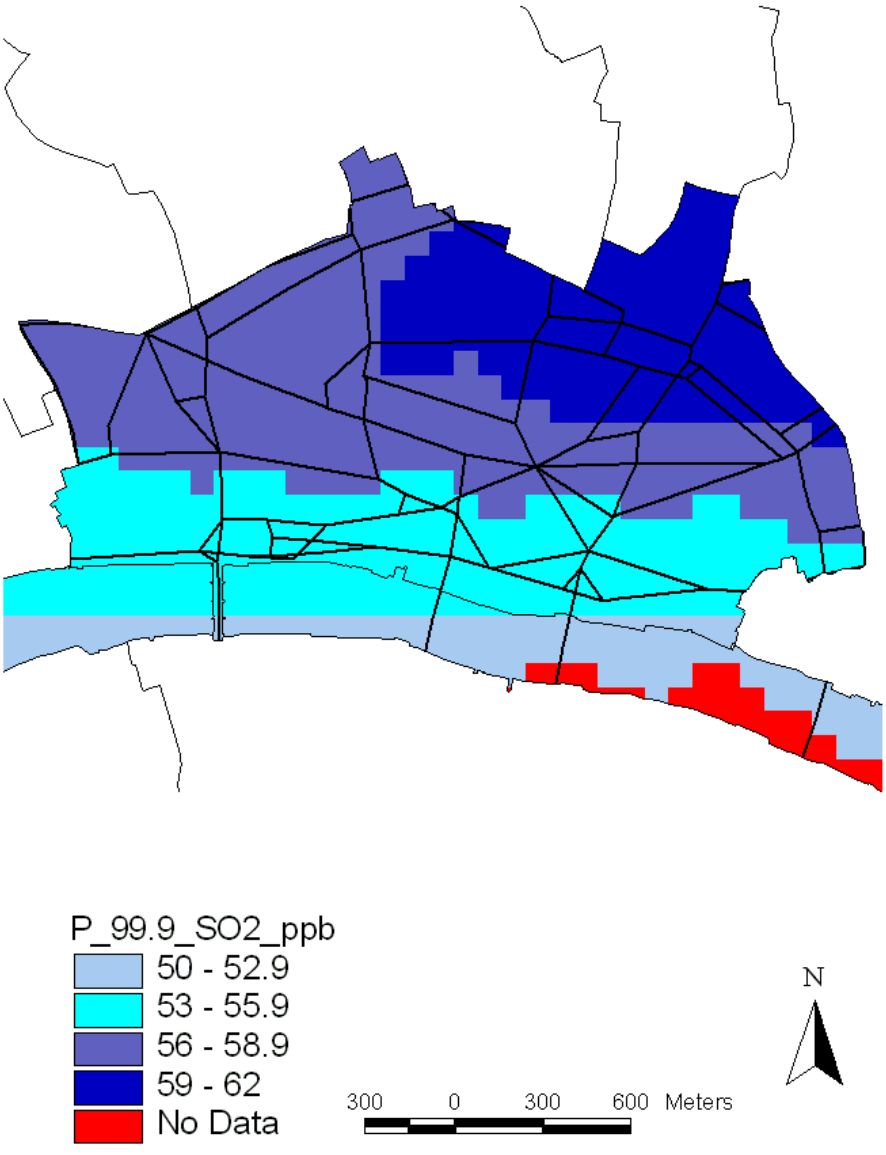

Figure 12

3. Accuracy of Air Quality Modelling

With any modelling exercise there is always an element of uncertainty in the modelled results due to unavoidable inaccuracies in the input data. In order to check the accuracy of the results a validation exercise is performed where the model is run for a given time period that has actual monitored data. The results of the model run are then compared to the monitored values.

In order to try and quantify the degree of error in the air quality modelling undertaken for this report, statistical analysis has been carried out on the data wherever possible. This involves taking the square root of the average sum of the squared differences between the predicted and measured concentrations. This quantity, the root mean square (RMS) can then be used to define a range of values above and below the concentration predicted by the model in which the actual concentration is expected to lie.

For the annual average nitrogen dioxide the error has been calculated at 2ppb using both 1996 and 1997 data at 11 sites across the central London area. Consequently, by taking a precautionary approach, the 19ppb contour line on Figure 6 would indicate likely areas of exceedence of the annual average concentration in the City.

The hourly average nitrogen dioxide concentration is more difficult to predict as maximum concentrations of a pollutant by their nature occur under relatively infrequent meteorological conditions. The root mean square of the 99^{th} percentile for 7 sites in 1996 is 19ppb and for 12 sites in 1997 15ppb. This is obviously a much greater margin of error than for the annual average. A straight comparison of the modelled against monitored data for the old air quality objective shows an over prediction of up to 49%.

In 1996 and 1997 there were very few PM_{10} monitoring sites in central London. The only data available was for 3 sites in 1996 and four in 1997. This is not considered sufficient to carry out a root mean square analysis on the data. A straight comparison of the modelled against monitored annual average data shows an under prediction of 6% in 1996 and an over prediction of 14% in 1997. The results are therefore fairly robust.

The 15-minute average sulphur dioxide concentration is very difficult to predict as like the hourly average nitrogen dioxide exceedences of the objective may only occur under unusual meteorological conditions. For 9 monitoring sites across central London in 1996 the root mean square was calculated to be 26ppb. There was not sufficient data capture in 1997 to make a reasonable statistical analysis. If this margin of error were added to the predicted concentrations for 2005 giving the worst case scenario, the values would still be below the air quality objective. A straightforward comparison of monitored and modelled data for 1996 gives an overall over prediction of 11% for the 15-minute average. It is considered therefore that the concentration of sulphur dioxide is unlikely to exceed the air quality objectives.

4. Exposure

In addition to taking into account the accuracy of the modelled results, it is essential to consider the relevant exposure of individuals when assessing the need for an Air Quality Management Area.

The main aim of the Air Quality Strategy and the Regulations is to ensure that ambient air quality in public places poses no significant risk to health and quality of life, without imposing unacceptable social or economic costs. It is important to consider where members of the public are present and likely to be exposed over the averaging time period of the objective. For the objectives with the relatively long averaging periods like the annual average nitrogen dioxide and 24-hour PM_{10} we need to consider background locations, roadside locations with housing and areas in the vicinity of housing, schools and hospitals.

The City is unusual in that a large number of people work and visit during the day and leave in the evening. Residential areas are scattered through the City, with large numbers of people living in the Barbican, Golden Lane, Petticoat Square and Mansell Street Estates. There has been an increase in the number of residential units in the City in recent years and this trend looks likely to continue.

Members of the public are currently exposed to concentrations of both nitrogen dioxide and PM_{10} exceeding the air quality objectives throughout the City, and this is likely to continue.

There are few locations in the City where, given the density of the heavily trafficked road network and the close proximity of housing, workplaces and schools to these roads, exposure of the public to nitrogen dioxide and PM_{10} over a substantial part of the day or year is unlikely to occur.

Although the majority of people exposed in the City are likely to be either workers or visitors, their exposure can not be discounted. This is because it can not be guaranteed that they will not be exposed for a substantial part of the day whether at work or in the streets.

5. Future Air Quality Management in the City of London

Section 83(1) of the Environment Act 1995 requires local authorities to designate areas that are unlikely to meet the prescribed air quality objectives as Air Quality Management Areas. This will involve the formulation of a written action plan setting out the action the local authority intends to take to achieve the air quality objectives. It will also involve further reviews and assessments within the Air Quality Management Area.

Following careful consideration of the potential for public exposure, potential margin of error in the air quality modelling and the practicalities of drawing a boundary, the Corporation of London propose to declare the entire City of London an Air Quality Management Area for annual average nitrogen dioxide, and for 24-hour average PM_{10}. The justification for this decision is given below.

Nitrogen Dioxide

This decision for annual average nitrogen dioxide is based on the 36μg/m^3 (19ppb) contour banding which takes in to account the predicted margin of error.

Figure 6 shows that only very small areas of the City fall below 36μg/m^3 (19ppb). These are specifically Fenchurch Street Station, a small area north of Liverpool Street Station and a small area in the South East corner of the City; these areas are all above 34μg/m^3 (18ppb). The Corporation of London considers it to be impractical to exclude these areas from the Air Quality Management Area and for reasons of clarity proposes to declare the entire City as an Air Quality Management Area for annual average nitrogen dioxide.

Due to the uncertainties in the modelled output for hourly maximum nitrogen dioxide, the Corporation of London does not propose to declare an Air Quality Management Area for this objective at this stage. As part of the next phase in the air quality review process, the Corporation of London will be carrying out further research into the anticipated future concentrations of hourly average nitrogen dioxide. In the mean time any action taken to bring down the concentration of the annual average nitrogen dioxide is anticipated to deal with any potential for exceedence of the hourly average objective.

PM_{10}

There are predicted to be exceedences of the 24-hour PM_{10} objective, principally along the major road network. Figure 9 shows that most of the City falls within the 49 - 50μg/m^3 band. The modelled results appear to be fairly well predicted and to take a precautionary approach the Corporation of London proposes to take the 49μg/m^3 band as the air quality management area. There are areas of the City that fall within the 48 - 49μg/m^3 band and these area include Petticoat Square and Mansell Street (two of the City's main residential areas). These areas broadly reflect the 34μg/m^3 to 36μg/m^3 (18ppb -19ppb) band for annual average nitrogen dioxide. For

reasons of clarity and to reflect the decision made for annual average nitrogen dioxide the Corporation of London proposes to declare the whole of the City of London an AQMA for 24-hour PM_{10}.

The annual average PM_{10} predicted concentrations are anticipated to be more accurate than the 24-hour average. The highest concentration in the City is 35.9μg/m^3. Even if 2μg/m^3 is added to this concentration the annual average objective of 40μg/m^3 will not be exceeded. Based on these results the Corporation of London considers it unlikely that the air quality objective for annual average PM_{10} will be exceeded. As part of the ongoing review into PM_{10} in the City the Corporation of London will carry out further assessments on annual average PM_{10} to ensure that the objective will be met.

Sulphur Dioxide

The modelling and potential margin of error for sulphur dioxide does not suggest that concentrations of sulphur dioxide will exceed the air quality objectives. The Corporation of London will however continue to monitor concentrations of sulphur dioxide in the City to ensure the objective is complied with.

6. Conclusion

The outcome of the Stage 3a Air Quality Review using the objectives laid down in the Air Quality (England) Regulations 2000 is that the Corporation of London proposes to declare an Air Quality Management Area for the entire City of London for annual average nitrogen dioxide and 24-hour average PM_{10}. The extent of the area is shown in Figure 13 below.

This decision is open to public consultation for a period of 3 months and the final decision will be made in the autumn of 2000.

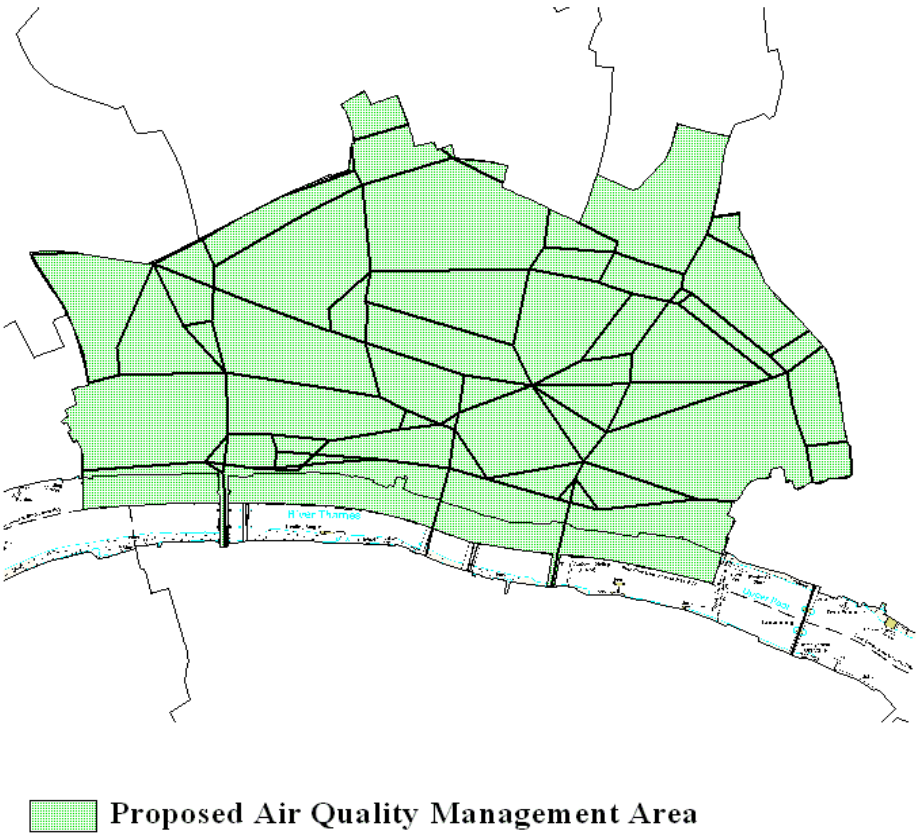

Figure 13

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