Corporation of London

Air Quality Review

Stages 1 and 2

September 1998

CORPORATION
OF LONDON

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Summary

The United Kingdom National Air Quality Strategy outlines national policy for controlling air pollution. It introduces a system of local air quality management by setting air quality objectives that need to be met by the year 2005.

Each local authority must review and assess the quality of air within its boundaries to ensure that the prescribed objectives will be achieved. If it is predicted that the objectives will not be met then Air Quality Management Areas will be established. Additionally, local strategies will be developed outlining the action that will be taken to improve the air quality. The review and assessment is to be carried out in three stages. This document combines stages 1 and 2 for the Corporation of London.

The assessment concludes that levels of carbon monoxide, lead, benzene and 1,3-butadiene will comply with the objectives by 2005 and hence require no further assessment. However, it is anticipated that levels of nitrogen dioxide, particulates and possibly sulphur dioxide in the City will exceed the standards and therefore will be included in a third stage review. This review will involve more detailed analysis and monitoring and is anticipated to be complete by the summer of 1999.

Index

1. Introduction

2. Air Quality Monitoring in the City

3. Stage 1 and 2 Review

4. Conclusion

5. Appendices

References

1. Introduction

1.1 National Air Quality Strategy and Local Air Quality Management

The United Kingdom National Air Quality Strategy [1] , which was published in March 1997, sets out a national policy for dealing with air quality. The strategy outlines the future of ambient air quality policy in the UK until the year 2005.

National and International policies are expected to deliver significant improvements in air quality throughout the Country. However the Strategy recognises that there is a significant local dimension to air quality due to factors such as traffic density, local topography etc. Consequently, any problem areas or 'hot spots' due to local conditions will need to be tackled at a local level.

The Environment Act 1995 laid the foundations for a nation-wide system of local air quality management. Under Part IV of the Act, local authorities are required to periodically carry out a review and assessment of air quality within their area. The primary objective is to identify areas where air quality is unlikely to meet the objectives prescribed in the Air Quality Regulations 1997 by the year 2005. The first full review and assessment must be completed by December 1999. In addition to the review, local authorities are required to ensure that air quality considerations are integrated into decision making processes such as land use planning and traffic management.

The National Air Quality Strategy sets *standards* and *objectives* for the following pollutants

- Benzene (C_6H_6)
- 1,3-butadiene
- Carbon Monoxide (CO)
- Lead (Pb)
- Nitrogen dioxide (NO_2)
- Particulates(PM_{10})
- Sulphur dioxide (SO_2)
- Ozone (O_3)

Air quality *standards* have been taken from the recommendations of the Governments advisory panel - the Expert Panel on Air Quality Standards (EPAQS). They are set with regard to scientific and medical evidence of the effects of a particular pollutant on health. The levels represent minimum or no significant risk to health. They are not based on costs and benefits or issues of technical feasibility.

Air quality *objectives* represent the Government's present view of achievable air quality by the end of 2005 having regard to the actual costs, benefits and feasibility. The objectives provide the framework for determining the extent to which local policies should aim to improve air quality. Where predictions show that by the end of 2005 the objectives will not be achieved, the authority will be required to establish Air Quality Management Areas (AQMA's). For each AQMA local authorities will prepare an action plan to achieve the air quality objectives in the designated areas.

Although ozone is one of the pollutants listed in the strategy it is not included as an air quality objective in the Air Quality Regulations 1997. This is because ozone is not emitted directly but arises from chemical reactions of oxides of nitrogen (NO_x) and Volatile Organic

Compounds (VOC's) in the atmosphere under the influence of sunlight. High ozone concentrations at a particular location may have been caused by emissions of NO_x and VOC's hundreds or even thousands of kilometres away. The responsibility for achieving the ozone objective lies at national and international level. The Corporation of London does, however monitor ozone levels in the city and will continue to do so as it is an important indicator of local air quality.

The air quality standards and objectives as detailed in the National Air Quality Strategy are given in Table 1 below

Pollutant	**Standard**		**Objective to be achieved by 2005**
	concentration	**measured as**	
Benzene	5ppb	running annual mean	5ppb
1,3-Butadiene	1ppb	running annual mean	1ppb
Carbon monoxide	10ppm	running 8 hour mean	10ppm
Lead	0.5μg/m^3	annual mean	0.5μg/m^3
Nitrogen dioxide	150ppb 21ppb	1 hour mean annual mean	150ppb hourly mean* 21ppb annual mean*
Ozone	50ppb	running 8 hour mean	50ppb measured as the 97th percentile*
Fine particles (PM_{10})	50μg/m^3	running 24 hour mean	50μg/m^3 measured as the 99th percentile*
Sulphur dioxide	100ppb	15 minute mean	100ppb measured as the 99.9th percentile*

ppm = parts per million
ppb = parts per billion
μg/m^3 = micrograms per cubic metre
* these objectives are to be regarded as provisional, they may be subject to change following a review of the National Air Quality Strategy

Table 1

1.2 Air Quality Review Procedure

The National Air Quality Strategy, along with subsequent guidance [9], outlines the way that a air quality review and assessment should be carried out.

For practical purposes the review is to be carried out in three stages. The complexity and detail of the review will be consistent with the risk of failing to achieve the air quality objectives by 2005. The results of the first stage indicate whether it is necessary to continue to the second stage. Similarly the results of the second stage will indicate whether it is necessary to go on to the third.

The first stage of the review is to consider the sources of pollution in the area, such as particular types of industry or traffic. The second stage requires a more detailed assessment of any pollutants of concern resulting from the stage 1 assessment. For stage 2 it is expected that information will be used from air quality monitoring and simple modelling techniques. The third stage requires more detailed monitoring and modelling and the preparation of emission inventories.

The Corporation has been carrying out comprehensive air quality monitoring in the City for a number of years and as such are in a position to combine stages 1 and 2 in this document. Additionally, along with seven neighbouring London Boroughs, the Corporation is in the process of obtaining sophisticated air quality modelling package that will enable a detailed assessment to be made of the pollutants of concern. The authorities involved form the Local Air Quality Network Central London Cluster Group which is made up of Westminster City Council, the London Borough of Camden, the London Borough of Islington, the London Borough of Hackney, the Royal Borough of Kensington and Chelsea, the London Borough of Southwark, the London Borough of Lambeth and the Corporation of London.

Due to the purchase of this modelling package it is considered that any basic modelling required for stage 2 would not provide any additional information. Following the review outlined in this document the authority will proceed directly to stage 3.

1.3 Air Quality in the City of London

The Corporation of London is part of the London Air Quality Network (LAQN). The network was set up in 1993 to co-ordinate and improve air quality monitoring so that action could be taken to improve air quality across the whole of London. The Network is managed by the South East Institute of Public Health (SEIPH) who publish quarterly and annual reports.

As part of the local air quality management process, a London wide review and assessment has been undertaken by SEIPH [11]. The review provides an overview of current pollution levels across London using data from the LAQN and other sites in London. It considers likely pollution trends for London as a whole and has provided a useful reference for this assessment, which is specific to the City of London.

The main source of pollution in the City is undoubtedly road traffic. The Corporation of London has already taken steps to reduce the impact that excessive traffic levels have on the City. In July 1993 an experimental traffic management scheme was implemented as part of

the Corporation of London Unitary Development Plan. One of the objectives of the scheme was to minimise pollution.

Vehicle access to the central area of the City is controlled by a cordon of points which restrict access. The effect is to reduce the flow of traffic in the central area by diverting it onto more suitable routes around the periphery. Other measures were taken such as the rephasing of traffic lights to optimise flows and increasing the capacity of Upper and Lower Thames Street to accommodate the diverted traffic.

The Transport Research Laboratory (TRL) carried out an assessment into the effects of the scheme on vehicle emissions [18]. The TRL calculated that overall emissions from vehicles in the City were reduced by 3%. Emissions within the area bounded by the traffic cordon reduced by 15% whilst outside the area they increased by 2%.

The TRL also evaluated the effects of the management scheme on air pollution concentrations[17]. The study concluded that where traffic flows were reduced there would be a corresponding reduction in pollution concentrations by up to 15%. Conversely where traffic flows increased so have pollution levels, by up to 20%.

The City of London is a smoke control zone where the burning of fuel with a high sulphur content is not allowed. This is enforced under Local Acts of Parliament which were implemented shortly after the notorious London smogs of the early 1950's.

2. Air Quality Monitoring in the City

Air quality monitoring has been taking place in the City of London since the late 1960's. A wide range of air quality monitoring is currently being undertaken, the techniques and locations are shown in Figure 1, Appendix I. The current range of monitoring has been chosen to provide a good spatial and temporal coverage of pollutants of concern.

The measurements produced are average values over a defined period of time which may range from a month to a few seconds. Passive sampling (diffusion tubes) is used to provide a simple cost-effective method of initially screening air quality to give a general indication of average pollution concentrations and highlight any 'hotspots'. The low cost per tube allows sampling at a relatively large number of locations. Active sampling (the 'bubbler' at Guildhall) provides valuable baseline data for trend analysis and comparison. The automatic analysers provide more accurate data with a high resolution (typically hourly averages) which is important for progressing to stage 3 of the review process. The Opsis provides even more accurate data over a relatively large, the Barbican, where a large proportion of City residents live.

The site locations are broken down into a series of classes. Department of the Environment Transport and the Regions (DETR) guidance: 'Monitoring for Air Quality Reviews and Assessments'[15] defines site classes in the following way:

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

The techniques used to monitor the air quality in the city are given in more detail below.

2.1 Passive sampling (diffusion tube) - Nitrogen dioxide; Benzene, Toluene and Xylene

Diffusion tubes are passive devices that are used for monitoring nitrogen dioxide (NO_2) and Benzene Toluene and Xylene (BTEX) in the City. A chemical media inside the tube adsorbs the gas and concentrations are determined later in a laboratory. Nitrogen dioxide tubes are exposed for four weeks and BTEX tubes for 2 weeks. They provide a general indication of average pollution concentrations and are very useful for highlighting 'hotspots' which may warrant more detailed investigation.

The Corporation is part of a London wide diffusion tube survey that commenced in 1986. It is co-ordinated by Stanger Science and Environment who carry out quality control procedures and validate the results. The Corporation is also part of the UK Nitrogen Dioxide Survey which is co-ordinated and quality controlled by AEA Technology.

With regard to the accuracy of the diffusion tubes, it has been estimated that NO_2 tubes over estimate ambient NO_2 by approximately 10% when compared to chemiluminescent analysers

(see section 2.6.1 for a description of a chemiluminescent analyser). Benzene diffusion tubes are estimated to be accurate within 10% of the measured value.

Table 2 details current diffusion tube monitoring sites in the City.

Diffusion tube sites in the City

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

Table 2

2.2 Opsis Analyser - (sulphur dioxide, nitrogen dioxide and ozone)

Sulphur dioxide (SO_2) , nitrogen dioxide (NO_2) and ozone (O_3) are continuously monitored using Opsis equipment. The technique is known as differential optical absorption spectroscopy. The Opsis analyser is located on the roof of the north block of the Guildhall. It receives a beam of light projected from the roof of the Barbican Arts Centre. The pollution levels are averaged across the length of the light beam providing information for a relatively large area. The equipment calculates the 60 second average concentration for each pollutant. Fifteen readings per hour are collected for each pollutant and the data is collected and analysed on a computer. The site is classified as Urban Background.

Envirotechnology plc calibrate the equipment once every 6 months. The Corporation of London carry out quality control on the data.

The accuracy of the data depends on a range of factors including the accuracy of calibration. It is estimated to be $\pm$ 10%.

2.3 Semi-Automatic Sampling BS1747- 'Bubbler' (sulphur dioxide and black smoke)

The semi-automatic sampler, monitoring for sulphur dioxide and black smoke, is located on the roof of the Guildhall north block. It is classified as an Urban Background site. The Station is part of the UK Smoke and SO_2 monitoring network which dates back to the early 1960's and currently consists of over 200 sites. The survey was set up to monitor the progress of the Clean Air Acts of 1956 and 1968 which were introduced to control urban smog.

The station belongs to both the Basic Urban Network (BUN) and the EC Directive Network. Sites in the BUN have been selected to provide a representative network of monitoring locations in major population centres and provide a long term database of smoke and SO_2 measurements. The EC Directive network is designed to monitor compliance with the EC Directive on Sulphur Dioxide and Suspended Particulate Matter. AEA Technology co-ordinate the network and operate a quality control procedures [23]. This method of air quality monitoring is well established and proven and has been used in monitoring networks world-wide for many years.

The equipment, which is commonly referred to as a 'bubbler', comprises of a simple 8 port sampler which gives average daily concentrations of SO_2 and fine suspended particles (black smoke). A measured amount of air is drawn through a filter paper where the fine particles are deposited. The filter paper is analysed for the concentration of particles by reference to a standard light source. The filtered air is then passed in to a dilute acidified solution of hydrogen peroxide. The concentration of SO_2 is determined by chemical laboratory analysis. Daily average concentrations of SO_2 measured can be used to estimate the 99.9th percentile of 15 minute averages.

An accuracy of $\pm$10% has been estimated for SO_2 measurements using this method.

2.4 Road Side Pollution Monitors - Carbon monoxide and nitrogen dioxide

The city has four roadside pollution monitors provided by Seimens Environmental Systems Ltd. The monitors which analyse nitrogen dioxide and carbon monoxide give a general indication of pollution levels at roadside locations. All four sites are classified as kerbside. They and are currently located at:

Mansion House: the central reservation of Queen Victoria Street outside the Magistrates Court

Fetter Lane: the south side of Fleet Street at the junction of Fetter Lane

Fish Street Hill: on the North side of Lower Thames Street by the junction with Fish Street Hill

Liverpool Street: the west side of Bishopsgate by the junction with Liverpool Street .

These instruments are not as accurate as automatic real time point analysers but provide a good indication of the trends of pollutants. They are serviced once a year by Seimens Environmental Systems.

2.5 TEOM Particulate monitor PM_{10}

A roadside particulate monitor has recently been established at the side of Beech Street, although on writing this report no data is available. The instrument is a TEOM (Tapered Element Oscillating Microbalance). The PM_{10} fraction is obtained via a separator and the air is passed through an oscillating balance head which traps the particulate matter. The weight of the dust slows down the oscillation and the energy required to obtain the original frequency is proportional to the weight of particulate matter. Fifteen minute average concentrations are collected from the analyser. The site is classified as roadside.

The unit will be serviced and calibrated once per year. The precision of the instrument has been estimated at $\pm 4 \mu g/m^3$.

2.6 Automatic Real Time point analysers

This equipment produces high resolution measurements at a single point. The sample is analysed on-line and in real time. In order to ensure that the data is accurate and reliable a high standard of maintenance, and operational and quality control procedures is required. Automatic real time analysers are currently located at:

Senator House, Queen Victoria Street - an urban background site

Beech Street tunnel - a roadside site

Walbrook Wharf - a roadside site

Until August 1998 the equipment which is now situated at Walbrook Wharf was located in Queen Victoria Street outside the Magistrates Court in the central reservation. It was referred to as the Bank Reference Site and the site classification was kerbside.

2.6.1 Chemiluminescent Nitrogen dioxide analyser

The NO_2 analysers at Beech Street, Walbrook Wharf and Senator House are chemiluminescence analysers.

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) to form chemiluminescent nitrogen dioxide. The analysers are compliant with the international standard for this type of equipment [26].

An accuracy of $\pm$ 8% has been estimated for NO2 measurements using this method. The precision of the instruments is estimated to be $\pm$3.5ppb.

The quality control procedures as detailed in the National Environmental Technology Centre (NETCEN) site operators manual[20] are followed for the equipment. The analysers are calibrated once every two weeks using gases traceable to national standards. All data is scaled in line with fortnightly calibration checks. The analysers also perform overnight span checks and are serviced every 6 months.

2.6.2 Ultra Violet Fluorescence Sulphur Dioxide Analyser

The sulphur dioxide analysers at Senator House and Walbrook Wharf are based on the principle of ultra violet fluorescence. SO_2 molecules are excited to higher but unstable energy states by UV radiation. The energy decays causing an emission of secondary florescent radiation with an energy proportional to the concentration of SO_2 in the sample.

An accuracy of $\pm$10% has been estimated for SO_2 measurements. The precision of the instruments is estimated as $\pm$1.2ppb.

As with the Nitrogen dioxide analysers, the quality control procedures as detailed in the NETCEN site operators manual are followed for the equipment. The analysers are calibrated once every two weeks using gases traceable to national standards. All data is scaled in line with fortnightly calibration checks. The analysers also perform an internal overnight span check and are serviced every 6 months.

2.6.3 Non-dispersive infra-red carbon monoxide analyser

Carbon monoxide is measured at Beech Street and Walbrook Wharf using an NDIR analyser. The analyser works by transmitting an infra red beam of light through a cell through which ambient air is pumped. The beam of light is of a frequency that is only absorbed by the presence of carbon monoxide. The absorbency is related to the carbon monoxide concentration.

As with the Nitrogen dioxide analysers, the quality control procedures as detailed in the NETCEN site operators manual are followed for the equipment. The analysers are calibrated once every two weeks using gases traceable to national standards. All data is scaled in line

with fortnightly calibration checks. The analysers also perform an internal overnight span check and are serviced every 6 months.

2.6.4 Ultra Violet Photometric Ozone Analyser

Ozone is measured at Senator House using an ultra violet photometric ozone analyser. Ozone concentrations are calculated from the absorption of ultra violet light. The equipment has its own internal analyser for routine zero / span checks. The analyser is serviced every 6 months.

Station Summary

A summary of the air quality monitoring stations is given in Table 3

Monitoring Station	Nitrogen dioxide	Sulphur dioxide	Carbon monoxide	Ozone	Particulates PM_{10}	Black smoke
Opsis, Guildhall	x	x		x		
BS1747, Guildhall		x				x
Senator House	x	x		x		
Beech Street tunnel	x		x			
Beech Street -TEOM					x	
Walbrook Wharf	x	x	x			
Mansion House RPM	x		x			
Liverpool Street RPM	x		x			
Fish Street Hill RPM	x		x			
Fetter Lane RPM	x		x			

RPM = Roadside Pollution Monitor

Table 3

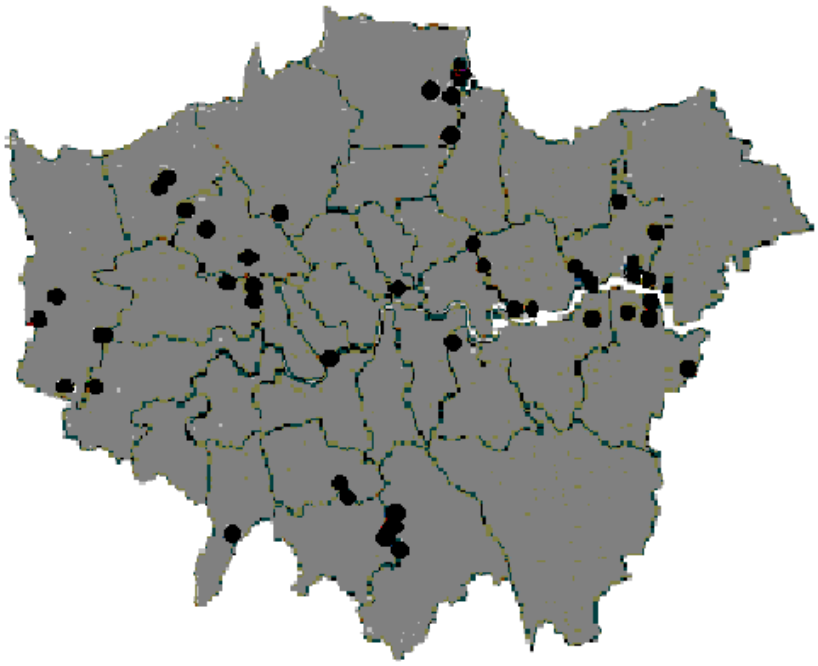
3. Stage 1 and 2 Reviews

3.1 Industrial Sources

Most large scale industrial emissions derive from processes that are regulated under Part 1 of the Environmental Protection Act 1990. They are divided into large processes which are regulated by the Environment Agency (Part A) and smaller operations regulated by local authorities (Part B). The aim of the regulation is to control emissions to air. Being a predominantly commercial zone, there are no operations which fall under this legislation within the City.

Due to its location, the City does have the potential to be affected by emissions from processes in adjacent Boroughs and on the east Thames corridor. On the border of the City there is a small power station 'Citigen'. The power station burns gas and is not considered to be a significant source of pollution for the City. However some Part A processes in South and East London have the potential to have an impact on the sulphur dioxide levels in the city. The location of industrial operations regulated by the Environment Agency throughout London are detailed in Figure 2.

Figure 2: Map of Part A Processes in London



3.2 Transport related sources

As previously stated, the main source of pollution in the City is transport. A key requirement of the review is to highlight any existing or proposed roads with traffic flows of over 25,000

vehicles per day or traffic speeds of less than 10km/hour for prolonged periods of time. These road networks are the most likely to suffer from high levels of pollution. The Corporation of London, through its Department of Technical Services, monitors traffic flows at 53 locations around the City and also monitors average vehicle speeds at regular six monthly intervals[13,14]. Appendix II contains traffic flow details for the City. Figure 3 indicates roads in the City with daily traffic flows of over 25,000 and 50,000. Figure 4 highlights the roads that have peak hour traffic speeds of less than 6mph (9.6km/hr) for one or more of the three time periods that were surveyed (morning peak, mid day peak and evening peak period).

In 1997 the London Research Centre carried out an Atmospheric Emissions Inventory for London[10]. The purpose of the inventory is to identify all of the significant sources of air pollution and the amount of each pollutant released in the London area. The inventory highlights that for the whole of London the contribution of road traffic to total emissions is as detailed below

Pollutant	Percentage from road traffic
NO_x	75
SO_2	23
CO	97
PM_{10}	77
Benzene	83
1,3-butadiene	97

3.3 Pollutant Specific Assessment

3.3.1 Carbon Monoxide (CO)

Carbon monoxide is produced by the incomplete combustion of organic material which occurs when there is not enough oxygen available. Most combustion processes produce some carbon monoxide, the amount largely depends upon the efficiency of the process and availability of oxygen.

Sources

Outdoors, the main source of carbon monoxide is from petrol driven motor vehicles; diesel engines produce very little carbon monoxide. In London road traffic accounts for 97% of CO emissions.

Health Effects

Carbon monoxide 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. The people most susceptible to exposure to carbon monoxide are those with angina and disease of the coronary arteries.

Air Quality Objective

The Air Quality objective for carbon monoxide has been set at 10 ppm measured as an 8 hour running average.

Data

Carbon monoxide levels are continuously monitored at 6 roadside locations across the city. The roadside locations give the worst case situation - levels of carbon monoxide fall off very quickly with distance from the roadside. Carbon monoxide concentrations are highest in the winter months.

Since its establishment in April 1997, the Beech Street monitoring station has exhibited the highest carbon monoxide levels. It analyses the air in the Beech Street tunnel, approximately 1 metre from the roadside. During its first year of operation the 10ppm objective was exceeded for a total of 86 hours. The maximum recorded level was 23 ppm which occurred during the winter months.

Compliance with the objective

The gradual increase in the percentage of petrol driven vehicles with catalytic converters will reduce emissions of carbon monoxide. The National Air Quality Strategy suggests that emissions will reduce by 32% in 2000, 48% by 2005 and by 54% in 2010 compared with 1995 levels. The Government guidance states that the background annual average carbon monoxide concentrations at the end of 2005 will be half of the 1996 value. The AEA Technology world wide web page gives the background concentration in the City of London as 0.76ppm in 1996, it is therefore anticipated to be 0.38ppm by 2005. The maximum 8 hour rolling average will be at least 4 times the annual mean, 4 multiplied by 0.38ppm gives 1.52ppm which is well below the 10ppm objective.

The Department of Environment, Transport and the Regions have predicted that the objective will not be exceeded by 2010, even under exceptional circumstances. Despite the levels of carbon monoxide shown in the London Air Quality Network over the past few years, SEIPH state that the objective will not be breached at any location in London by the year 2005, even in the vicinity of the busiest roads [11].

Consequently, no further assessment of this pollutant is required in the air quality review. The Corporation of London will however, continue to monitor carbon monoxide levels in the city to assess the anticipated national reduction in emissions and ensure that the objective is met.

3.3.2 Benzene

Benzene is one of a group of substances known as VOC's (Volatile Organic Compounds). It is a liquid at normal ambient temperature but readily evaporates into the atmosphere. Almost all of the benzene in the air is a direct result of human activity, in particular from the

combustion and distribution of petrol. Benzene is a primary pollutant and concentrations are generally highest close to the emission source.

Health Effects

Concerns about normal ambient exposure to benzene are that it is a genotoxic carcinogen. People exposed to high levels of benzene in the workplace have an increased risk of contracting leukaemia.

Air Quality Objective

The air quality objective is set as an annual average of 5ppb.

Data

Benzene levels have been monitored at five locations across the city since April 1997, with a further five sites being established in August 1998. The initial results indicate compliance with the air quality objective even at busy roadside locations (see figure 5). The Corporation of London is part of the London wide benzene diffusion tube survey that is co-ordinated by Stanger Science and Environment. Sixteen London boroughs participate in the survey and, in 1997, the air quality objective was not exceeded at any of the 92 sites being monitored [19].

Figure 5

Compliance with the Objective

Three way catalytic converters, which have been fitted to all new petrol driven vehicles in the UK since 1 January 1993, reduce VOC emissions by approximately 75%. In addition, national controls are in place to reduce emissions of petrol from filling stations and at refineries and distribution terminals. Consequently, benzene emissions are expected to reduce by over 50% by the year 2005, based on 1995 levels. The Government has predicted that there will be no breaches of the air quality objective by 2005 even adjacent to the most heavily trafficked roads[1].

The Government Guidance states that only those authorities with major industrial processes which either handle, store or emit benzene and have the potential to result in elevated levels of benzene are expected to need to undertake a second or third stage review [12]. There are no such sources in the City and therefore no further assessment of this pollutant is required in the air quality review. The Corporation of London will, however, continue to monitor annual average benzene levels in the City.

3.3.3 1,3-butadiene

1,3-butadiene is a VOC that is a gas at normal ambient temperature and pressure. All emissions of 1,3-butadiene to the atmosphere are a result of human activity. The motor vehicle is the largest source, accounting for 67% of national emissions in 1995 [1]. Petrol and diesel fuels do not naturally contain 1,3-butadiene. It is formed in the combustion process from olefins in the fuel. In industry, it is used in the manufacture of synthetic rubber tyres.

Health Effects

1,3-butadiene is a genotoxic carcinogen. Evidence suggests that workers exposed to high levels have a marginally increased risk of developing cancers of the lymphoid system and bone marrow, lymphomas and leukaemia's.

Air Quality Objective

The air quality objective is set at an annual average of 1ppb.

Data

1,3-butadiene has not been monitored in the City. Monitoring has taken place in the neighbouring London Borough of Camden at UCL in Russell Square since 1994. The objective has not been breached during this monitoring period.

Compliance with the Objective

As with benzene, the main area to target for a reduction in 1,3-butadiene is motor vehicle exhausts. The use of three way catalysts reduces emissions of 1,3-butadiene by 95%. Emissions are anticipated to decline by 55% by the year 2000 of 1992 values and 73% by 2010 [1]. By 2005 the UK Government anticipate that there will be no exceedences of the air quality objective even at heavily trafficked roadside locations.

The Government guidance states that only those authorities with major industrial processes which either handle, store or emit 1,3 butadiene and have the potential to result in elevated levels are expected to need to undertake a second or third stage review [12]. There are no such sources in the City and therefore no further assessment of this pollutant is required in the air quality review.

3.3.4 Lead

Lead is the most widely used non ferrous metal and has a very large number of applications. The most significant use in relation to emissions to atmosphere is as an additive in petrol. In 1995 road transport accounted for 72% of emissions of lead in the UK.

Health Effects

Lead can be absorbed into the body by ingestion and breathing. Children are more susceptible to the effects of lead than adults. Studies have shown that lead can affect the nervous system and lower the IQ and learning ability of children. A major historical source of lead in the City was the newspaper printing industry in Fleet Street, the operations have now ceased.

Air Quality Objective

The air quality objective is 0.5 μ/m^3 measure as an annual average.

Data

There is no routine monitoring of lead carried out in the City. The neighbouring authority of Westminster City Council monitor lead levels and the levels have been below the standard since 1989.

The graph below shows the annual average lead levels at a site in central London from 1976 to 1994 and it is clear that there has been a steady decline and that levels are well below the air quality objective [11].

Figure 6

Compliance with the Objective

During the 1970's and early 1980's the lead content of petrol was reduced. Unleaded petrol was introduced in 1987, 70% of petrol now sold in the UK is unleaded. Since 1993 all new petrol engine cars have been fitted with catalysts and must run on unleaded petrol. These policies have drastically reduced the amount of lead in the atmosphere and are expected to enable the air quality objective to be met throughout the country at all locations where traffic is the major source.

Existing national policies are expected to deliver the prescribed objective for lead at all locations by 2005. The Government guidance states that only local authorities with significant industrial sources of lead are expected to need to undertake a second or third stage review [12]. There are no industrial operations emitting lead into the atmosphere in the City and no operations emitting significant levels of lead in neighbouring authorities. Consequently no further assessment of this pollutant is required in the air quality review.

3.3.5 Nitrogen Dioxide

Nitrogen dioxide is produced by the reaction of nitrogen and oxygen in the combustion process. Most emissions of nitrogen are usually in the form of nitric oxide (NO) which will react with ozone(O_3) or oxygen(O_2) to produce nitrogen dioxide(NO_2). Nitrogen dioxide and nitric oxide are both oxides of nitrogen and together are referred to as nitrogen oxides (NO_x). Nationally, the main source of nitrogen oxide emissions is road transport which accounted for 46% in 1995. Power stations are the next significant source accounting for 22% of emissions in 1995 [1]. In London road transport accounts for 75% of emissions of NO_x .

Health Effects

Nitrogen dioxide is an irritant gas. Exposure can bring about reversible effects on lung function and increased reactivity to natural allergens. In December 1991 premature mortality and hospital admissions rose dramatically in central London when NO_2 levels peaked at 423ppb during evening rush hour. Young children and people suffering from asthma and chronic respiratory diseases are particularly susceptible to nitrogen dioxide

Air Quality Objective

Two air quality objectives have been set for nitrogen dioxide. An hourly average of 150 ppb and a long term annual average of 21 ppb.

Data

Nitrogen dioxide is continuously monitored in the City at eight different locations. Diffusion tube sampling is also carried out at 12 locations.

Annual average nitrogen dioxide concentrations have exceeded the 21ppb objective at Senator House, the Bank reference site and the Guildhall. The Opsis, which monitors NO_2 levels at the Guildhall, represents an urban background site. The annual average levels from 1994 to 1997 are fairly constant and are illustrated in figure 7, below.

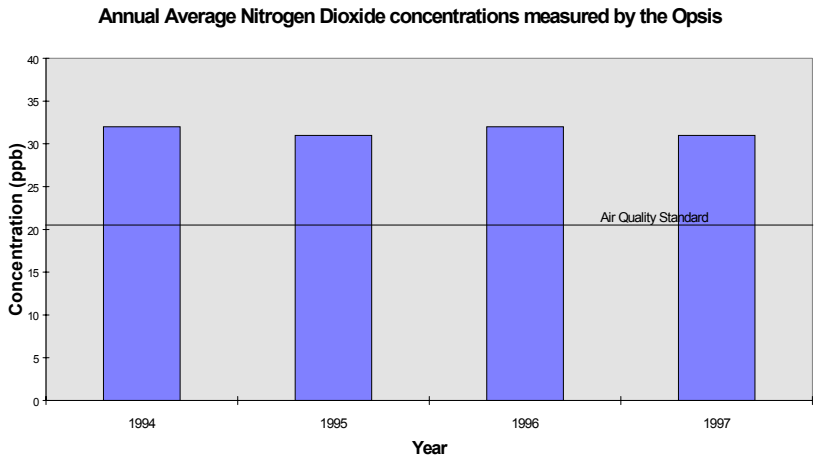


Figure 7

The diffusion tube data provides annual averages for a variety of locations, both urban background and roadside sites The results for a selection of the sites is illustrated in figure 8. The air quality objective is being breached at most locations.

Figure 8

The table below indicates the number of times that the hourly air quality standard was breached at different sites

Year	Opsis (Guildhall)	Beech Street	Bank Reference
1993	0	N/A	N/A
1994	0	N/A	N/A
1995	5	N/A	571
1996	0	N/A	821
1997	1	55	980

Table 4

Compliance with the Objective

The National Air Quality Strategy predicts that emissions of NO_x will fall by 40% by 2010 based on 1995 levels. However this trend of decreased emissions is set to reverse due to an anticipated growth in traffic.

The Government guidance recommends that a second or third stage review is undertaken if any of the following criteria are met:

- An annual mean urban background in 1996 of > 30ppb

  Information taken from the AEA Technology world wide web page gives a nitrogen dioxide background concentration for the City as greater than 35ppb.

- one or more existing or planned roads with an average daily traffic flow of >25,000 vehicles in 2005

  Figure 3, Appendix II, shows that there are a number of roads in the City with daily traffic flows of over 25,000 vehicles.

- One or more significant industrial source

  There are no significant industrial sources

- Diffusion tube or automatic measuring results giving an annual average of >30ppb

  Data from the Opsis indicates that the annual average NO_2 level in the City for an urban background site is >30ppb.

It is clear, therefore, that further assessment is required. The Government guidance [12] indicates that following a stage 1 review, an authority may proceed directly to a third stage review of NO_2. The Corporation of London does not consider that any basic modelling required by stage 2 will provide any additional information. Therefore this authority will proceed directly to stage 3 for a detailed review and assessment of nitrogen dioxide.

3.3.6 Sulphur Dioxide

For the first half of the century emissions of sulphur dioxide were dominated by the combustion of coal, not only in the domestic sector but also in commercial and industrial premises. Following the first Clean Air Act in 1956 there was a shift towards natural gas and power generation was concentrated in much larger more efficient stations in rural areas. Power stations now account for over 70% of SO_2 emissions nationally [1]. Today another significant source of sulphur dioxide is diesel engines. In London, road transport accounts for approximately 23% of sulphur dioxide emissions [10].

Health Effects

Sulphur dioxide, being acidic in nature, 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. With the range of concentrations that occur in pollution episodes it may provoke asthma attacks.

Air Quality Objective

The air quality objective is 100ppb as a 15 minute average measured as the 99.9th percentile. This means that only 35 periods of 15 minutes can exceed 100ppb in any one year.

Data

The City of London has been monitoring SO_2 levels since the late 1960's. Figure 9 shows how annual average levels of SO_2 monitored using the bubbler have declined dramatically over the past 30 years.

Existing sulphur dioxide monitoring data in the City is predominantly in the form of hourly averages. This is because the air quality guidelines used to be based on hourly averages. Table 5 shows the data collected in 1996. The levels shown are likely to be lower than the 99.9th percentile for 15 minute values as the hourly data is not as sensitive to fluctuations.

Air Quality Site	99.9th percentile for SO2, 1 hour average (ppb)	Highest hourly average concentration (ppb)
The Bank 1996	90	113
Senator House 1996	72	100
Opsis 1996	82	112

Table 5

The Opsis monitor has been collecting hourly average SO_2 data since 1993. In October 1997 changes were made to the equipment to enable it to collect 15 minute average data. Since this date there has been only one exceedence of the 15 minute average.

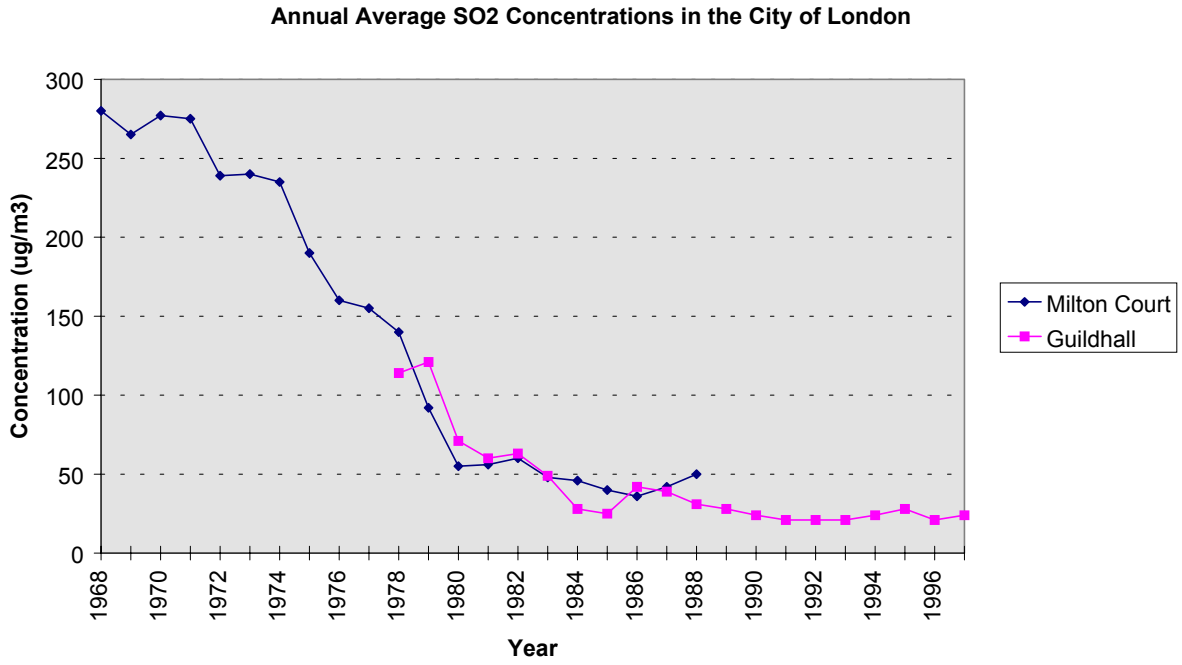


Figure 9

Compliance with the Objective

The Government guidance [12] provides a simple equation for calculating whether the air quality objective is likely to be met using data from the bubbler. The calculations are given in Appendix III and the results shown below.

Year	99.9th percentile of 15 minute average SO_2
1990	218
1991	257
1992	201
1993	173
1994	144
1995	132
1996	135
1997	178

Table 6

As can be seen from the above results, the 99.9th percentile has been above the 100ppb air quality objective using the bubbler data for the past seven years.

The occasional levels of high SO_2 in the City are likely to be from power generation along the east stretch of the Thames. SEIPH mapped sulphur dioxide data during the summer of

1995 and showed that a plume of SO_2 that occurred came from the East [11]. The DETR has launched a strategy for dealing with national emissions of SO_2. Compared with 1980 levels, SO_2 emissions should reduce by 70% by 2005. However as monitoring results indicate that the objective has the potential to be exceeded, the Corporation of London will undertake a third stage review and assessment on this pollutant.

3.3.7 Fine Particles PM_{10}

Particulate matter in the atmosphere may be classified as either primary or secondary. Primary particles are composed of a wide range of materials from a variety of sources. Man made sources include carbon particles from combustion, ash, road dust, brake and tyre wear. Natural sources include sea salt, pollens and fungal spores. Secondary particles are formed within the atmosphere by a series of chemical reactions and by the condensation of gases

PM_{10} particles (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.

The largest source of particles in the City is from road vehicles. Over 87% of total PM_{10} emitted in London is from diesel engines [10].

Health effects

Particulate air pollution appears to be associated with a range of symptoms including asthma and effects on cardiovascular and respiratory system. In addition they may carry surface absorbed carcinogenic compounds into the lungs.

Air Quality Objective

The air quality objective is 50μg/m^3 expressed as the 99th percentile of the daily maximum running 24 hour average. This means that only four days can exceed 50μg/m^3 in any one year.

Data

There is currently no monitoring data available for PM_{10} levels in the City itself but data is available for neighbouring authorities from the London Air Quality Network. The SEIPH report highlights that the air quality objective was exceeded at all continuous monitoring sites in London in 1995 and 1996 [11]. The highest value was recorded at Westminster in 1996 (116.28μg/m^3).

Compliance with the Objective

The Government guidance recommends that a second or third stage review is undertaken if any of the following criteria are met

- Annual average background due to secondary particles is >8μg/m^3

  Information taken from AEA Technology world wide web page gives a background concentration due to secondary particles of 11μg/m^3 for the City

- Emissions from low level dispersed sources of >10 tonnes in any 1km x1km grid

Information from the AEA Technology world wide web page gives the level as > 10 tonnes for the whole City

- One or more existing or planned road with an annual average daily traffic flow of >25,000

  There a number of roads in the City with a daily traffic flow of over 25,000 (see Appendix II)

- One or more Part A or Part B industrial operations that is a significant source of PM_{10} or dust

  There are no industrial operations in the City regulated under this legislation (see section 3.1).

The SEIPH report indicates that despite the large number of control measures that will influence concentrations of both primary and secondary particulate matter, evidence suggests that the objective will be exceeded throughout London in 2005 [11].

The Government has established an Airborne Particles Expert Group to advise on the sources of, and current and future ambient concentrations of, PM_{10} in the UK. There report is expected by the end of 1998.

It is considered that levels of PM_{10} will be exceed the air quality objective in 2005 and consequently this pollutant will be assessed further in the stage 3 review.

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