

**A Report on the Air Quality in
The County of Gloucestershire
in 2002**

A Report Prepared for

The Gloucestershire Pollution Group



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by

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Cover picture: Cirencester Market Place, site of NO₂ monitoring (courtesy of Cotswold DC)

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Executive Summary

This report is a review of air quality measurements made in Gloucestershire in the year 2002. As of 2001, air quality in Gloucestershire remains generally good. The main source of air pollution in the County is emissions from vehicular traffic. Government controls on traffic emissions are causing them to steadily reduce. The Government headline indicators for air pollution show a reduction in 2002 over 2001 and 2000, matching the trend in declining emissions. This reduction has been recorded in Gloucestershire by the monitoring carried out by the local authorities. The weather in 2002 was more conducive to the dispersion of air pollutants than 2001.

Nitrogen dioxide levels continue to show a steady reduction in line with Government predictions, owing mainly to the introduction of catalytic converters in cars. Instances where nitrogen dioxide is not falling would indicate increasing road traffic.

The Air Quality Management Area declared due to nitrogen dioxide pollution alongside the M5 initially has been rescinded. A thorough two year investigation of the problem by Tewkesbury BC and Stroud DC has shown that levels of nitrogen dioxide should fall within the National Air Quality Objective.

Levels of particulate pollution fell in line with Government predictions.

Levels of sulphur dioxide in the County are still negligible.

Levels of ozone were not as high in 2002 as in 2001, due to less sunny weather, with 20 as opposed to 43 days exceeding the National Objective value. Levels were exceeded that are known to causing breathing impairment in children. Ozone formation depends on sunshine, and it is also a regional pollutant, affected by emissions from outside of the County. Monitoring for ozone is being extended in the County.

Levels of benzene, toluene and xylene (emitted from petrol) continued to fall.

The State of the Countryside 2020 a March 2003 report to the Countryside Agency on the future of the countryside predicts an increase in commuting from rural areas. Road traffic emissions will increase on rural roads in the county and consideration might be given to putting in place monitoring to measure the changes.

The Gloucestershire Pollution Group are to formulate an Air Quality Strategy to encompass their ongoing duty to manage air pollution and to actively seek to reduce it.

1 Introduction

This report is a review of the air quality in the county of Gloucestershire, for the year 2002. It has been compiled on behalf of the Gloucestershire Pollution Group (GPG) by Casella CRE Energy, now a trading division of the Casella Group Limited, and formerly EMC Environment Engineering Ltd. Part IV of the Environment Act 1995 requires Local Authorities to assess and review air quality within their region in relation to the objectives prescribed in the Air Quality Regulations 2000. The Local Authorities within Gloucestershire have adopted a collaborative approach to Assessment and Review of air quality for the County. This work is co-ordinated by the GPG, a technical sub-committee of the Directors of Environmental Services in Gloucestershire. The GPG comprises Environmental Health Officers from six Local Authorities within the County identified below:

Tewkesbury Borough Council,
Cheltenham Borough Council,
Cotswold District Council,
Gloucester City Council,
Stroud District Council, and,
The Forest of Dean District Council.

The members of Gloucestershire Pollution Group are now carrying out Updating and Screening Assessments as part of their statutory duty of Local Air Quality Management. This process is to highlight any changes that may be impacting on local air quality since the Stage II Review and Assessments completed in 2001. For historical and geographical reasons South Gloucestershire District Council, although within the County, tends to operate in conjunction with initiatives from Bristol and the North Avon municipalities. Hence measurements of air pollution made in South Gloucestershire are not within the scope of this report.

1.1 '2001 Report on Air Quality in the County of Gloucestershire' April 2002

EMC Environment Engineering Ltd (now Casella CRE Energy) was contracted to provide an Annual Report reviewing air quality in the county for the years 2001 and 2002. This is the second of these reports. It reviews the air pollution measurements made by the local authorities in the GPG during the year 2002. Comparisons are made with previous years' measurements and with measurements made outside of the county.

The findings of the 2001 report were as follows. The report was a review of air quality measurements made in Gloucestershire in the year 2001. Air quality in Gloucestershire was on the whole good. The main source of air pollution in the County was emissions from vehicular traffic. Government controls on traffic emissions are causing them to steadily reduce. However, unfavourable meteorological conditions in the year 2001 meant that pollution levels in some instances did not show the same steady reduction.

Particulate pollution increased on 2000, owing in part to a light wind pollution event in January.

Where there was complete data, nitrogen dioxide levels showed a steady reduction in line with Government predictions, owing mainly to the introduction of catalytic converters in cars. These reductions were not shown in Gloucester, Lydney, Stow-on-the-Wold or Bourton. The reason for this may have been the limited available data or increasing road traffic.

The declaration of the Air Quality Management Area due to nitrogen dioxide pollution alongside the M5 initially appeared to have erred on the side of caution. Levels of nitrogen dioxide were not as high as they were predicted to be, and appeared likely to fall within the National Air Quality Objective. A full twelve months monitoring was to be completed before any decision was made, to allow for the speed restriction that was in place on the M5 in the AQMA over the winter. Levels rose in January and February 2001 after the lifting of a speed restriction. However, monitoring at Withybridge, within Tewkesbury BC, indicated that there might have been an exceedence there.

Levels of sulphur dioxide in the County were negligible.

Levels of ozone were high in 2001, due to sunny weather, with 43 days exceeding the National Objective value. Levels were exceeded that are known to causing breathing impairment in children. Ozone formation depends on sunshine, and it is also a regional pollutant, affected by emissions from outside of the County.

Levels of benzene, toluene and xylene (emitted from petrol) continued to fall.

1.2 Air Quality Strategy for Gloucestershire

Local authorities and regional groups are encouraged, but not bound, to adopt Air Quality Strategies. The Gloucestershire Pollution Group has decided to draw up an air quality strategy for Gloucestershire. It will be drawn up with the help of Casella CRE Energy. Its basis will be the air quality strategy for the former-Avon area prepared for the four local authorities in it by the Air Quality Research Group of the University of the West of England. The aim of the Group is that the Air Quality Strategy will be developed over 2003, and produced in 2004 alongside the review of air quality in 2003.

The principal difference between the two areas is that the former Avon area is relatively urban, heavily trafficked and industrial, whilst Gloucestershire is more rural. The former Avon area has several Air Quality Management Areas within it. For this reason their Strategy addresses the statutory duty of the Local Authorities to produce Action Plans to reduce air pollution to within the specified levels. Gloucestershire may be without AQMAs, therefore the Gloucestershire Air Quality Strategy will focus on preserving the good air quality that most of its inhabitants enjoy, and improving it in areas where there is room for improvement. The major issue will be dealing with increased road traffic.

The principal recommendations of the Air Quality Strategy will be for actions that will establish the place of air quality in local and regional government. This will require work to promote the issue of air quality by increased dissemination of information and collaboration and communication with involved parties. These include Local Authority planning, transport planning and sustainability colleagues. External bodies include the Public Health Trusts, Highways Agency, Environment Agency, Government Office for the South West, South West Regional Development Agency, business and commerce, non-governmental organisations (Greenpeace and Friends of the Earth) and members of the public.

2 An Overview of Air Pollution

Air pollutants are a major public health issue because of their known or suspected harmful effects on health. Furthermore, air pollution remains high on the list of public concern because of its deleterious effects on the environment. In more recent times people have become less willing to accept the adverse health effects arising from air pollution resulting from activities over which they have no control.

2.1 Combustion of Fuel

Air pollution in Europe results primarily from energy utilisation by the combustion of fuels. Traditionally, the universal local pollution source was the combustion of wood and coal for industry, space heating and cooking. Centralised electricity generation and the provision of mains gas have removed and reduced the emissions arising from these energy requirements in Gloucestershire. The internal combustion engine is now the predominant form of local combustion and associated pollutant emissions. Fossil fuels are burnt in vehicle engines to provide energy for transport. Gases and particles are emitted from exhaust pipes immediately into the air breathed by the local population (referred to technically as ‘receptors’).

Air pollutants and their precursors can be quickly transported tens and hundreds of miles. Thus the local population in Gloucestershire are receptors for air pollutants from sources that may be as far away as continental Europe. Air masses over Gloucestershire originating on the Continent and passing over South East England are typically polluted with fine particulate matter. It is noticeable that haziness (reduced visibility due to atmospheric aerosols) normally increases over the duration of a high pressure system with Easterly winds in this area. Acid gases and ozone are similarly transported into the county.

2.2 Primary and Secondary Pollutants

Species in the air that cause harm to humans when inhaled are either emitted in that form (primary pollutants) or result from the transformation of other emitted species (secondary pollutants). For example, sulphur dioxide is a primary pollutant emitted in that form from combustion. When oxidised to sulphuric acid aerosol, it becomes a secondary pollutant, adding to the burden of suspended particulate in the air. Nitrogen dioxide, ozone and part of PM10 are also secondary pollutants.

2.3 Meteorology

Once pollutant species have been released into the atmosphere, the prevailing meteorology determines their concentration and therefore their potential to cause harm or damage to the environment. The most important aspect of the weather that affects air pollution is wind speed. Calm conditions allow ambient pollutant concentrations to build up. The wind helps to disperse pollutants through mixing. Other aspects of the weather (e.g. sunshine in ozone formation and boundary layer height in dispersion) are also significant. Low boundary layer height and the lack of mixing through convective heating, make the winter worse for air pollution episodes.

Figure 1 displays a windrose for the year 2002, from data obtained by the Air Quality monitoring station in Cheltenham. As is normal for this part of the UK, the prevailing wind direction was west-south-westerly. There were a greater number of hours with easterly winds in 2002 over 2001.

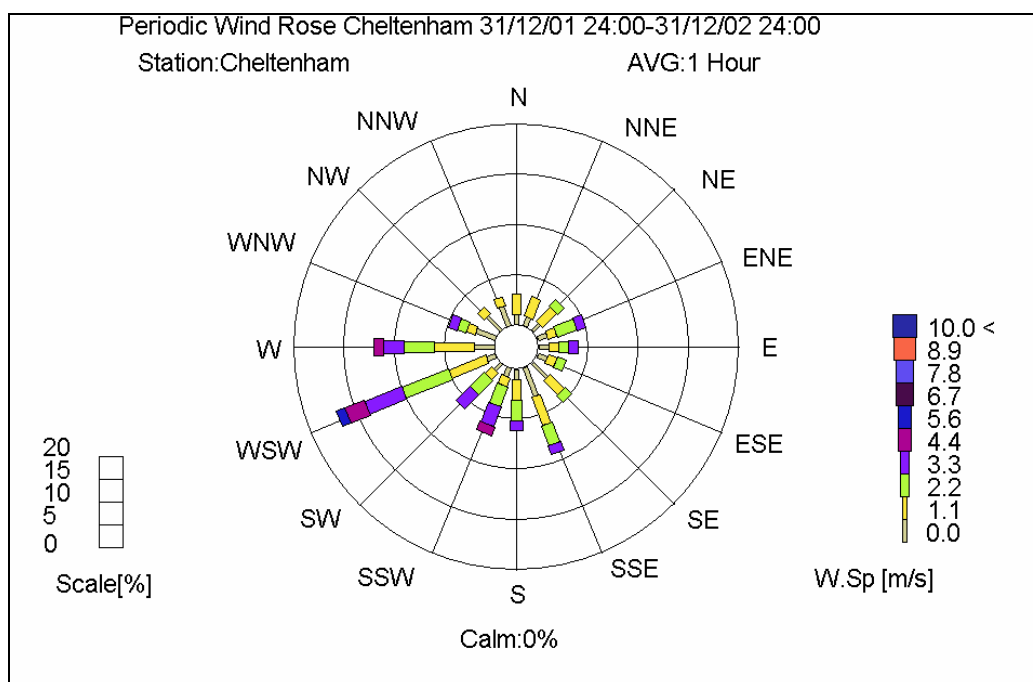


Figure 1: Windrose for Cheltenham - 2002

2.4 Changing Sources of Pollution

Historically in Britain, coal-burning was the major source of local pollution. In addition to the particles released, coal contains up to two or three percent sulphur, so that large quantities of sulphur dioxide are also released on combustion. Sulphur dioxide is a toxic acid gas that causes immediate bronchio-constriction (involuntary tightening of the airways) when inhaled at sufficient concentrations. A heavy burden of suspended particulate combined with sulphur dioxide and fog droplets caused the famous London smogs of last century. These resulted in the implementation of effective smoke and emission control policies such as the Clean Air Act and its subsequent revisions, and these types of smogs no longer occur in Britain.

In the late 1980's similar meteorological conditions of winter fog in London revealed a new source of pollution: motor vehicle transport. 'Smogs Return to London' was the message broadcast by the news media in November 1988 and November 1989. On 15-16 November

1988, carbon monoxide eight-hour concentrations reached 17 ppm and one-hour nitrogen dioxide levels 345 ppb. (Elstom, 1996, 'Smog Alert')

The major threat to clean air in the UK, is now considered by many to be posed by emissions from road vehicles. Petrol- and diesel-engined motor vehicles emit a wide variety of pollutants. These include carbon monoxide (CO), sulphur dioxide (SO₂), oxides of nitrogen (NO_x) volatile organic compounds (VOCs including benzene and 1,3-butadiene) and particulates. In addition, photochemical reactions resulting from the action of sunlight on NO₂ and VOCs from vehicles and other sources lead to the formation of ozone, a secondary pollutant, which impacts in rural areas often far from the original emission site.

2.5 Particulate Matter (PM₁₀)

Particulate matter suspended in the atmosphere is the air pollutant now considered to pose the most significant harm to human health in the UK. Intense research around the world is being devoted to the question of whether particle size causes the toxic effect or the actual chemical composition of the particles. It is well known that the size of the particles has to be sufficiently small so that they can penetrate deep into the lungs to cause respiratory and cardio-pulmonary health problems. Thus measurements are made of these small particles. They are referred to as 'PM₁₀' particles, being 'particulate matter having an average aerodynamic diameter of ten micrometres' (10⁻⁵ metres across). Subsequent to the measurement standard for particulate pollution in the air being made PM₁₀, it was found that the toxic effects are associated with the smaller fraction of particulate, below 2.5 micrometres in diameter (PM_{2.5} also known as fine particulate). However, it was deemed not necessary to change the measurement standard, because measurements of PM₁₀ provide a good surrogate for atmospheric concentrations of PM_{2.5}.

Atmospheric concentrations of PM₁₀ result from direct emissions from combustion and other anthropogenic activities such as agriculture, mining and road traffic. There is also the contribution from natural sources such as volcanic activity, wind blown sea salt and erosion of the land. Naturally occurring (also known as crustal) PM₁₀ represents most of the PM_{2.5-10} size range (also referred to as PM_{coarse}). Perhaps unsurprisingly, the major source of the fine particulate component, which is the component harmful to human health, is the source that is new to human health in evolutionary terms. Combustion is the major source of fine particulate. Combustion also contributes indirectly to this particulate matter in the form of nitrate and sulphate aerosol from the atmospheric transformation of NO_x and SO₂. There is a

gradient of sulphate particulate concentration across the country with the highest levels in the South East. Levels decline the further North West you move away from the heavily populated South East, and from the near Continent that is also a significant source of this matter.

2.6 The UK Air Quality Strategy (AQS) – Updating and Screening Assessments

The UK Air Quality Strategy was published in 2000, and lays down strict guidelines for local air quality for the protection of human health. The onus of assessing local air quality was placed on Local Authorities.

Using a staged approach with guidance from the then DETR, local authorities were obliged to determine where in their localities there might be exceedences of the pollutant levels stipulated in the Regulations. Moreover, the levels of different pollutants are set to be met by varying deadlines some years in the future. These are shown in Appendix 1. Detailed evaluation of their local air quality was therefore carried out by all the Local Authorities in the Gloucestershire Pollution Group, with some assistance from CRE. Review and assessments by Stroud District Council and Tewkesbury Borough Council resulted in the declaration of Local Air Quality Management Areas (AQMAs) along the east side of the M5 motorway. The basis of the declaration was that it appeared unlikely that the annual average nitrogen dioxide concentration would fall below the required level by the year 2006 at some residential properties close to the motorway. A twelve month survey of the joint AQMA began in June 2001. Nitrogen dioxide measurements suggested that the Councils may have erred on the side of caution, and that the Declaration would be revoked. The councils fully complied with the precautionary approach demanded by the AQS. After a rigorous analysis of the diffusion tube measurements by Tewkesbury Borough Council, consultation with the Highways Agency and independent consultants, it has been found that the AQMA can be undeclared.

All the local authorities are carrying out an Updating and Screening Assessment to be finished by the end of May 2003. New Technical Guidance¹ and Policy Guidance² has been published by DEFRA in early 2003. The purpose of the USA is to identify any changes that have taken place since the initial Review and Assessment that might cause exceedences. If any locations are highlighted by the screening exercise they will have to undergo a Detailed Assessment by April 2004. Local Authorities have been advised to look to the future when carrying out the USAs, particularly forward to 2010 by which time there will be stricter

objectives for benzene (annual mean of $5 \mu\text{g m}^{-3}$) and PM_{10} (annual mean of $20 \mu\text{g m}^{-3}$, maximum of 7 annual exceedences of the $50 \mu\text{g m}^{-3}$ 24 hour mean).

A national objective for the oxidising, toxic gas ozone is laid down in the AQS. There is no obligation on local authorities to review, assess or put in place management plans for ozone because it is a regional rather than local pollutant. The objective is that there should be less than 10 exceedences of $100 \mu\text{g m}^{-3}$ for the 8 hour mean by the end of 2005.

2.7 Vegetation and Ecosystems

The Air Quality Strategy has also laid down national objectives for the protection of vegetation and ecosystems. It is not within the remit of the Local Authorities for the purposes of local Air Quality Management to ensure that Gloucestershire falls inside these objectives. The information is included in order to give a comprehensive picture of air pollution within the county. Levels of ozone in the County (as in much of Southern England) were again sufficiently high to cause damage to vegetation in the year 2002 as in 2001. The daily maximum of the running 8 hour mean of ozone exceeded $100 \mu\text{g m}^{-3}$ on 20 days in the year in Cheltenham (the national objective is for only 10 days by 2006). For the most part, it is probable that annual levels of nitrogen oxides (NO_x) were again within the $30 \mu\text{g m}^{-3}$ specified in the AQS for the protection of vegetation and ecosystems in the out-of-town parts of the county. The annual mean concentration of NO_x within Cheltenham actually exceeded this level at $36 \mu\text{g m}^{-3}$. There is a $20 \mu\text{g m}^{-3}$ objective for sulphur dioxide in the AQS, but levels of sulphur dioxide are very low in the County in any case. The annual mean sulphur dioxide concentration measured in Cheltenham was less than $4 \mu\text{g m}^{-3}$.

3 Air Pollutants Measured in Gloucestershire

The ongoing air pollution monitoring undertaken within the County, that is within the scope of this report, is listed in Table 1 by pollutant, method and location/local authority.

A continuous monitoring station is operated by Cheltenham BC in Montpellier, Cheltenham (near the Eagle Star tower block). It continuously measures most of the important pollutants as well as wind speed and direction. Continuous monitoring is very important in the County. Measurements made in Cheltenham should be reasonably representative of other similar parts of the County.

The continuous monitoring station in the Forest of Dean has been moved from Cinderford and is now situated and operating at Albany Engineering, Church Road, Lydney. Due to technical problems the station did not collect data in 2002. This is a different type of location to the Cheltenham station, so it will provide very useful data.

Table 1: Pollutants Measured Within Gloucestershire

Pollutant	Measurement Method	Location/Local Authority
Nitrogen dioxide	Diffusion tube	All
Sulphur dioxide	Diffusion tube	Cotswold Forest of Dean Stroud Tewkesbury
Ozone	Diffusion tube	Stroud Tewkesbury Cotswold
Benzene	Diffusion tube	Gloucester Cotswold
Toluene & Xylene	Diffusion tube	Cotswold
Nitrogen dioxide	Continuous	Cheltenham Forest of Dean
Sulphur dioxide	Continuous	Cheltenham Forest of Dean
Ozone	Continuous	Cheltenham
Carbon monoxide	Continuous	Cheltenham
PM ₁₀	Continuous	Cheltenham Forest of Dean

Nitrogen dioxide is a toxic gas formed as a result of combustion of nitrogen-containing materials, and is a primary indicator of traffic pollution. Nitrogen dioxide monitoring by diffusion tube has been undertaken nationally since 1993. All of the local authorities within the county measure nitrogen dioxide by diffusion tube. Gloucester and Tewkesbury submit measurements to the National Network operated on behalf of the Government (now DEFRA) by NETCEN, the National Environmental Technology Centre.

Measurements of sulphur dioxide are made primarily to monitor the effect of solid fuel (particularly coal) combustion in parts of the County. A recommendation as such was made by the South East Institute for Public Health (SEIPH, an external consultant), and endorsed by EMC at the time of 2000 Review of Air Quality in the County of Gloucestershire .

Measurements of sulphur dioxide in 2001 were sufficiently low that we made the recommendation that the deployment of sulphur dioxide diffusion tubes was discontinued.

To a greater or lesser extent, the other pollutants measured within the county derive from local traffic pollution. PM₁₀ particulate has other significant sources, from within the county as well as outside, as does ozone. PM₁₀ particulate is partly a secondary pollutant i.e. not directly emitted, and ozone is only formed by complex photochemical reactions involving emitted pollutants (especially NO_x).

Benzene, toluene and xylene (commonly grouped together as 'BTX') are volatile organic compounds that are components of petrol. They are emitted either unburnt from the exhaust pipes of vehicles or earlier on in the supply and use of fuel, for example from filling stations.

An analysis has been undertaken of air quality data collected within the six Local Authorities comprising the Gloucestershire Pollution Group. Each Local Authority carries out monitoring programmes to provide information on air quality within its own area. In this report, results from the monitoring programmes are discussed by pollutant, in order that Air Quality in the county as a whole may be evaluated. Comparison is made with data from previous years in order that the long term trends may be evaluated.

4 Nitrogen Dioxide

Nitrogen dioxide is an irritant toxic acid gas. Nitrogen dioxide (NO₂) and nitric oxide (NO) together are referred to as NO_x. Nitric oxide is a relatively harmless gas. During combustion in air, high temperatures cause atmospheric nitrogen and oxygen to react to form NO_x, normally comprising over 95% NO with the balance being NO₂. The NO formed is fairly rapidly oxidised to NO₂, depending on the availability of atmospheric oxidant species such as ozone. Nitrogen dioxide concentrations may not be a maximum at the source of release of the NO_x.

Nitric oxide, nitrogen dioxide and ozone concentrations are related by a series of complex reactions including the photolysis of nitrogen dioxide. Commonly, formation of nitrogen dioxide is represented as the oxidation of nitric oxide by ozone, but this is a simplification that can be misleading.

The main local source of NO_x, and therefore nitrogen dioxide, is fuel combustion in road vehicle transport. Measurements of nitrogen dioxide are made by diffusion tube at over a hundred sites throughout the County. The earliest measurements began in 1993 at the instigation of central government. Publication of the National Air Quality Strategy focused

the measurements made on the protection of human health. As a result, more measurements were made to represent receptors (i.e. in places where people spent appreciable amounts of time) rather than in places which tended to show maximum pollution (i.e. on lamp-posts next to busy main roads). Nitrogen dioxide is an irritant gas that affects humans within a few minutes at sufficiently high concentrations.

The most commonly used diffusion tubes are clear plastic tubes (about the size of a cigarette lighter), open at one end and containing a known amount of chemical reagent. There are four common reagent mixes. Tubes are hung up, exposed to the atmosphere by removing the end cap, and left outside for a recorded number of hours (normally approximately one month) before being capped and submitted for analysis. Nitrogen dioxide diffuses into the tube at a rate that is known to be dependent on the nitrogen dioxide concentration in the air. Measuring the amount of nitrogen dioxide reacted within the tube and knowing the number of hours for which the tube was exposed allows the average nitrogen dioxide concentration during the exposure period to be calculated. Simplistically, nitrogen dioxide diffusion tubes record monthly average nitrogen dioxide concentrations. However, comparisons with continuous chemiluminescence analysers show that diffusion tubes are biased according to location, season, reagent, and analytical laboratory. The Technical Guidance recommends that an annual bias is calculated for diffusion tubes from a particular laboratory from tubes collocated with a continuous analyser. Due to a seasonal variation in bias, a minimum of 9 months collocation data is required. Collocation studies were started for Gradko (Tewkesbury BC) and Bristol Scientific Services (Cheltenham BC) diffusion tubes at the monitoring station in Cheltenham in September 2002.

The analysis of nitrogen dioxide measurements made in each local authority compares them with the fall in concentration level predicted by the latest Technical Guidance. As an aid to visualising the gradient of the predicted fall, plots are made of a 'Technical Guidance predicted value', showing how levels should fall from an imaginary value of $43 \mu\text{g m}^{-3}$ measured in 1999. The predicted fall is taken from the latest Technical Guidance, p.6-9, using the "correction factors to estimate annual average NO₂ concentrations in future years from measured data at roadside sites". The decline in nitrogen dioxide is due to a tightening of vehicular emission standards promulgated by the European Union, and in particular the penetration of the three way catalyst (mandatory in new petrol cars since 1993) through the car fleet. The decline is expected to continue until about 2010, when increases in traffic will outweigh reduced emissions.

4.1 Updating and Screening Assessment for Nitrogen Dioxide

In the first review and assessment, most of the Air Quality Management Areas declared nationally were on the basis of predicted likely exceedences of an annual mean concentration of nitrogen dioxide of $40 \mu\text{g m}^{-3}$. In the current Updating and Screening Assessment, this is again considered to be the objective that will be most difficult to meet. Where roads are carrying between 10,000 and 20,000 vehicles per day and there are residents living less than 5m from the carriageway, these locations will have a high likelihood of exceeding the objective. Otherwise, it is considered that congested residential streets may still be in danger of exceeding. Proactive work by Tewkesbury BC in 2002 using continuous monitoring for NO_2 found that the congested residential High Street already fell below the target. Continuous measurements made over the months of April, May and June in a first floor room in a High Street building adjacent to a residential property obtained an average figure of $38.2 \mu\text{g m}^{-3}$.

Gloucester City Council are aware that they are the most likely to have to declare AQMAs due to heavily trafficked residential roads. A co-location study is being carried out with Bristol Scientific Services diffusion tubes by Cheltenham BC at the continuous monitoring in Montpellier, Cheltenham. Depending on the outcome of the co-location study for the Bristol Scientific Services diffusion tubes employed by GCC, annual mean concentrations of nitrogen dioxide may not be set to fall below the threshold in several locations now being monitored. The bias adjustment factor calculated for the four months between September and December 2002 was 1.10 for the Bristol Scientific Services tubes. A full 9 months study has to be completed, but if the bias adjustment factor remains the same, then combining this with the correction factor for 2006, which from 2002 NO_2 data is 0.89, then Bristol Scientific Services diffusion tube results from 2002 will be fairly representative of 2006 nitrogen dioxide levels. That is to say locations showing exceedences in 2002 will exceed in 2006. There is a potential issue with the co-location study in Cheltenham, in that the Montpellier site is not a roadside site, and thus is not the same site type as those locations where exceeding the annual mean is an issue, as is required by the Technical Guidance (page 6-7), which was only issued 5 months after the start of the study. Consideration ought to be given to examining the results of other appropriate co-location studies.

At the moment, in towns in Gloucestershire, levels of nitrogen dioxide should be falling by generally slightly less than $1 \mu\text{g m}^{-3}$ per year at roadside/kerbside sites, according to the projections in the latest Technical Guidance. Instances where they are not may indicate rising traffic levels.

4.2 Tewkesbury Borough Council

Tewkesbury Borough Council made a reasoned decision to change their supplier of diffusion tubes in April 2002. A change was made to a laboratory that was consistently performing better in independent quality assessment tests, with a smaller bias. It is difficult to rigorously adjust diffusion tubes results for the bias from one laboratory and situation with another, hence annual average figures produced in 2002 cannot be used to show trends over time. Figure 2 shows an analysis of annual average nitrogen dioxide levels taken from measurements made in Tewkesbury town. Close scrutiny of the graph in Figure 2 shows that 2002 having a step decrease over 2001 that is probably partly attributable to the change in supply of diffusion tubes to ones having a lower bias. The Mitton School site was moved in the end of the year nearer to Carrant Road and is likely to show an increase in the future

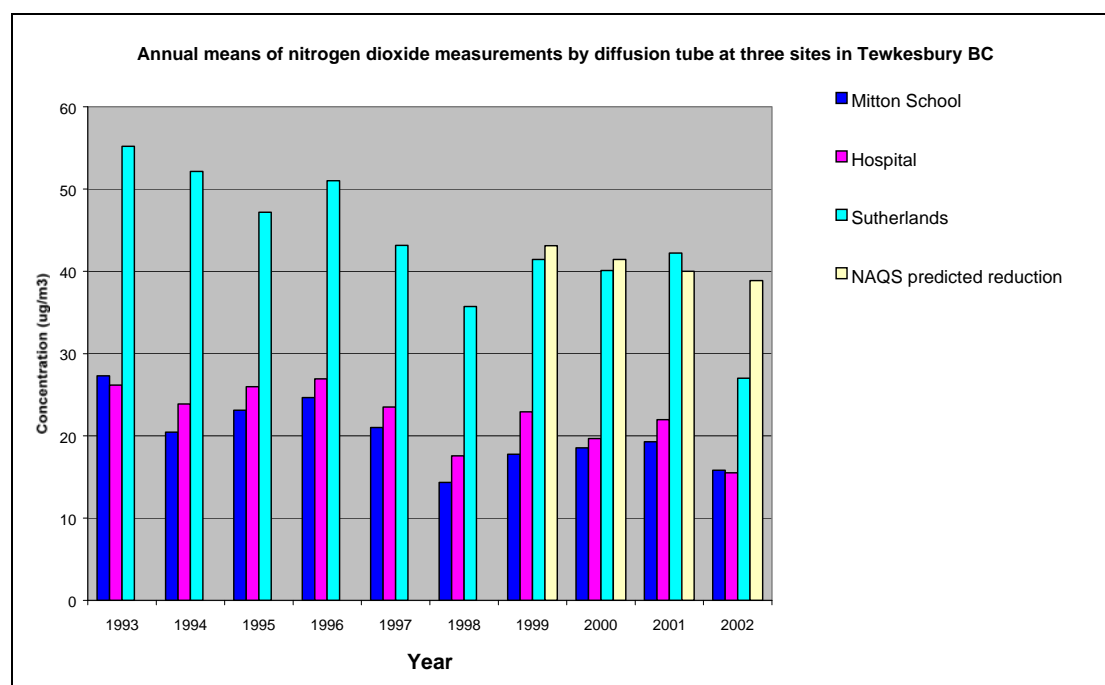


Figure 2: Analysis of Annual Average Nitrogen Dioxide Levels in Tewkesbury Town

The annual average nitrogen dioxide level measured in Tewkesbury High Street in 2002 was $32 \mu\text{g m}^{-3}$. As mentioned previously, continuous measurements of nitrogen dioxide were made in the months of April, May and June and found to be $38 \mu\text{g m}^{-3}$.

As in 2001, other than at sites affected by the M5 motorway and Tewkesbury High Street, nitrogen dioxide levels within Tewkesbury Borough Council were well within the limits stipulated by the AQS. The revocation of the AQMA is dealt with elsewhere.

4.3 Cotswold District Council

Levels of nitrogen dioxide are declining at sites in Cirencester (Gloucester Street), Bourton-on-the-Water, and, Moreton-in-Marsh as shown in Figure 3. In Stow-on-the-Wold in 2001, levels of nitrogen dioxide appeared to be rising by $1.6 \mu\text{g m}^{-3}$ per year, against the predicted trend of a fall of $1 \mu\text{g m}^{-3}$ per year. As of 2002, levels in Stow-on-the-Wold over the past four years now show a fall in line with the latest Technical Guidance predictions. In 2002, levels of nitrogen dioxide were well below the objective level for 2006 at all measurement sites within Cotswold District Council.

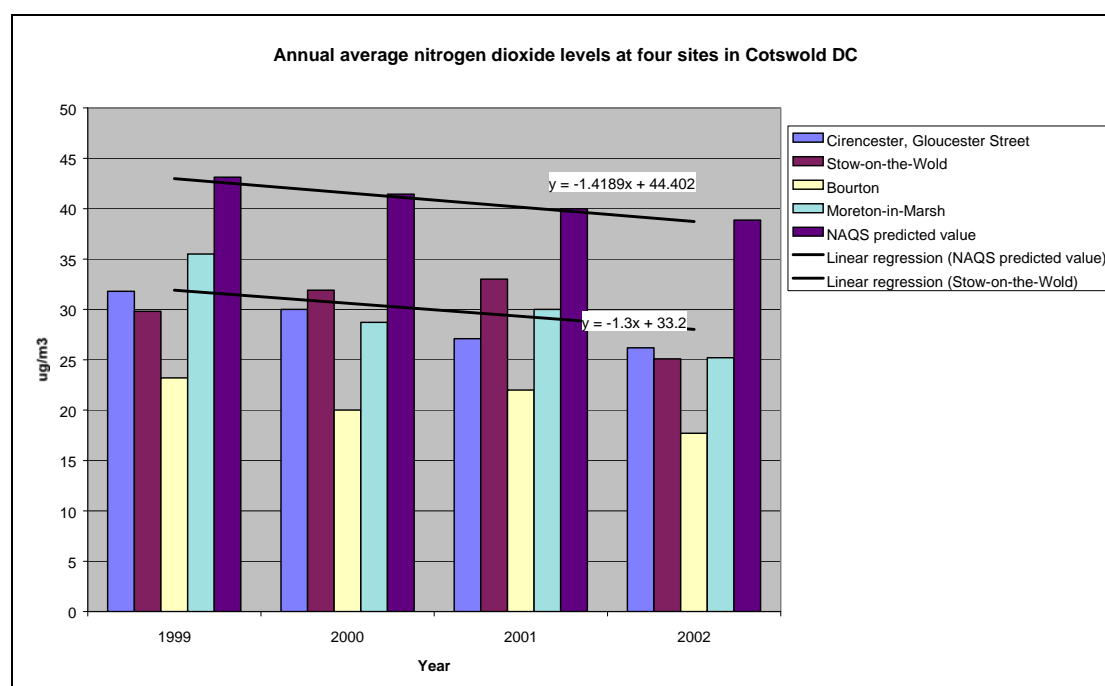


Figure 3 Annual Average NO₂ Concentrations at Sites in Stow-on-the-Wold, Bourton, Moreton-in-Marsh and Cirencester

4.4 Cheltenham Borough Council

Complete datasets obtained by Cheltenham Borough Council show clearly that nitrogen dioxide levels are falling in the town. Correlation of the measured decline over eight years

with the fall predicted by the new Technical Guidance is still close.

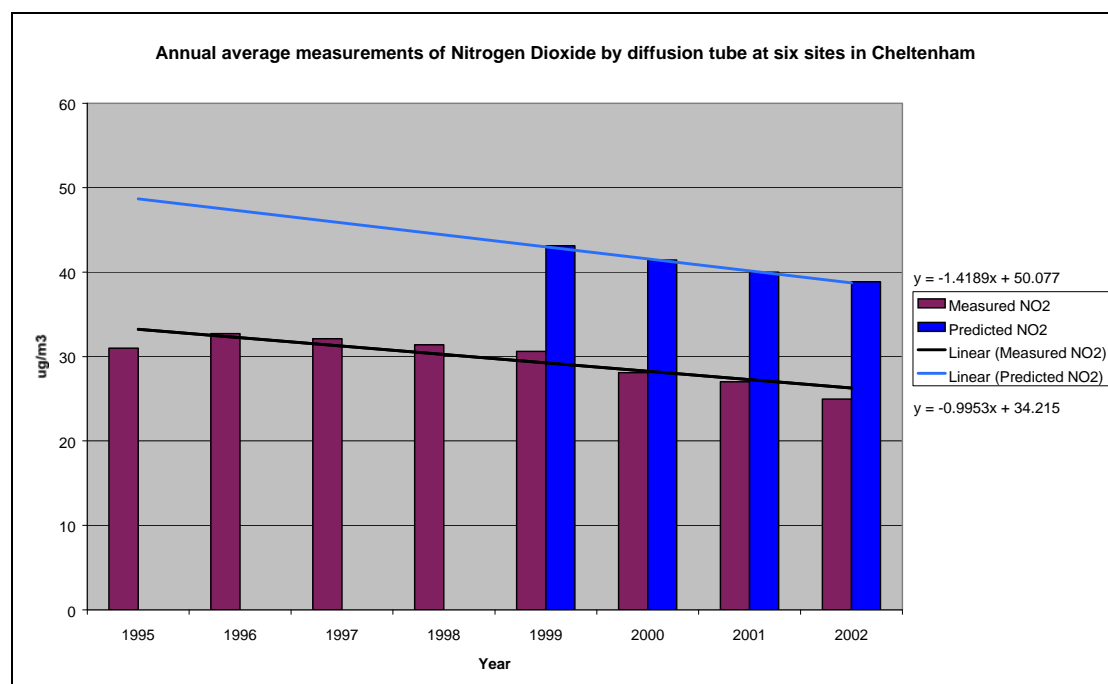


Figure 4 Annual Average NO2 Concentrations, Averaged from Six Sites in Cheltenham

All sites monitored within Cheltenham Borough Council were within the AQS annual objective value in 2002.

4.4.1 Continuous Monitoring Data

Cheltenham Borough Council operate an automatic air quality monitoring station in the Montpellier area of the town. Analysers continuously measure atmospheric pollutants, including nitrogen dioxide, and measurements are logged every fifteen minutes. Results from 2001 have been averaged into calendar months, and are illustrated in Figure 5.

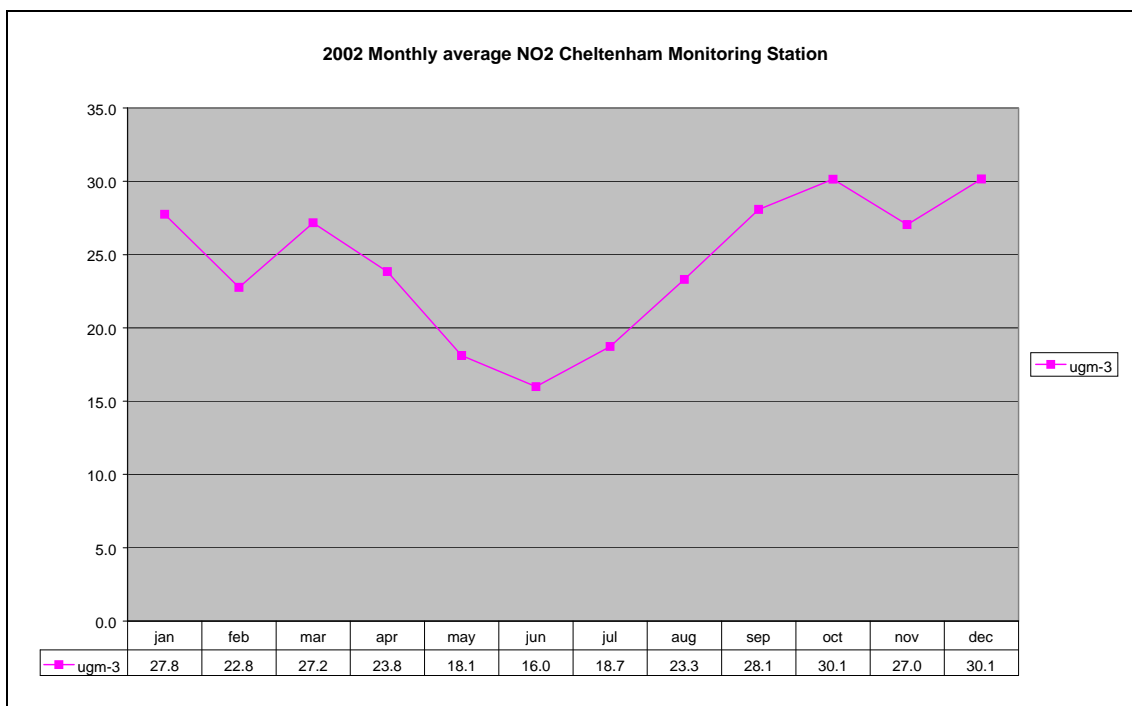


Figure 5 Monthly Average Data from Continuous Measurement of Nitrogen Dioxide in Cheltenham (2002)

No data are recorded when the analysers are not measuring due to routine maintenance or breakdown. The percentage data capture for nitrogen dioxide for 2002 was over 98%. The average nitrogen dioxide level recorded for the year was $24.8 \mu\text{g m}^{-3}$. The average recorded for the year 2001 was $25.6 \mu\text{g m}^{-3}$. The decrease from 2001 is due probably both to the predicted decrease in vehicular emissions and to less adverse weather conditions.

The AQS stipulates a 1 hour mean objective value for nitrogen dioxide of $200 \mu\text{g m}^{-3}$, not to be exceeded more than 18 times a year. There were no exceedences of this level in 2002, just as in 2001 (when the maximum was 118), and the maximum hourly mean recorded was $89 \mu\text{g m}^{-3}$. This was recorded on the 25th of March during a period of light winds. Similarly, there were no exceedences in 2000.

4.5 Gloucester City Council

Monitoring of nitrogen dioxide by diffusion tube is currently being undertaken at twenty sites by Gloucester City Council. Exceedences of the annual objective have been shown for sites on Priory Road and some on Barton Street. Annual averages for 2002 for these sites were 42.3 for Priory Road and around $41 \mu\text{g m}^{-3}$ respectively, albeit for incomplete datasets. There are residential properties on these roads, so it is possible that the Updating and Screening Assessment may result in the requirement to carry out a Detailed Assessment for the Annual Mean nitrogen dioxide for some locations in Gloucester.

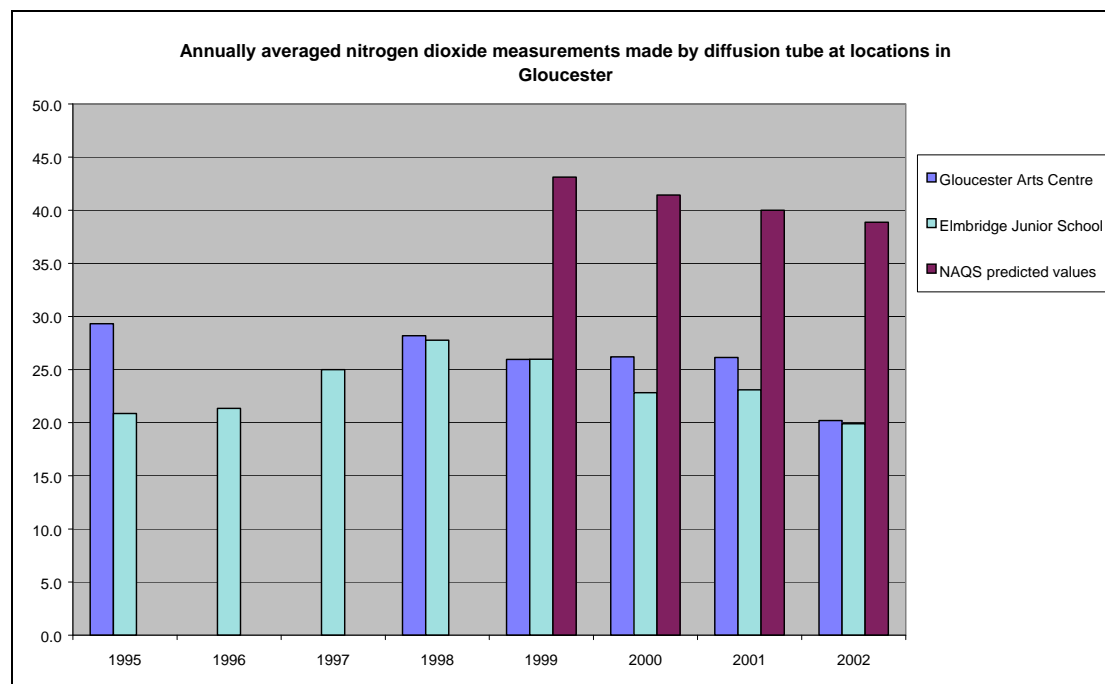


Figure 6 Annual Average Nitrogen Dioxide Concentrations at Elmbridge Junior School, and the Arts Centre in Gloucester

Figure 6 shows annual average nitrogen dioxide levels measured at two sites in the city of Gloucester. Results show that in 2002 levels are declining more in line with the Technical Guidance predictions than appeared to be the case in 2001.

4.6 Forest of Dean District Council

Nitrogen dioxide monitoring is carried out extensively in different towns in the Forest of Dean. Figure 7 shows a comparison of annual average nitrogen dioxide data at four sites in Lydney, alongside the rate of fall in levels predicted by the latest Technical Guidance. These sites were chosen because there is nine year's data available for them. The site at Newerne Street shows a consistent fall in nitrogen dioxide levels, but the other three show that nitrogen dioxide pollution levels are still not falling quickly in this part of Lydney. Put in the context of the Air Quality Strategy, levels are still far below the 40 µg m⁻³ annual average for NO₂ not to be exceeded by 2006. Nevertheless, the inference to be made is that pollution from combustion sources (most likely traffic pollution) is becoming worse in Lydney.

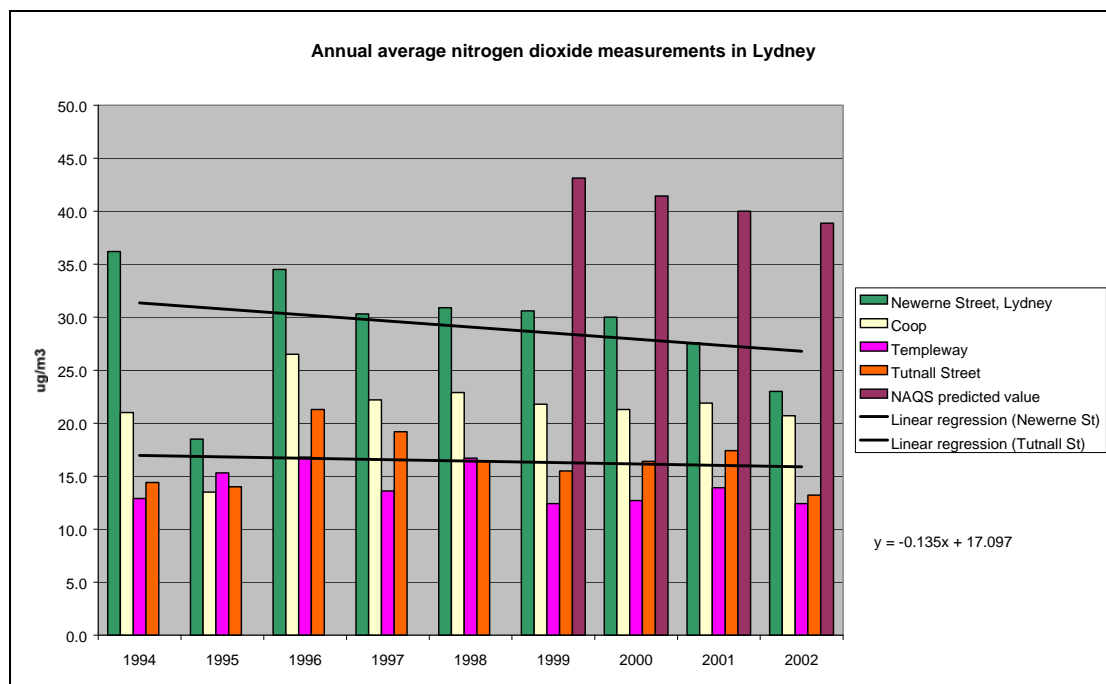


Figure 7 Annual Average Nitrogen Dioxide Concentrations at Four Sites in Lydney, Forest of Dean

Figure 8 shows annual averages of measurements made in Coleford, Newnham-on-Severn and Mitcheldean, all continuing to show a steady decline in nitrogen dioxide levels. Monitoring being carried at sites close to the M50 motorway showed them to be well within the objective for nitrogen dioxide in 2002.

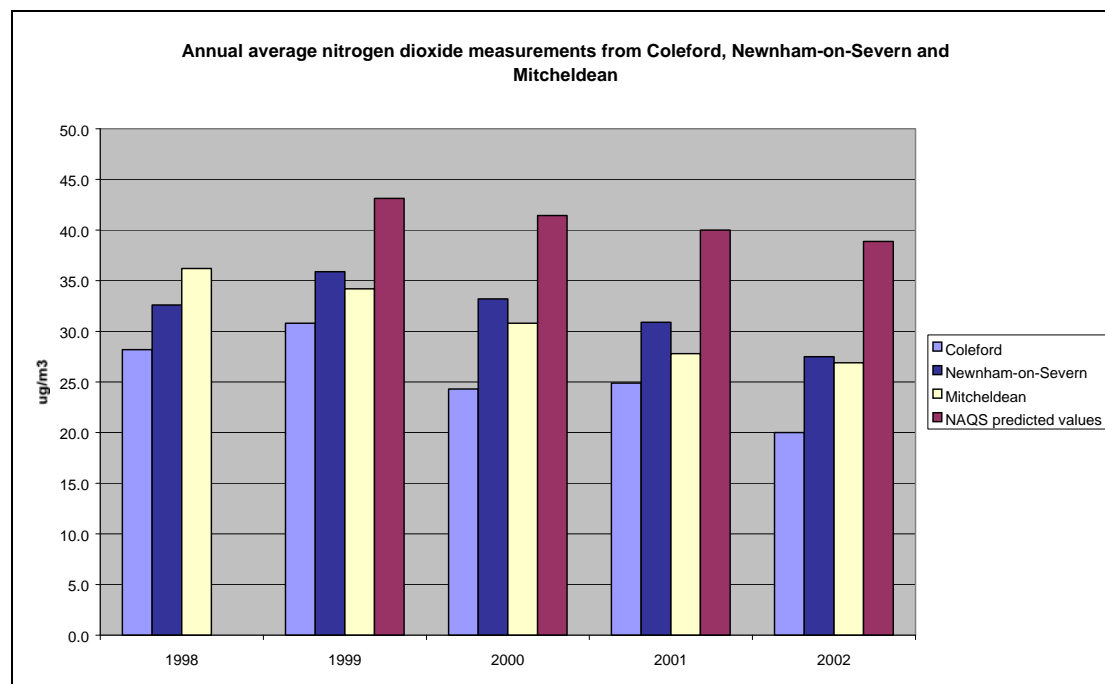


Figure 8 Annual Average Nitrogen Dioxide Concentrations at Coleford, Newnham-on-Severn and Mitcheldean

4.7 Stroud District Council

Figure 9 shows annual average nitrogen dioxide concentrations at three sites in the Stroud District. As within other areas covered by the GPG, NO₂ concentrations are still falling consistently, and there were no sites above the 40 µgm⁻³ level in 2002. Figure 9 also shows the places within settlements with the highest recorded values in the District (although Stroud Music Centre was slightly higher than Stroud Bowbridge).

The M5 motorway is a major source of nitrogen dioxide within the County. The average nitrogen dioxide level measured on the M5 road bridge at Stinchcombe in 2002 was up on 2001, at 68.25 µg m⁻³, although with one month's data missing.

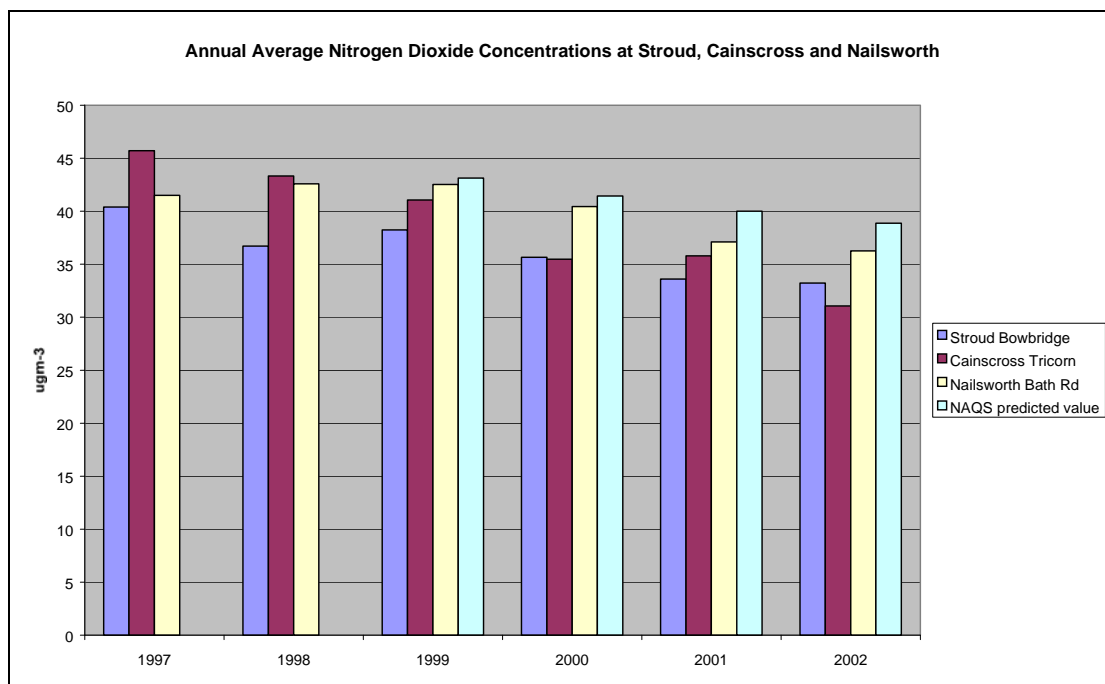


Figure 9 Annual Average Nitrogen Dioxide Concentrations at Stroud, Cainscross and Nailsworth

Figure 10 shows the summer/winter seasonal variation of nitrogen dioxide levels around Stroud DC. The seasonal change arises from poorer dispersion in the winter due to the lower boundary layer height.

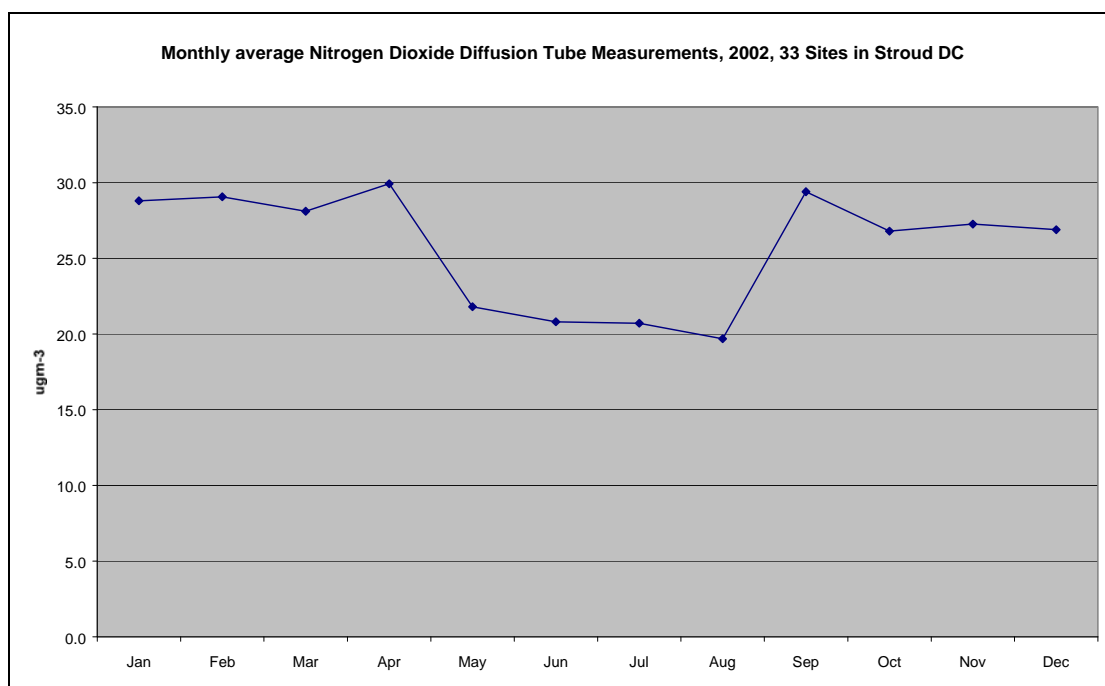


Figure 10 Monthly average Nitrogen Dioxide Diffusion Tube Measurements, 33 Sites in Stroud DC in 2002

5 Particulates

Particulate matter suspended in the air has been demonstrated to cause adverse health effects in humans. In terms of threat to human health, it is considered to be the most serious air pollutant. Research evidence suggests that it is man-made 'smoke' rather than naturally occurring dust particles that cause the adverse health effects. Particles small enough to penetrate deep into the lungs cause alveolar inflammation that increases deaths by respiratory failure, cardio-pulmonary obstructive disease and heart failure.

Since it is only the smaller size range of particles that have the adverse health effects, it is the mass of these particles in the air that is monitored. Particles with an average aerodynamic diameter of less than 10 μm (PM_{10}) are measured as opposed to the whole fraction of suspended particulate matter. In the UK an instrument known as a TEOM (Tapered Element Oscillating Microbalance) is used predominantly in the national network to provide continuous measurement of PM_{10} particulate matter in the air. Two TEOMs are operated in the county: one at the Cheltenham monitoring station and the other at the Lydney station.

Recent research has found that particles smaller than 2.5 μm in aerodynamic diameter are potentially more harmful than PM_{10} . These are called $\text{PM}_{2.5}$ or fine particles. The statutory air quality standard still relates to the measurement of PM_{10} particles. This was decided because PM_{10} are considered sufficiently representative of $\text{PM}_{2.5}$ particles for it not to be worth altering the whole monitoring network to accommodate the new findings.

The main sources of airborne particulate matter are soot particles from combustion and secondary aerosols from acid gases (SO_x and NO_x) that are also derived from combustion. Small suspended particles have a relatively long life-span within the atmosphere (7 to 10 days), and can thus be transported over long distances, for example from the Continent to Gloucestershire.

The Air Quality Objective for PM_{10} (gravimetric) is that the 24 hour mean should not exceed 50 $\mu\text{g m}^{-3}$ on more than 35 days per year, and the annual mean should not exceed 40 $\mu\text{g m}^{-3}$ by 2005. However, it must be stressed that there does not appear to be a threshold for the adverse health effects of PM_{10} pollution. Results from a recent study in Europe report a 0.6 % increase in the daily number of deaths for a 10 $\mu\text{g m}^{-3}$ increase in PM_{10} . For this reason, lower objectives have been set for the future. By the end of 2010 there should be no more

than 7 exceedences of the $50 \mu\text{g m}^{-3}$ 24 hour mean per year, and an annual mean of less than $20 \mu\text{g m}^{-3}$ in all of England except London.

Measurements of particulates made at the Cheltenham station, whose location would be described as urban background, are representative of similar locations within the County. The problem with the site for the purposes of Local Air Quality Management is that it is not representative of the roadside locations that are likely to show exceedences of PM_{10} objective values.

5.1 Particulates Measured in Cheltenham

Figure 11 shows daily PM_{10} measurements made during 2002 by the TEOM instrument located at the Montpellier monitoring station. This TEOM has an inlet temperature of 50°C and samples at 3 litres per minute.

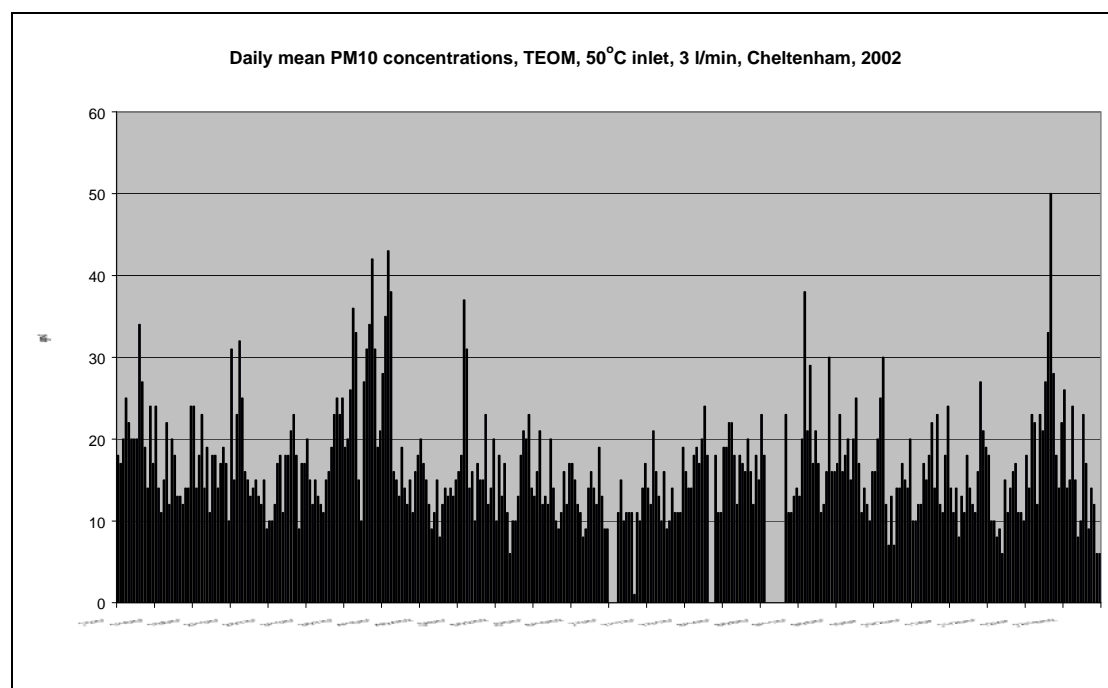


Figure 11 Daily Average PM_{10} Data for Cheltenham (2001)

The Technical Guidance instructs that TEOM data must be multiplied by a factor of 1.3 to obtain the gravimetric equivalent (page A1-23). TEOM instruments operate at 50°C , at which temperature, volatile compounds such as ammonium nitrate in the particulate matter are lost, and therefore tend to under-read when compared with instruments sampling dust onto unheated filters. It is well known that the under-read of the TEOM instrument is variable but this correction factor must be applied in the absence of any locally-obtained factor. Even with the conservative 1.3 correction factor applied, Cheltenham falls well within the objectives for

PM₁₀. There are 3 exceedences of the 50 µg m⁻³ level in the year, and the annual mean is 21.7 µg m⁻³, with 96.7% data capture.

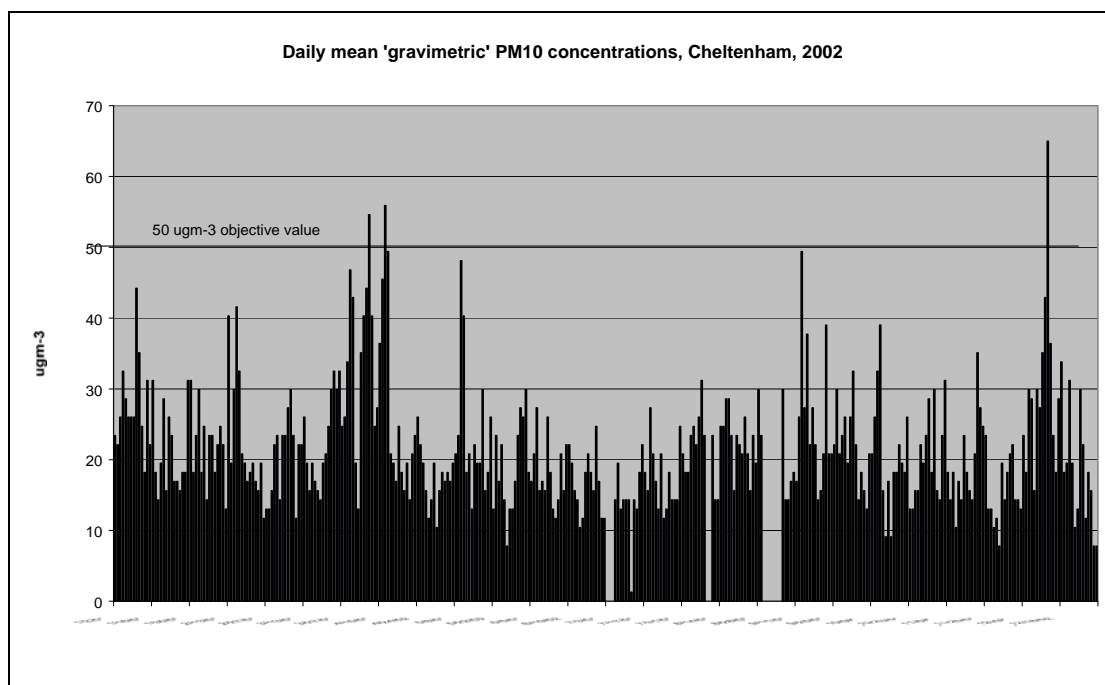


Figure 12 'Gravimetric' PM₁₀ daily means, Cheltenham, 2002

In order to compare the 2002 mean with the previous years, it is necessary to look at the uncorrected data. The uncorrected mean PM₁₀ in 2002 was 17 µg m⁻³ with 96.7% data capture, for the year 2001 was 18.0 µg m⁻³, with 92.3% data capture. The corresponding mean PM₁₀ for the year 2000 was 17.7 µg m⁻³, with 82.3% data capture.

5.2 Conclusions for PM₁₀ Particulates

Annual average PM₁₀ levels at the Cheltenham station showed a slight decrease in 2002 over the previous year's data. At the levels measured, Gloucestershire will not meet the proposed Objective level for PM₁₀ for 2010, which is an annual average of 20 µg m⁻³, unless levels fall as predicted.

6 Sulphur Dioxide

Sulphur dioxide is an irritant toxic acid gas. It is formed from the combustion of fuels containing sulphur. The principal source of sulphur dioxide emissions in Gloucestershire is the burning of solid fuel for domestic heating. Coal may have a sulphur content of up to three

per cent by weight. Sulphur levels in petrol and diesel have been reduced as a result of EC legislation so that emissions from traffic are no longer a major source.

High levels of sulphur dioxide rapidly cause bronchio-constriction, an involuntary tightening of the airways. Asthmatics are more susceptible and also vulnerable to severe consequences of an asthma attack. Although the effect occurs in seconds or minutes, the AQS specifies a 15 minute mean level not to be exceeded more than 35 times per year. Fifteen minutes is the shortest averaging time employed on the Automated Urban Network of monitoring stations. The AQS objectives are summarised in Table 2.

Table 2: AQS Objectives for Sulphur Dioxide

Concentration	Averaging period	Year to be achieved by
350 $\mu\text{g m}^{-3}$ (132 ppb) not to be exceeded more than 24 times a year	1 hour	2005
125 $\mu\text{g m}^{-3}$ (47 ppb) not to be exceeded more than 3 times a year	24 hours	2005
266 $\mu\text{g m}^{-3}$ (100 ppb) not to be exceeded more than 35 times a year	15 minutes	2006

The maximum averaging period for sulphur dioxide is 24 hours. No annual limits are set because the adverse health effects of the gas are short term (acute) and not long term (chronic).

6.1 Continuous Monitoring Data from Cheltenham

Sulphur dioxide is continuously measured at the monitoring station in Montpellier, Cheltenham.

There were no exceedences of any of the time-weighted average limit values for sulphur dioxide in 2002. Throughout the year levels of sulphur dioxide measured were negligible. On the 12th of December, at the time of the peak recorded PM_{10} , the maximum hourly average of sulphur dioxide did not exceed 21.3 $\mu\text{g m}^{-3}$.

Proper identification of exceedences in annual data must be done by long-handed validation, as continuous instruments are prone to recording momentary spurious spikes that produce erroneous monitoring data, if they are not excluded. Even the ratified data from Cheltenham still contains peak values of sulphur dioxide that are almost certainly spurious spikes as there are no correlated rises in other pollutant gases generated from combustion.

The annual mean sulphur dioxide concentration in Cheltenham in 2002 was $2.7 \mu\text{g m}^{-3}$, at the lower limit of detection for the gas.

6.2 Measurements of Sulphur Dioxide by Diffusion Tube

Sulphur dioxide is measured by diffusion tubes by the Forest of Dean DC and Stroud DC. Tewkesbury BC have replaced their sulphur dioxide monitoring with ozone monitoring as requested. Results of diffusion tube measurements of sulphur dioxide for 1999 to 2002 are summarised below in Table 3.

Table 2: Annual Average Sulphur Dioxide Data from Diffusion Tube Measurements

Site	Concentration ($\mu\text{g m}^{-3}$)			
	1999	2000	2001	2002
Sevenside, Forest of Dean	4.0	3.3	4.0	2.3
Woodlands, Forest of Dean	6.7	6.2	5.2	2.9
Lydbrook, Forest of Dean			6.8	*
Chipping Campden	2.8	4.2		
Bevington, Stroud			7.4	6.9
Kingswood, Stroud			5.1	6.4
Forthampton, Tewkesbury	6.9	4.3	3.7*	discontinued

*incomplete data

Daily sulphur dioxide measurements are made in Gloucester by 8-port sampler. The mean value recorded in 2002 was $10.4 \mu\text{g m}^{-3}$, with 2 months data missing.

6.3 Conclusions for Sulphur Dioxide

In all instances in Gloucestershire in 2002 very low ambient concentrations of sulphur dioxide were recorded by diffusion tube. If anything, measured concentrations were slightly lower than in 2001.

Annual mean concentrations of sulphur dioxide are also well within the $20 \mu\text{g m}^{-3}$ limit prescribed by the AQS for the protection of vegetation and ecosystems.

Tewkesbury BC have replaced their sulphur dioxide monitoring with ozone monitoring as we recommended.

As suggested in last year's report, serious consideration should be given as to whether diffusion tubes should be used to measure sulphur dioxide. Since the longest time period for which there is a regulated objective for sulphur dioxide is 24 hours, and diffusion tubes are deployed for a period of four weeks, diffusion tube measurements cannot be used to ascertain whether the 24 hour objective is exceeded in any case. Sulphur dioxide diffusion tubes should be employed in specific locations in response to local needs only. Widespread coal-burning in the Forest of Dean warrants the continued use of sulphur dioxide diffusion tubes there, also given the local topography.

7 Ozone

Ozone is an oxidising, toxic irritant gas. At ground level it is a secondary pollutant formed principally by the presence of sunlight and primary pollutant gases including nitric oxide and nitrogen dioxide. Its formation is further encouraged by the presence of hydrocarbons (either from petrol fumes or naturally arising from vegetation). Ozone is one of the toxic components of the photochemical smog now affecting with increasing frequency, towns and cities with high traffic densities and sunny climates. Ozone is a regional as opposed to local pollutant (for example it can be carried here from the Continent) and therefore the objective level set by the AQS is not within the remit of Local Authorities. Levels of ozone tend to be higher in rural rather than urban areas because nitric oxide suppresses its formation. The objective level is $100 \mu\text{g m}^{-3}$ measured as the daily maximum of the running 8 hour mean, which is not to be exceeded more than ten times per year, to be achieved by 2006.

Ozone is measured continuously at the monitoring station in Cheltenham. In 2001 there were 43 recorded exceedences of the $100 \mu\text{g m}^{-3}$ level. In 2002 there were only 20 days on which the maximum 8 hour running mean exceeded the prescribed level. This is no doubt due to 2002 being a less sunny year than 2001. The maximum of the 8 hour rolling averages was $124 \mu\text{g m}^{-3}$ which occurred on Sunday the 2nd of June during the Jubilee weekend, when a strong south-easterly flow was bringing air from the Continent. The objective is not set to be achieved until 2006, but it appears that this may be difficult.

Table 3: Annual mean ozone levels measured in Cheltenham

Year	2000	2001	2002
Ozone $\mu\text{g m}^{-3}$	45.2	49.2	46.4
Data Capture (%)	90.8	93.4	98.0

Ozone is also measured by diffusion tube at Bevington by Stroud District Council. The measured values for May, June and July were 102.2, 89 and 64.4 $\mu\text{g m}^{-3}$ respectively. The mean recorded at Bevington in 2002 was 68 $\mu\text{g m}^{-3}$ (missing December's result) slightly lower as well than the mean recorded in 2001, which was 70.3. It was significantly higher than that recorded in Cheltenham. Ozone levels are normally higher in rural areas, due to lower levels of NOx. Ozone monitoring by diffusion tube has been started at the Todenham Road site by Cotswold DC in 2003, and by Tewkesbury BC at the Forthampton rural site in September 2002.

7.1 Conclusions for Ozone

Measured values for ozone concentration continue to show that the pollutant is a major concern in the County. Although ozone is not within the remit of Local Authorities for the purposes of local air quality management, the Local Authorities have extended the diffusion tube survey to assess and highlight the problem within the County. Ozone is a pollutant that is largely brought into Gloucestershire from outside the County. By measuring levels more widely within the County, the Gloucestershire Pollution Group can gather independent data, to encourage national measures to reduce the sources of the pollutant, particularly road traffic emissions. Individual Local Authorities can therefore reasonably represent the interests of their inhabitants in expressing concern that they are being subject to air pollution over whose source they have no control.

8 Benzene, Toluene and Xylene

Benzene is a Category 2 carcinogen. It is a volatile organic compound that was formerly a major component of petrol. The percentage of benzene in petrol was limited to 1% at the end of 2000. Cohort studies of workers in a tyre factory in America found elevated instances of lung cancer associated with the presence of benzene in the workplace atmosphere. Toluene and xylene are compounds similar in chemical structure to benzene but without the carcinogenic effects.

8.1 Diffusion Tube Measurements by Gloucester CC

The main source of all three compounds in Gloucestershire is from unburnt petrol. Petrol can pass unburnt through a vehicle engine and evaporates from petrol tanks especially during filling, and from all handling operations.

The annual average of benzene measured at Cirencester Market Place was $2.1 \mu\text{g m}^{-3}$ in 2000, $1.9 \mu\text{g m}^{-3}$ in 2001, and was $1.7 \mu\text{g m}^{-3}$ in 2002.

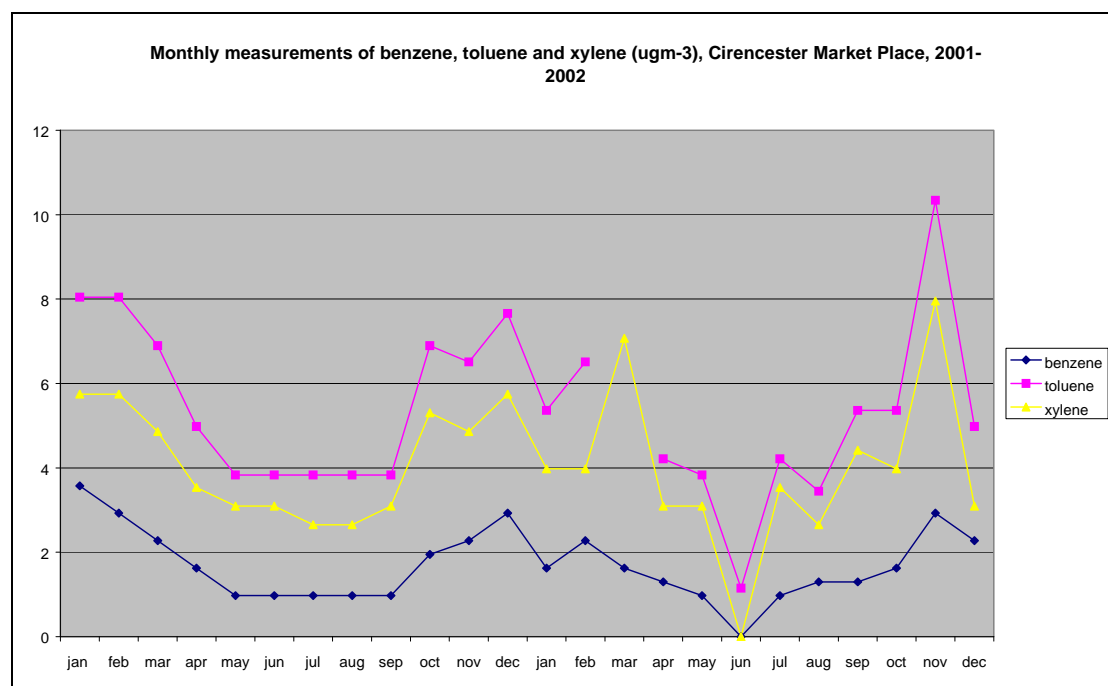


Figure 14 Monthly Measurement of Benzene, Toluene and Xylene in the Market Place, Cirencester (2001-2002)

8.3 Conclusions for Benzene

Benzene concentrations in Stroud and Cotswold District Councils are low and well within statutory limits. Similar conditions are expected elsewhere within the County.

9 The Stroud-Tewkesbury Air Quality Management Area (AQMA)

One of the conclusions of the review and assessment procedure, carried out by the GPG in 2001, was that it could not guarantee that nitrogen dioxide levels would meet the annual mean objective value in parts of the County. Monitoring and modelling of nitrogen dioxide levels in the vicinity of the M5 motorway, for part of its length in Stroud District and Tewkesbury Borough, indicated that levels of nitrogen dioxide along the motorway might not fall below $40 \mu\text{g m}^{-3}$ as an annual mean by the year 2006.

Vehicular emissions are primarily responsible for increasing the levels of nitrogen dioxide, and modelling indicated a narrow corridor to the east of the motorway, where exceedence of the $40 \mu\text{g m}^{-3}$ objective value may occur. Since there are residential properties very close downwind of the motorway, members of the public are likely to be regularly present there for the relevant averaging period for the annual mean.

In this instance, there was no option for the local Authorities concerned but to investigate the levels of nitrogen dioxide further. Therefore, the two Authorities (Tewkesbury BC and Stroud DC) declared an Air Quality Management Area with effect from 30th June 2001, to the east of the M5.

The effect of the order was for the two Authorities to undertake additional monitoring for a 12-month period in order to determine if the AQMA should be confirmed, altered in extent or revoked. The precise area is the length of the M5 motorway between a point where it crosses over the A417 (just south of Junction 11A within the borough of Tewkesbury (Hucclecote) and a point on the M5 some 400 metres north of where the M5 crosses over the B4073 within the Stroud District (Upton St Leonards) and extending laterally from the westernmost boundary of the M5 outwards for a distance approximately 65 metres east of the boundary of the M5.

Extensive monitoring was carried out in the affected areas of Hucclecote and Upton St. Leonards. In October 2002 Tewkesbury BC reviewed their Hucclecote AQMA. Nitrogen dioxide measurements made between May 2001 and July 2002 were corrected for bias and an allowance was made for the effect of a contra-flow on the M5 reducing speeds and therefore emissions. The maximum mean concentration of nitrogen dioxide over that time was $36 \mu\text{gm}^{-3}$, within the air quality objective of 40. Tewkesbury BC recommended that the AQMA be reduced in extent, still taking a precautionary view that an exceedence might occur. They undertook to have an Action Plan, to address the predicted exceedence, in place by the 31st of March 2003. Traffic on the motorway falls under the jurisdiction of the Highways Agency, not the local authority. The review was sent out for consultation, including to the Highways Agency and independent consultants. New DMRB³ modelling calculations by the Highways Agency showed that it was unlikely that the annual mean for nitrogen dioxide would be exceeded by 2006. The modelling was checked by the council using independent consultants, who found that the Highways Agency had used an incorrect width for the carriageway, but that nevertheless the overall conclusion was correct, and the AQMA has been rescinded.

10 References

¹ Technical Guidance LAQM TG(03), DEFRA, 2003

² Policy Guidance LAQM PG(03) DEFRA 2003

³ Design Manual for Roads and Bridges

11 Glossary of Terms

Air pollution

A term used to describe any unwanted chemicals or other materials that contaminate the air that we breathe resulting in the degradation of air quality.

Airshed

The general atmosphere contained within a defined boundary such as a Local Authority or county.

Annual mean

The average of the concentrations measured for each pollutant for one year. Usually this is for a calendar year, but some species are reported for the period April to March, known as a pollution year. This period avoids splitting a winter season between 2 years, which is useful for pollutants that have higher concentrations during the winter months.

Carbon monoxide (CO)

A highly poisonous gas, consisting of molecules of carbon (1) and oxygen (1) atoms, produced when fuel is burnt during incomplete combustion. It is emitted mainly from car exhausts.

Catalytic converter

A device fitted to the exhaust system of a vehicle, which converts the majority of harmful exhaust pollutants, such as hydrocarbons, into less harmful ones.

Clean Air Acts

Acts passed in 1956 and 1968 to reduce the amount of pollution from industries and homes in the UK.

Combustion

Burning, e.g. of fossil fuels or biomass.

Concentration

A measure of the atmospheric content of a gas, defined in terms of the proportion of the total volume that it accounts for. Trace gases in the atmosphere and are usually measured in parts per million by volume (ppmv), parts per billion by volume (ppbv) or parts per trillion (million million) by volume (pptv).

Department of Environment, Transport and the Regions (DETR)

Central government department that used to be responsible for environmental matters.

Department of Environment, Food and Rural Affairs (DEFRA)

Central government department now responsible for environmental matters

Diffusion tube

A simple device for measuring the concentration of a specific pollutant in the atmosphere based on passive diffusion of ambient air into a tube containing a chemical that reacts with the species under investigation.

Emissions

The discharge of waste gases into the atmosphere.

Emissions inventory

Information concerning the distribution of pollution sources in a certain area and the amount and types of pollutants being emitted.

EPAQS

Expert Panel on Air Quality Standards. EPAQS provides advice and guidance to the UK Government on air quality.

Exceedence

A period of time where the concentration of a pollutant is greater than, or equal to, the appropriate air quality standard.

Fossil fuel

Any hydrocarbon deposit that can be burned for heat or power such as coal, oil or natural gas. Fossil fuels are formed from the decomposition of ancient animal and plant remains.

Hydrocarbons

Organic compounds containing carbon and hydrogen.

Lead

A toxic blue/white metal emitted as particles by vehicles using leaded petrol. Lead toxicity in the body can lead to the impairment of intelligence, particularly in children.

Micron

One millionth of a metre

$\mu\text{g m}^{-3}$

Microgrammes per cubic metre. A measure of concentration in terms of mass per unit volume. A concentration of $1\mu\text{g m}^{-3}$ means that one cubic metre of air contains one microgramme (millionth of a gramme) of pollutant.

Air Quality Strategy (AQS)

A national programme to monitor and manage air pollution levels and air quality in the UK. Published in spring 1997 following the Environment Act of 1995.

National Centre for Environmental Technology (NETCEN)

Part of AEA Technology Ltd with responsibility for managing certain aspects of central government's air quality programmes.

Oxides of nitrogen (NOX)

The collective term for nitric oxide (NO) and nitrogen dioxide (NO₂).

Ozone (O₃)

A gas formed when nitrogen oxides and hydrocarbons react in the presence of sunlight. Consequently, it is known as a secondary pollutant.

Particulates

Coarse and fine particles of organic or inorganic substances present in the atmosphere.

Particulate matter (PM₁₀)

Particles of organic or inorganic substances present in the atmosphere that are less than 10 microns (µm) in diameter.

Percentile

A value that is the rank at a particular point in a collection of data. For instance, a 98th percentile of values for a year is the value that 98% of all the data in the year fall below, or equal.

ppb

Parts per billion. The concentration of a pollutant in air in terms of volume ratio. A concentration of 1 ppb means that for every billion (10⁹) units of air, there is one unit of pollutant present.

ppm

Parts per million. The concentration of a pollutant in air in terms of volume ratio. A concentration of 1 ppm means that for every million (10⁶) units of air, there is one unit of pollutant present.

ppt

Parts per trillion. The concentration of a pollutant in air in terms of volume ratio. A concentration of 1 ppt means that for every million million (10¹²) units of air, there is one unit of pollutant present.

Pollutant

Atmospheric pollution may be defined as “the presence of substances (pollutants) in the atmosphere, resulting from man-made activities or from natural processes, causing adverse effects to man and the environment”.

Running mean

This is a mean - or series of means - calculated for overlapping time periods, and is used in the calculation of several of the national air quality standards. For example, an 8 hour running mean is calculated every hour, and averages the values for eight hours. The period of averaging is stepped forward by one hour for each value, so running mean values are given for the periods 00:00 - 07:59, 01:00 - 08:59 etc. By contrast a non-overlapping mean is calculated for consecutive time periods, giving values for the periods 00:00 - 07:59, 08:00 -

15:59 and so on. There are, therefore, 24 possible 8-hour means in a day (calculated from hourly data) and 3 non-overlapping means.

Sulphur dioxide (SO₂)

A colourless gas, consisting of molecules of sulphur (1) and oxygen (2) atoms, which is given off during fossil fuel combustion.

Smog

Pollution consisting of smoke and sulphur dioxide are trapped at ground level. It usually occurs on cold, calm winter days. The term smog was derived from smoke and fog.

TEOM®

A sampling system for real time measurement of airborne particulate concentrations based on measurement using a tapered element oscillating microbalance (TEOM®).

Transboundary

A term used to describe the movement of air pollution that is emitted in one country and crosses national boundaries to affect other countries.

Appendix 1: Summary of Objectives for Air Quality in the UK

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration ¹	Measured as	
Benzene			
All authorities	16.25 µg/m ³	running annual mean	31.12.2003
Authorities in England only ¹	5 µg/m ³	annual mean	31.12.2010
Authorities in Scotland [Wales] and [Northern Ireland] only ²	3.25 µg/m ³	running annual mean	31.12.2010
1,3 Butadiene	2.25 µg/m ³	running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m ³	Maximum daily running 8-hour mean	31.12.2003
Lead	0.5 µg/m ³ 0.25 µg/m ³	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide³	200 µg/m ³ not to be exceeded more than 18 times a year 40 µg/m ³	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM₁₀) (gravimetric)⁴	50 µg/m ³ not to be exceeded more than 35 times a year 40 µg/m ³	24 hour mean annual mean	31.12.2004 31.12.2004
Particles (PM₁₀) (gravimetric)⁴	50 µg/m ³ not to be exceeded more than 7 times a year 20 µg/m ³	24 hour mean annual mean	31.12.2010 31.12.2010
Particles (PM₁₀) (gravimetric)⁴	50 µg/m ³ not to be exceeded more than 7 times a year 18 µg/m ³	24 hour mean annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 µg/m ³ not to be exceeded more than 24 times a year 125 µg/m ³ not to be exceeded more than 3 times a year 266 µg/m ³ not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

1. Regulations 2002 have not yet been laid for England and Wales
2. The Welsh Assembly Government has yet to make a decision on the objectives to be included in the Regulations 2002, and these values stated in this table are subject to confirmation. In Northern Ireland the objectives are to be given legal effect in Regulations following the introduction of the Local Air Quality management Bill, in June 2003
3. The objectives for nitrogen dioxide are provisional
4. Measured using the European gravimetric transfer sampler or equivalent.
5. These 2010 air quality objectives for PM₁₀ apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

**APPENDIX 2: Recommended local air quality management time table
until 2010, by Central Government¹**

LAQM Activity	Completion Date	Which local authorities?
Updating and screening assessment	April 2003	All authorities
Detailed assessment	April 2004	Those authorities which have identified the need for one in their April 2003 updating and screening assessment
Annual Progress Report	April 2004	Those authorities which identified that there was no need for a detailed assessment in their April 2003 updating and screening assessment
Annual Progress Report	April 2005	All authorities
Updating and screening assessment	April 2006	All authorities
Detailed assessment	April 2007	Those authorities which have identified the need for one in their April 2006 updating and screening assessment
Annual Progress Report	April 2007	Those authorities which identified that there was no need for a detailed assessment in their April 2006 updating and screening assessment
Annual Progress Report	April 2008	All authorities
Updating and screening assessment	April 2009	All authorities
Detailed assessment	April 2010	Those authorities which have identified the need for one in their April 2009 updating and screening assessment
Annual Progress Report	April 2010	Those authorities which identified that there was no need for a detailed assessment in their April 2009 updating and screening assessment

¹ From the draft Local Air Quality Management Policy Guidance note (LAQM.PG(02)). Department for Environment, Food and Rural Affairs.