Leicester
City Council

Forward Timetable of Consultation & Meetings:

CABINET (INITIAL CONSIDERATION)	**4th September 2000**
ARTS, LEISURE & ENVIRONMENT SCRUTINY	**7th November 2000**
CABINET (FINAL CONSIDERATION)	**20th November 2000**

ENVIRONMENT ACT 1995:
REVIEW AND ASSESSMENT OF AIR QUALITY

Report of the Director of Environment and Development.

1. Purpose of Report

To inform members of the findings of the statutory Review and Assessment of Air Quality (including proposed Air Quality Management Areas) and to seek member approval of the proposed consultation arrangements.

2. Summary

The Environment Act 1995 requires all local authorities to undertake a review and assessment of air quality in their areas. The main aim is to identify areas where national air quality objectives (future targets based on health-related standards) will not be achieved. These must be declared as Air Quality Management Areas (AQMAs), and an Action Plan must subsequently be prepared and implemented.

The Review and Assessment is a three-stage process. Stage I (a simple screening process) was completed and reported to Environment & Development Committee in December 1998. This then necessitated the City Council proceeding to Stage III of the Review & Assessment for nitrogen dioxide, carbon monoxide and PM_{10} particulates.

The DETR's "suggested deadlines" for completion are detailed below:

December 2000	Completion of final report after consultation and formal designation of any Air Quality Management Areas (AQMAs)
November 2001 (Within 9-12 months of AQMA designation)	Completion of a more detailed review within AQMAs and preparation of a draft Action Plan for consultation.
May 2002 (Within 12-18 months of AQMA designation)	Action Plan should be in place.
December 2003	Completion of a second full Review & Assessment

Stage III of the Review and Assessment is far more complex and requires the use of air quality models to predict future levels of pollutants at all locations. The findings of this work are detailed in the “Leicester Air Quality Review and Assessment 2000 Final Report - Consultation Draft”. This will mark the start of a six-week consultation period. The report will be considered by Arts, Leisure & Environment Scrutiny on 7th November 2000. Feedback will be reported to Cabinet on 20th November 2000, with a view to declaring the proposed AQMAs.

3. Recommendations

Cabinet is asked to:

a) Note the findings of the Air Quality Review & Assessment and proposed Air Quality Management Areas detailed in the “Leicester Air Quality Review and Assessment 2000 Final Report - Consultation Draft”, and to approve this as a basis for public consultation; and

b) Approve the consultation proposals summarised in the Appendix to this report, with feedback being reported to Scrutiny and Cabinet in November

4. Headline Financial and Legal Implications

This work has largely been undertaken within existing departmental budgets. However, in recent years capital costs associated with air quality monitoring and modelling have been supported through a number of successful SCA bids.

Under the Environment Act 1995, the City Council has a statutory duty to complete this Review & Assessment and declare any Air Quality Management Areas (by the suggested deadline of October 2000). Under Section 85 of the Act, if it appears to the Secretary of State that a local authority is not meeting its obligations under the Act, the Secretary of State may direct the local authority to undertake a review as directed, revoke or modify AQMAs, prepare or modify its action plan, or to implement any measures in its action plan.

5. Report Author

Adrian Russell, Pollution Control Group, Extension 6411

APPENDIX

Consultation

The process of undertaking this Review & Assessment of Air Quality has involved widespread internal and external consultation, which is reflected in the text of the "Leicester Air Quality Review and Assessment 2000 Final Report - Consultation Draft". An overview of the findings of the Review & Assessment were presented to Directors Board on 25th July 2000 and to Chairs & Directors on 14th August 2000.

Wide-ranging consultation is key element of the local air quality management process, and there is a wide range of statutory and recommended consultees. These are detailed in Appendix F ("Consultation Strategy") of the Final Report.

In relation to public consultation, it is recognised that the Review and Assessment is a very complex and technical process, and the Final Report is a lengthy document. Therefore, the main aim is to be produce a simple summary leaflet explaining the main findings and providing details of how and where copies of the full report can be viewed (libraries, internet, etc.) by anyone interested. Provision will be made for the translation of the summary information contained in the consultation leaflet. The proposed timetable for consultation is:

4th September	Cabinet consideration Publication of Consultation Draft Report **Start of public consultation period.** Summary leaflets in public access buildings Copies of full report in libraries, on internet, and sent to consultees
11th September	Leicestershire Air Quality Forum joint consultation meeting (targeted towards "common" consultees such as Health Authority, Environment Agency, Highways Agency, key industries, etc.)
27th September	Article appears in October LINK
30th September	Exhibition/display at City Rooms (enabling the public to discuss findings with officers)
13th October	**End of public consultation period**
7th November	Arts, Leisure & Environment Scrutiny
20th November	Report back to Cabinet and declaration of AQMAs

Policy Implications

These are detailed in Section 4.4 of the Full Report.

Equal Opportunities Implications

Disadvantaged groups are more likely to live in areas of the City subject to higher levels of pollution.

Sustainable and Environmental Implications

The local air quality management process aims to ensure that future national air quality objectives are achieved within the City; a key urban sustainability issue.

Leicester
City Council

Leicester Air Quality Review and Assessment 2000

Final Report - Consultation Draft

September 2000

Pollution Control Group,
Environment & Development Department,
Leicester City Council,
New Walk Centre,
Welford Place,
Leicester
LE1 6ZG

Telephone: 0116 2526438
Fax: 0116 2526444
Email: air-quality@leicester.gov.uk

This is the Report on Leicester City Council's first Review and Assessment of Air Quality. It is done to fulfil the legal requirements detailed in the box below.

It identifies the areas in Leicester where further action is needed to achieve the legal Air Quality Objectives laid down by the Government.

It is a consultation draft of the report to seek peoples' views before the final Report is published.

If you have any comments or questions, they should be sent by 20th September 2000 to:-

Pollution Control Group,
Environment and Development,
Leicester City Council,
New Walk Centre,
Welford Place,
Leicester LE1 6ZG

Telephone: (0116) 252 6438
Fax: (0116) 252 6444
E-mail: air-quality@leicester.gov.uk

Statutory Requirements Fulfilled by this Report:

ENVIRONMENT ACT 1995, PART IV

This Report is compiled and published by Leicester City Council in compliance with its duty:-

- ***under Section 82 (1) of the above Act, to perform from time to time a Review of air quality for the time being and likely future air quality in its area, within the "relevant period" (defined in Regulation 3(2) and Schedule of the Air Quality Regulations 2000).***
- ***under Section 82 (2) of the Act, to perform an Assessment of whether the Air Quality Objectives prescribed in the Air Quality Regulations 2000 (Regulation 4 and Schedule) will be achieved at locations which are situated outside of buildings or other natural or man-made structures above or below ground and where members of the public are regularly present.***
- ***in relation to the requirement of Section 88 (2) of the Act that the Council shall have regard to Guidance issued by the Secretary of State for the Environment, Transport and the Regions under Section 88 (1) of the said Act, to complete a consultation draft of the first such Review and Assessment by 30th June 2000. 2000 (or as soon thereafter as is reasonably practicable).***
- ***in accordance with the requirements of Guidance issued under Section 88 (1), to compile specified information.***
- ***in accordance with the requirements of Section 90 and Schedule 11 of the Act, and Guidance issued under Section 88 (1), to consult on the said Review and Assessment of air quality with specified persons and to publish a final Report thereon by 31st October 2000 (or as soon thereafter as is reasonably practicable).***

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Summary of Report.

Air quality will improve significantly in Leicester between now and 2005 due to the combined effects of City Council and national policies. The main residual problem will relate primarily to nitrogen dioxide emissions from traffic: This will occur in situations in which people are exposed in close proximity to the major road network.

In the light of the Review and Assessment of air quality detailed in this Report, it is the opinion of the Leicester City Council that:-

The statutory Objectives for the following pollutants WILL be met by the respective prescribed dates:-

Benzene
1,3-butadiene
Lead
Sulphur dioxide
Carbon monoxide

The annual statutory Objective for Nitrogen dioxide will NOT be met by the prescribed date, at sites near to major roads.

It has not been possible to predict with certainty but it is considered likely that the hourly statutory Objective for nitrogen dioxide and both of the Objectives for PM_{10} particulates may NOT be met, at some situations very close to major roads, (within about 10 metres of roads having an average daily flow in excess of about 20,000 vehicles).

It is considered that the maximum extent of exceedances of the air quality Objectives will be governed by areas of exceedance of the annual mean Objective for nitrogen dioxide. This is subject to the proviso that persons in close proximity to major roads may be subjected to levels of nitrogen dioxide and particulates considerably greater than are implied by the method used to determine the maximum areas of exceedance.

Subject to consultation, it is therefore recommended that the Leicester City Council declare Air Quality Management Areas in accordance with the areas identified on the map issued in conjunction with this Report, "Leicester City Council Review and Assessment of Air Quality, Stage 3, 2000: Proposed Air Quality Management Areas." (Fig. 1).

The key factor in all predicted cases of failure to meet the statutory air quality Objectives is traffic emissions from the busiest roads in the City. Policy should therefore be directed toward the minimisation of the impact of these emissions.

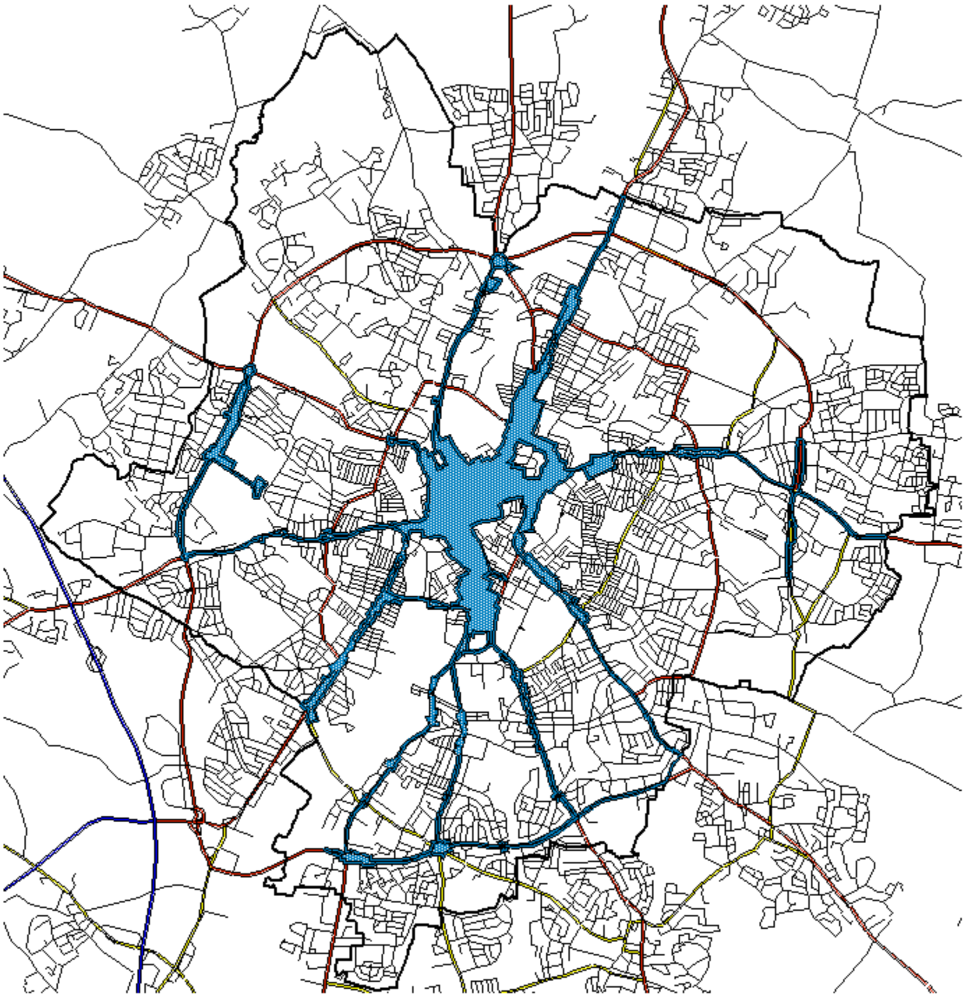

Figure 1

Proposed Air Quality Management Areas

THE CITY COUNCIL PROPOSED AIR QUALITY MANAGEMENT AREA IS SHOWN IN LIGHT BLUE

Part 1: THE BACKGROUND TO REVIEW AND ASSESSMENT

1.1 What is Air Quality?

It is easy to take the air which we breathe for granted: We all pollute it by the things we do in our daily lives. There is a growing realisation that this is having serious effects-

- GLOBAL EFFECTS: Acid rain, thinning of the ozone layer and global warming;

- LOCAL EFFECTS: Spoiled surroundings and harm to human health.

This Report has a local focus: It is about how we are checking to make sure that pollution in the air of Leicester will not harm the health even of vulnerable people.

Government experts have estimated that up to 24,000 people die early each year in the United Kingdom from the effects of poor air quality[1]. (For comparison, about 327,500 people were injured in road accidents and about 3,500 died in 1997[2]). In Leicester, a study has shown that more people go into hospital with breathing problems after summer smog incidents[3].

Previous legislation had successes: From 1956, the Clean Air Acts gradually ended things like -

- black smoke from factory chimneys,
- palls of blue haze from hundreds of household coal fires,
- blackened public buildings
- winter “pea-soup” smogs,

- which some will remember as features of our cities. Under this Act, all of Leicester has been a Smoke Control Area for many years.

This only controlled the use of fuels like coal and oil in home fireplaces and industrial plant. As airborne grime disappeared, other, invisible pollutants were being pumped out into the atmosphere from new industries and ever-growing numbers of motor vehicles. These emissions, both local and from further afield, can combine with the changing pattern of weather to cause episodes of high pollutant levels.

Now, the Environment Act has brought a change in the way in which the City Council manages local air quality:-

- ***Key pollutants, which might harm our health, are identified.***
- ***Levels are set for each of these pollutants in the air, which will avoid health risks.***
- ***Deadlines are set for achieving these levels.***
- ***The City Council must check whether these deadlines will be met.***
- ***If they won’t be met, Action Plans must be drawn up.***

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1. *Quantification of the Effects of Air Pollution on Health in the United Kingdom,* Committee on the Medical Effects of Air Pollutants (COMEAP), Department of Health, HMSO, 1998.
2. DETR figures.
3. *An Investigation into Hospital Admissions and Ozone Levels in Leicester*. C. A. Mallon, Institute of Public and Environmental Health, Faculty of Science, University of Birmingham., December 1995.

1.2 The Environment Act.

1.2.1 What the Legislation Requires.

The Environment Act 1995 (Part IV) introduced the concept of **Local Air Quality Management**.

Under the terms of the Environment Act, the Government produced the first **National Air Quality Strategy** in March 1997, with an updated version in early 2000, *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*. This document outlines the way in which air quality will be managed in the UK in the years to come.

The National Air Quality Strategy sets **Air Quality Objectives** for levels of exposure to these pollutants at which adverse health effects are very unlikely, even among vulnerable groups. These are based on the advice of the Expert Panel on Air Quality Standards (EPAQS), which was set up by the Government for this purpose, and on the requirements of the EC Air Quality Daughter Directive (AQDD). Assessments of appropriate health-based Standards are translated into Objectives by adding target dates for compliance and allowing for a small number of unavoidable exceedances for certain pollutants.

The Air Quality Regulations 2000 (S.I. 2000 No. 928), made under the Act, gave statutory force to the revised Air Quality Objectives. The reasons for this revision of the Objectives are:

- Changes in the state of scientific knowledge about the nature and behaviour of pollutants.

- The need to harmonise UK legislation with the somewhat different requirements of the EC Air Quality Daughter Directive.

The Act also requires the City Council to carry out a periodic **Review and Assessment** of air quality in relation to these Objectives. The first of these must be completed by late 2000. The aims of this are:-

- To identify areas of Leicester where national measures will not achieve the Air Quality Objectives by themselves, so local action is needed.

- To provide a basis for integrated local policy on air quality, in matters such as land use planning and traffic management.

The Act and the Guidance refer to the processes of air quality "Review" (Section 82 (1)) and air quality "Assessment" (Section 82(2)): Guidance Note LAQM. G1(00), *Framework for Review and Assessment of Air Quality*, paragraph 1.08, defines "review" as, *"consideration of the levels of pollutants in the air for which objectives are prescribed in regulations, and estimation of likely future levels"*, and "assessment" as, *"the consideration of whether estimated levels for the relevant future period are likely to exceed the levels set in the objectives"*.

Where the Review and Assessment identifies areas in which the Air Quality Objectives will not be met between now and the various deadlines laid down for the different pollutants, affected areas must be declared as **Air Quality Management Areas**.

In Air Quality Management Areas, Councils must draw up a time-based **Action Plan**, which integrates the full range of their functions to ensure that the Air Quality Objectives are met. Councils are also expected to consult widely on the Review and Assessment and to work in partnership with local communities and business.

1.2.2 Table of the Key Pollutants, Showing Air Quality Objectives

Pollutant	**Sources**	**UK 1995 emissions (1,000's of tonnes)**	**% of UK emissions from traffic**	**Air Qualit**
Benzene	Petrol use	35	67	16.25 μg.m^{-3} (5 ppb) annual mean
1,3-Butadiene	Petrol use	9.6	77	2.25 μg.m^{-3} (1 ppb) annual mean
Carbon monoxide	Poor combustion of carbon fuels	5478	75	11.6 mg.m^{-3} (10 ppm) running 8 ho
Lead	Industry. Being phased out in petrol	1.5	78	0.5 μg.m^{-3} , annual mean 0.25 μg.m^{-3} , annual mean
Nitrogen dioxide	Motor vehicles. Combustion plant	2293	46	200 μg.m^{-3} (105 ppb) (18 exceedances perm 40 μg.m^{-3} (21 ppb) annual mean
Particulates (PM_{10})	Primary: Motor vehicles and combustion plant. Natural sources Secondary: Remote combustion plant.	232	26	50 μg.m^{-3} , 24 hour (35 exceedances perm 40 μg.m^{-3} , annual
Sulphur dioxide	Combustion plant (power stations)	2365	22	266 μg.m^{-3} (100), 15 (35 exceedances perm 350 μg.m^{-3} (132 ppb), (24 exceedances perm 125 μg.m^{-3} (47 ppb), 2 (3 exceedances permi
Ozone	Secondary from action of sunlight on NOx and VOC's			**NO STATUTORY OB** Provisionally: 1000 μ maximum of running 8 (10 exceedances perm ***[See in Appendix C:*** ***Ozone".]***

μg.m^{-3} = microgrammes per cubic metre. (conversion from ppm at 20 Celsius and 1013 mb pressure).

1.2.3 Explanation of the Air Quality Objectives

(a) Averaging Times

Pollutants vary in the time-scale over which they have their effects:

Benzene and 1,3-butadiene cannot be assigned a level below which there is absolutely no cancer risk. Similarly with lead, it has not proved possible to define a level in the blood below which there are no effects.

Therefore the Objectives for these pollutants are set at a level where the medical evidence suggests that significant health effects are very unlikely over a long averaging period for exposure, i.e. one year.

At the other end of the scale, sulphur dioxide is noted for its acute, short-term effects and so one of the three Objectives for this pollutant is based on a 15 minute averaging time, in addition to 1 hour and 24 hour Objectives.

Nitrogen dioxide has both acute effects at high concentrations and more insidious health effects at lower concentrations. Therefore, Objectives are set both with an hourly and a one-year averaging period.

(b) Percentile Compliance

In the case of nitrogen dioxide, PM_{10} particulates and sulphur dioxide, we have seen that Objectives are set which have relatively short averaging times. The National Air Quality Strategy acknowledges that it will never be possible for these pollutants to achieve one hundred percent compliance; there will always be short periods of exceedance due to weather conditions. In the case of particles, special events such as Bonfire Night will also tend to create short-term peaks.

Allowance is made for this problem by adopting a *percentile* approach to limits for these pollutants.

For example, an annual *90th percentile* Objective is adopted for one of the Objectives for PM_{10} particulates and for one of the sulphur dioxide Objectives, which means that the Standard can be exceeded for about 10% of the days in each calendar year: Allowing for rounding, the daily maxima can therefore exceed the limit value on 35 days in each year before the Objective is breached.

(c) Running Means

Monitoring values at a single, fixed point are likely to fluctuate over short periods because of variations of microclimate and nearby transient sources. Short-term variations are therefore smoothed out by expressing the Objective for some pollutants as a running mean over an appropriate time-scale.

For example, the problem for benzene is caused by exposure over a long period, so the Objective is stated as a running annual mean of hourly values.

Similarly, the Objective for carbon monoxide is expressed in terms of a running 8 hour mean.

(d) Exposure

The purpose of the Air Quality Objectives is to protect human health: Exceedances of the Objectives are only therefore a valid basis for further action where they occur at outdoor locations at which members of the public (*not* persons occupationally exposed) are regularly present *for periods equal to the averaging time specified for the relevant pollutant.*

Therefore, for Objectives with short averaging times (e.g. the short-term Objectives for sulphur dioxide and nitrogen dioxide) the Review and Assessment could be focused on any near-ground, outdoor location. This is because exposures for actual people are possible there, sufficient for the Objectives to be breached.

Where Objectives for pollutants are based on longer averaging times, the Review and Assessment should only consider locations where a person might reasonably be expected to spend periods of exposure equivalent to the averaging time, e.g. housing, schools, hospitals or residential care establishments.

1.2.4 Consultation and Liaison

The Environment Act and supporting Guidance require Leicester City Council to consult widely on the Air Quality Review and Assessment. The specified list of consultees includes:-

- The Secretary of State for the Environment, Transport and the Regions.
- The Environment Agency.
- All neighbouring local authorities.
- Other relevant public authorities as the Council considers appropriate.
- Bodies representative of local business interests.
- Other bodies as the Council considers appropriate.

In addition, the Guidance recommends that community and environmental groups should be brought into the process.

It is the intention of Leicester City Council to consult as fully as possible with all stakeholders in the City. The Council extends an invitation to all interested parties to make their contribution to better air quality in Leicester.

Any air quality concerns or comments expressed in response to this consultation draft of the Leicester Air Quality Review and Assessment Report will receive consideration in completing the final published version of the Report.

Details of the consultation process are given in Appendix F.

Not only has the City Council a legal duty to consult on this Review and Assessment, it must also consult in the same way on:-

- Any subsequent Review and Assessment.

- The preparation (or revision) of any consequent Action Plan.

In addition to the list of Statutory Consultees, the Council has conducted a survey of local business, community and environmental groups, plus anyone who has declared an interest following the publication of the *Leicester Air Quality Strategy* (August 1998). All of these have been placed on a **Register of Consultees**. All persons on this Register will automatically be consulted on any subsequent developments in Local Air Quality Management which carry a statutory duty to consult.

Air pollution is no respecter of boundaries: Leicester forms part of a larger urban area, which lies within the districts of a number of local authorities. It would not, therefore be appropriate to attempt to carry out a Review and Assessment solely within the administrative boundary of Leicester City Council.

Conversely, in view of the very different needs and characteristics of neighbouring local authorities, the decision was taken at a relatively early stage that it would not be appropriate to carry out a joint air quality Review and Assessment for this wider area. However, as suggested by Government guidance, there is still considerable scope for fruitful inter-authority collaboration.

For these reasons, the District Councils of Leicestershire, together with Leicestershire and Rutland County Councils and the unitary Leicester City Council have combined to form a co-ordinating body, the *Leicestershire and Rutland Air Quality Forum.* The remit of this body is to exchange air quality information and to discuss matters of common interest and, in particular, the technical and administrative aspects of Local Air Quality Management.

In addition, specific co-operative arrangements have been arrived at with some neighbouring local authorities concerning compilation of emissions inventories, dispersion modelling of areas contiguous to the City and sharing of expertise.

1.3 Description of Leicester.

(See Fig. 2).

Leicester is one of the largest cities in the East Midlands, with a population approaching 300,000. It stands in the broad, shallow valley of the River Soar at the centre of a network of communications, including various major radial and tangential roads. The urban area of which it forms part extends into the areas of several surrounding local authorities.

Established industries such as textiles, footwear, engineering and printing have in recent decades been complemented by relative newcomers such as food processing and packaging. There has been a general decline in footwear and some sectors of textiles; indeed, Leicester reflects the general downward trend in the UK of “traditional” manufacturing industries and the transfer of activity into the service sector. While there are several very large employers, there has been a tendency, especially in the textile industry, for large concerns to close and be replaced by a large number of small businesses, often intimately intermixed with residential areas.

Although there are a few substantial employers in the engineering and foundry sectors, Leicester cannot in general be described as a “heavy” industrial area. The heavy chemical, heavy metallurgical/engineering and power generation industries are virtually unrepresented within the City’s boundaries.

Details of processes authorised under Part I of the Environmental Protection Act 1990 and considered in relation to emissions of the specified pollutants can be found in Appendix A3.

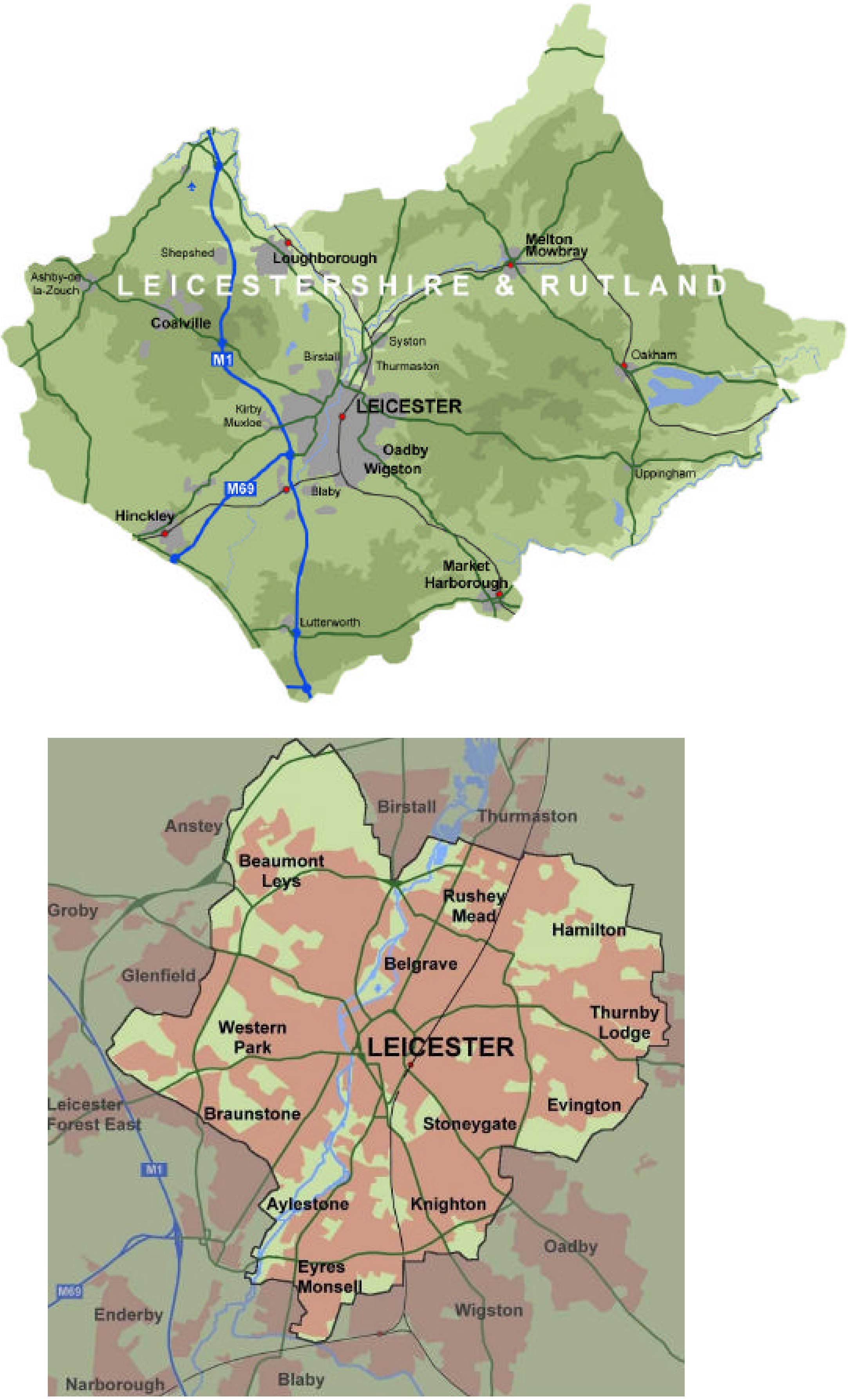


Figure 2

Maps showing general location of Leicester (top) and administrative area of Leicester City Council (bottom).

Part 2: HOW THE REVIEW AND ASSESSMENT IS DONE

2.1 The Prescribed Approach.

2.1.1 A Three Stage Process:

In the statutory Guidance, the Government has laid down the general principle that the effort devoted to Air Quality Review and Assessment should be proportionate to the risk of the Objectives being breached. Therefore, the relevant guidance document prescribes a phased approach in three stages of progressively increasing complexity. (Local Air Quality Management Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality*): The results of the first stage indicate whether it is necessary to go on to the second stage and, similarly, the results of the second stage indicate whether it is necessary to proceed to the third. Only if the requirements of each stage are satisfied, is progression to the next stage justified.

Leicester City Council has already completed the first two Stages of its statutory Air Quality Review and Assessment as prescribed by statutory Guidance. The procedure and findings were published in *Leicester Air Quality Review and Assessment: INTERIM STAGE I / II REPORT, December 1998*.

This Report reviews the course and outcome of the first two stages and goes on, where appropriate, to detail the results of the third stage.

In order to make the Report easier to read, technical details of the methodology used in the Review and Assessment have been placed in a series of Appendices. Reference is made to these as appropriate in the main text so that any reader wishing to consider the fine detail of the steps by which the conclusions of the Report were reached can readily refer to them.

2.1.2 The Methods used in Stages 1 and 2 of the Review and Assessment:

The methodology followed in Stages 1 and 2 of this Review and Assessment follows that laid down in Local Air Quality Management Guidance Note LAQM. G1(97), *Framework for the Review and Assessment of Air Quality*.

In summary, the first stage consists of screening for the existence of specified sources or background levels of each of the key pollutants: These vary from pollutant to pollutant but examples would be roads with daily traffic flows greater than a specified amount or specific kinds of industrial process. The existence of any of these specified conditions provides a justification for proceeding to the succeeding stages of the process. Otherwise, it can safely be assumed that there is no need to progress to the next stage.

The second stage is optional and consists of the application of more elaborate screening models. Since Leicester City Council was already equipped to carry out the third stage, it was decided that, in cases of pollutants where the Stage 1 tests were satisfied, the investigation would proceed directly to Stage 3. Certain Stage 2 methodologies have been adopted as a cross-check on findings. (LAQM.TG4 (00), para. 6.60).

The conclusions of these stages are summarised for each pollutant in Part 3 of this Report, below, and further details appear in Appendix A.

2.1.3 The Methods Used in Stage 3 of the Review and Assessment:

The methods used in the third stage Review and Assessment are also based on statutory Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality,* which superseded LAQM.G1(97) after the completion of the Stage 1 / 2 exercise. These comprise detailed investigations. using monitoring and dispersion modelling:

Monitoring with high quality instruments, properly calibrated, gives us an accurate picture virtually in real time of pollutant levels at our monitoring stations. However, we cannot monitor everywhere in Leicester; it would not be affordable or practicable. Neither can we use monitoring to tell us what is going to happen in the future, as the Environment Act requires.

On the other hand, computer modelling enables us to map what is happening over the whole city and also to predict future pollutant levels. However, the outputs of dispersion models are inevitably subject to considerable errors.

In order to create a credible picture of air quality in future years, we put these techniques together: We run dispersion models to predict air quality at points in space and time for which we have actual monitoring data, i.e. at monitoring stations. Comparison of modelled and observed data enables us to estimate the range of error in the model's predictions. This is known as *validation* of the model.

We can then use the dispersion model to map out contours of air quality in future years and use our estimate of the error in the model's calculations to modify these contours and thus to define the geographical extent of any exceedance of the Air Quality Objectives across the whole City.

2.2 Monitoring.

2.2.1 General

"Monitoring" means the use of devices of different degrees of sophistication to measure the concentration of specific pollutants at a given point.

The technology now exists to monitor air quality automatically with good accuracy, precision and time resolution: An extensive national network has been established over the last few years with such equipment, including a monitoring site in Leicester. Leicester City Council has also established its own monitoring network throughout the City, as shown on the accompanying map. (Fig. 3).

As a general rule, the better and more detailed the data produced by a piece of equipment, the more expensive it tends to be to buy and operate. However, cheap simple devices are useful as a survey tool.

Full technical details of the various monitoring sites summarised in this section are given in Appendix B.

2.2.2 Types of Monitoring

(a) Automatic (Analysers)

These are sophisticated, automatic instruments which continuously measure pollutant levels. Data is stored and transmitted to a central control-point for checking and analysis. The instruments are subject to elaborate calibration checks to ensure the reliability of the data generated. Variations in pollutant levels can be seen virtually in real time with these instruments.

The Government has a network of these analysers in cities across the United Kingdom, known as the Automated Urban Network (AUN). These are organised in monitoring stations containing instruments for measuring Carbon dioxide, Nitrogen oxides (NO and NO_2), Sulphur dioxide, Ozone and PM_{10} particulates. One of the stations is located at the New Walk Centre, in the City centre, and is managed by the City Council.

The data produced is used nationally to prepare bulletins for TV, Teletext and other media and it is also made available to anyone who wants access to it, for example via the Internet.

Leicester City Council has established its own network of analysers approved to a similar standard. investigate air quality at different places of interest in the City.

In addition to the Automatic Urban Network, the Government also operates a chain of specialised monitoring stations looking at levels of rural ozone, benzene and 1,3-butadiene. Although this type of monitoring unit is not represented in Leicester, the data obtained by them is generally available to the public via the Internet etc.

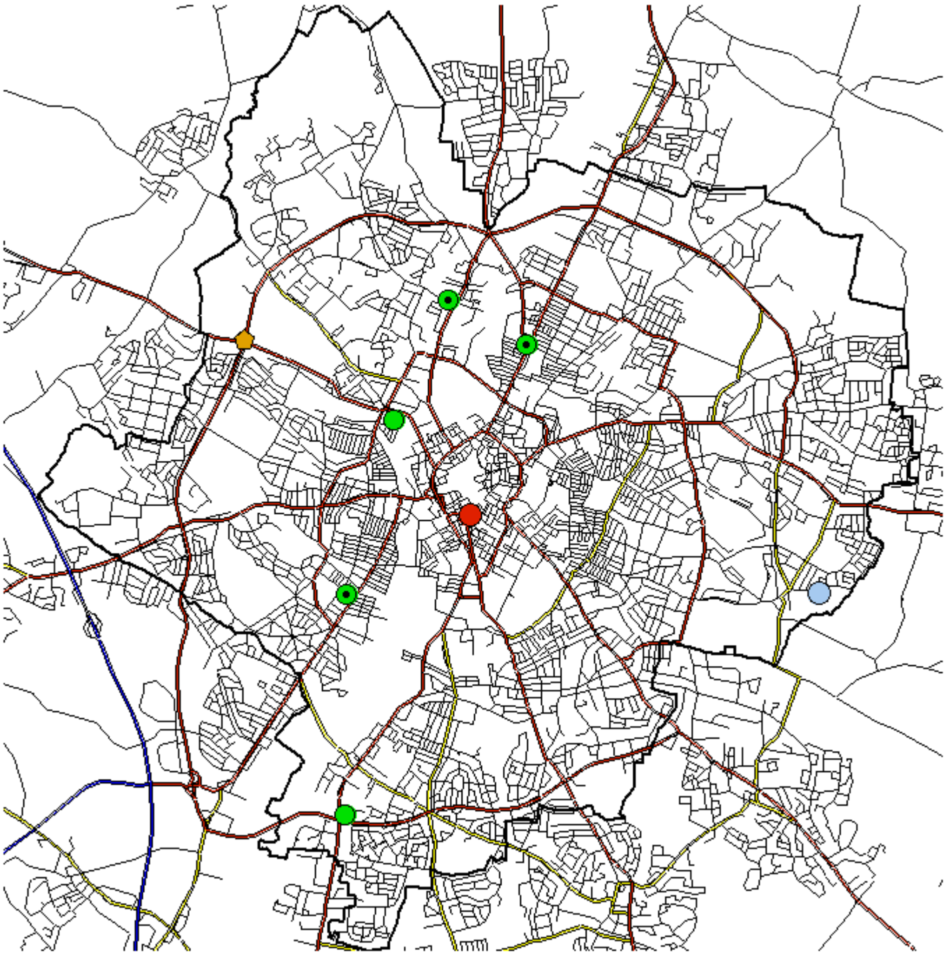


Figure 3

Automatic Air Quality Monitoring Network

🔴 AUN MONITORING STATION (NOX, SO2, CO, O3, PM10)
🔵 MARYDENE DRIVE MONITORING STATION (NOX, SO2, CO, O3, PM10)
⊙ PM10 PARTICULATES & NOX MONITORING STATION
🟢 NOX MONITORING STATION
⬟ METEOROLOGICAL STATION

(b) Passive (Diffusion Tubes)

This device consists of a small plastic tube which can be fixed for, say, a month at a convenient location, e.g. on a building or a lamp-post. It is open at one end and contains a mesh coated in a chemical which will absorb the pollutant in which we are interested. The most common type of diffusion tube is designed to measure nitrogen dioxide (NO_2), but other types are available: The City Council has carried out a one-year survey of benzene at different sites using diffusion tubes.

When the desired exposure is complete, the tube is sent to a laboratory for analysis, which shows the "average" concentration of the pollutant where it has been exposed. Tubes can be deployed at a number of sites at regular intervals to build up a picture of pollutant levels over a wide area.

Diffusion-tubes are cheap and easy to use but they are of low accuracy and miss fine detail. They are therefore useful for surveying air quality at a large number of points to determine the best points for more elaborate investigation.

2.2.3 Purposes of Monitoring

Monitoring of pollutant levels has several functions:

- It enables us to identify areas of Leicester where further investigation is required. For example, simple, cheap devices like diffusion tubes can be used to determine the best site for an automatic monitoring station.
- It provides a general view of prevailing pollutant levels, enabling warnings to be issued when an incident is occurring or is expected.
- It provides a baseline for the Review and Assessment of air quality, enabling places where the air quality Standards are now being breached to be identified. This can then be used, in conjunction with projected changes in the emissions affecting those locations, to assess the likelihood of those breaches continuing until the Objective deadline date.
- When we are attempting to predict future patterns of air quality, it enables us to validate modelled projections by comparing current, measured levels of pollutants with model runs, using as input data current emissions inventory and weather data.

2.2.4 Types of Monitoring Site

A source of a pollutant, for example a busy road full of cars emitting oxides of nitrogen, will cause high levels of those pollutants in close proximity to it. However, pollutant levels will decline sharply with increasing distance, until, at a few tens of metres from the centre of even the busiest road, levels will have fallen to the background level prevailing over the whole area. Of course, in a large built-up area, the background levels may themselves be undesirably high.

This is reflected in the choice and classification of monitoring sites. They may be characterised as:-

- Kerbside: Right at the side of a major road and showing the maximum levels of pollution being generated by the road.
- Roadside: At a location such as level with the back of a pavement. Affected by pollution from the road but not as much as the Kerbside situation. Conversely, it may represent a place at which people are actually exposed to the levels recorded.
- Urban Background: More than, perhaps, 30 metres from a busy road, this type of station will show levels typical of the area as a whole and therefore of the levels to which people might actually be subjected for long periods in their daily lives.
- Rural Background: These sites will show the relatively low levels of background pollution in areas well away from towns. They are useful in showing what amounts of pollution are imported into areas like Leicester from elsewhere in the UK or even Europe.

Details of the classification of individual monitoring sites in Leicester are given in Appendix B.2.1 and B.4.4.

2.2.5 Quality Assurance

When carrying out a Review and Assessment of air quality or simply monitoring to provide information on air quality for the public, the data collected must be trustworthy and scientifically credible. It is vital, when monitoring pollution to know the *accuracy* and *precision* of the technique used.

Accuracy is defined as “the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value.”

Precision is “the closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions.”

Another important aspect of monitoring is *data capture*. This is the proportion of the time that the instrument in question is gathering good data, i.e. it is not malfunctioning or out of service. With respect to monitoring performed in connection with Stage 3 of the air quality Review and Assessment, the statutory Guidance prescribes 90% data capture as the minimum standard to aim for.

Detailed, documented procedures are laid down to ensure that accuracy and precision are kept with acceptable limits. These are referred to as *Quality Assurance / Quality Control* ("QA/QC") procedures. In compliance with the Government Guidance detailing how this Review and Assessment should be done, full details of these matters, together with estimates of the accuracy and precision of the various monitoring techniques used are set out in Appendix B.2.2 and B.4.3.

The factors taken into account can be summarises as follows:

- Site Selection

  Sites are chosen to represent the appropriate site classification, as discussed above. Sites should be broadly representative of population exposure, if that is their purpose. Sites at likely pollution "hotspots" will be selected using a combination of local knowledge, passive diffusion tube data, traffic flow and other emissions data and model simulations.

  Sites must also be considered in terms of accessibility, security and public safety, power supply and availability other services, and freedom from interference from very localised sources of the pollutants being monitored.

- Equipment Selection.

Except for broad survey work, the most accurate and proven analytic technique for each pollutant is selected, using equipment which has been type tested and approved by an expert Government body, the National Air Quality Technical Centre (NETCEN). It is important to ensure the intercomparability of measurements made between sites, not only across Leicester but also across the UK and beyond.

- Equipment Maintenance.

As well as regular inspections of equipment and checks on the data being collected by Council staff, service agreements are in place with suppliers of the equipment to ensure regular preventative maintenance and prompt rectification in the event of malfunction.

- Calibration

Regular tests of instruments are carried out according to prescribed procedures by subjecting them to calibration with known gas concentrations. Details vary between instruments but this is done automatically daily and / or manually fortnightly, together with regular, full maintenance checks every few months. In this way, any drift in the output of the instruments is corrected.

With simpler techniques like diffusion tubes, precise procedures are also laid down. These include the use of “blank” tubes to act as controls and periodic intercomparison exercises between analytical laboratories to ensure that uniform standards are maintained.

2.2.6 Data Collection, Processing and Validation

Data is automatically collected by telephone from all automatic monitoring stations every six hours and inspected manually every day for unusual data or gaps in the data which might indicate an instrument malfunction. This ensures that the maximum of reliable data is collected and data loss minimised.

Each month, the data is then processed by checking it against the fortnightly calibration results. The data is adjusted to take account of any instrument drift. The processed data is then scrutinised for any signs of "bad" data such as unlikely or unusual measurements, based on experience of the local behaviour of pollutants, the meteorological conditions, results from other, comparable sites etc.

Bad data is rejected before it is published or any conclusions are drawn from it but all of the original "raw" data is always retained in case it needs to be re-examined at a later date.

2.3 Meteorology.

In the long term, gross emissions of pollutants will slowly change: Industrial or automotive technologies will advance; cycles of economic activity will rise or fall; legislation will bring about improvement. However, from day to day, from week to week and from year to year, the broad levels of emissions from sources *within* Leicester are much the same. The weather is the vital factor in causing the major variations the levels of pollutants actually found in the City at any particular moment. For instance:

- Still, cold, winter conditions with no overcast, where the air is colder nearer the ground than higher up (a "temperature inversion"), tend to trap and concentrate emissions near ground level. If these conditions persist over several days, pollution levels can rise alarmingly. This is known as *winter smog.*

- The formation of ozone depends on the action of strong sunlight on various emissions: A hot, calm, sunny spell of several days in the summer will therefore tend to bring with it a build-up of ozone. This is known as *summer smog.*

- Conversely, if the mixing layer in the atmosphere is deep and turbulent and there is a reasonable wind speed, local emissions will be mixed throughout a much larger volume of atmosphere and carried away; on a day like this, typically fine with light cloud and a moderate breeze, background pollution levels will be relatively low. If there is a gale with heavy rain, they might be lower still.

- On the other hand, plumes from tall chimneys will be less stable under these conditions and may touch the ground nearby periodically, causing localised peaks in pollutant levels.

- Concentrations of a pollutant will increase if there is a significant emitter of that substance, for example a power-station or a big city, some miles away upwind of the prevailing wind. Therefore, wind direction may be significant.

- Some pollutants are *secondary* pollutants which have formed over a period of time from chemical reactions involving emissions of other substances. A proportion both of the ozone and of the particulates experienced in Leicester fall into this category. These, together with some primary pollutants, can be transported for great distances, even from sources in continental Europe. It follows that the levels of a proportion of these substances observed in Leicester depend upon the origin of the air we breath as it circulates around the large-scale weather systems passing over the area.

In some years, we will experience some or any of these effects much more or less than the average.

Pollution monitoring data must therefore be analysed in conjunction with data about both local and large-scale weather conditions. The City Council has its own local meteorological station and the data from it is used during the Air Quality Review and Assessment to determine how and to what extent the weather influences pollutant levels in the City.

For these reasons, meteorological data is an important input into computer dispersion modelling. Weather data from different previous years is used to represent "typical" or "untypical" future years. For example, in 1996 the UK experienced unusually persistent easterly air-flows which brought in exceptional amounts of secondary particulates from industrial Europe, although these conditions might only recur every 5 or 10 years. Meteorological data for 1996 is therefore used in modelling, if it is desired to look at what impact emissions projected over a future year like 2005 would have when combined with "worst case" climatic conditions. Alternatively, we might select input data from a year which represents "typical" or "average" conditions.

2.4 Emissions Inventories.

2.4.1 General

In order to assess the nature and impact of pollution in Leicester, we need to know what sources of the key pollutants exist and how important they are. Therefore, we have compiled an **Atmospheric Emissions Inventory.**

An emissions inventory is simply the identification and cataloguing of sources of the pollutants in which we are interested. Most of these will be within the City but there may be significant, identifiable sources further afield.

Emissions inventories have three main purposes:-

- To obtain a picture of the scale and position of emission sources.
- To provide input data for computer modelling of the behaviour of pollutants.
- To assess which sources are most important and thus to prioritise any necessary remedial action.

Emissions inventories vary in the methods used: One approach is to divide an area into grid squares and to estimate roughly the quantity of a pollutant emitted in each. Factors such as known consumption of fuels, population, traffic levels and various forms of economic activity are taken into account. There is a nationally available inventory (The United Kingdom National Atmospheric Emissions Inventory), which uses this approach, based on a one-kilometre grid. This is known as a *top-down* approach.

Alternatively, the more detailed approach used by Leicester City Council is performed by collecting information on individual sources or types of source: Data gathered includes the quantity of pollutant emitted as well as the exact location of sources such as chimneys, major roads or areas of housing. Time variations may also need to be taken into account, for example whether a factory shuts down at night or runs around the clock. This approach is known as a *bottom-up* emissions inventory.

It is clearly impracticable to record the behaviour of numerous small sources such as individual houses and motor-vehicles, although their combined impact is significant: These are therefore dealt with by *aggregating* them i.e. by making reasonable assumptions about the overall behaviour of a large group of similar sources and adding them together.

Thus, in the Leicester Emissions Inventory, there are three main types of source, which are reflected in the kinds of input which the dispersion models can deal with:-

- *Point sources*, such as large factory chimneys, which are by themselves sufficiently important to merit being dealt with individually. Information is collected about the physical characteristics the emission, such as its height, velocity and the temperature of the gases. The geographical co-ordinates of the of the point source are also put into the model.
- *Line sources*, which represent major roads: The main road-network is divided up into individual sections or *links* between significant junctions; the flow, behaviour and make-up of traffic along each is estimated; using emission factors, an aggregate emission from traffic on each section is calculated. The co-ordinates of the ends of each link form inputs to the model.
- *Area sources* include blocks of minor roads between more important highways, and areas of housing or minor industry. Aggregate emissions are built up using factors such as estimated

average gas consumption per household in an area, estimated numbers of vehicle movements within residential areas etc.

Leicester City Council's area forms part of a larger urban area. Emissions from outside Leicester affect the City; similarly the City is a significant source of emissions for its immediate neighbours. Therefore, arrangements have been made with neighbouring Local Authorities to exchange emissions data.

Conditions change over time: Significant sources may appear, disappear or change their behaviour. Therefore, arrangements must be made to carry out periodic reviews of the Inventory and to keep it up-to-date.

A full methodological statement relating to the compilation of the Emissions inventory is given in Appendix D.

2.4.2 Point Source Data

No processes classified as Part A or Part B processes under Part I of the Environmental Protection Act 1990 were found to be significant for the purposes of the Review and Assessment. These are processes which are likely to be large-scale emitters of atmospheric pollutants.

Data was collected by means of a survey of large combustion sources within Leicester. This was taken to be boilers of heat input 60 kW or more. Details of the methods used and the information collected are given in the *Point Sources* Section of Appendix D.

It was assumed for the purposes of the Review and Assessment that there would be no significant change in the emissions included in the inventory over the relevant period.

Because of inevitable omissions from the survey, the point source emissions inventory can be considered to be a somewhat conservative estimate of mass emissions per unit time from large sources within the City.

The potential effects of the proposal by Scottish Power plc to construct a combined cycle gas turbine electricity generating station at Enderby, to the south west of the City, have not been considered in the present Review and Assessment. The scheme is, at time of writing, frozen pending review by central Government and its future is uncertain. Calculations in connection with the planning submission indicated that emissions of nitrogen dioxide would make a difference to annual mean levels within the boundaries of Leicester of less than one part per billion.

2.4.3 Area Source Data

Nine large Council housing estates were treated as area sources. The data were based on an existing City Council energy use survey of a significant sample of properties.

It was assumed for the purposes of the Review and Assessment that there would be no significant change in the emissions included in the inventory over the relevant period.

Of the three main categories of source, point, area and line, this one can be considered the least comprehensive, since it only covers approximately 25-30% of the residential area in Leicester.

Moreover, there has been no attempt to treat traffic emissions on an area source basis outside the specific road links considered in the Line Source methodology (q.v.)

The area source component of the emissions database can therefore be regarded as very conservative in terms of mass emissions of the specified pollutants.

2.4.4 Line Source Data (Traffic and other Transport Sources.)

(a) Traffic Flows

In Stage 1/2 of the Review and Assessment, traffic flows were taken from runs of the Greater Leicester Traffic Model (GLTM), which is based on the TRIPS (Transport Planning Software) Model (MVA). This has been widely used in Leicester and Leicestershire as a planning tool for traffic purposes.

In compiling traffic emissions inventory data for dispersion modelling carried out in Stage 3 of the Review and Assessment, it was decided to modify the same traffic model. It was reconfigured to assume continued progress with the City Council’s rolling programme of traffic and transport schemes and optimal impact of those schemes in reducing traffic over the period of interest. These assumptions generated widely differing growth factors for traffic in different parts of the area modelled. In particular, significant *reductions* in volumes were posited for the City centre area. Other conservative assumptions were also made in relation to future traffic volumes, for example the “low” forecast of growth from the National Trip End Model (NTEM) was taken in assessing peak daily flows, in order to reflect the impacts of highway capacity reductions and other restrictive policies.

The TRIPS Model is designed to calculate traffic flow from land-use factors such as population, housing, industrial activity etc. The model also takes account of physical characteristics of roads such as carriageway widths and speed limits. Roads are separated into "links", i. e. lengths of road between significant junctions. The Model uses data on around 3,500 links for the area covered by the pre-Unitary Status County of Leicestershire. The percentage of heavy and light vehicles using a particular road is calculated from the road type. Hourly averages are then calculated for the heavy and light vehicle categories. For each road link, the Model outputs morning peak, evening peak and off-peak flow and speed data.

Prior to its use in Stage 3 dispersion modelling the TRIPS model output needed updating to take into account a number of factors:-

- The existing TRIPS Model outputs dated from 1995. Validation using a rolling programme of actual traffic counts had last been performed in 1996.
- It was considered that different parts of the area forming the subject of dispersion modelling would experience widely different rates of traffic growth, ranging from substantially positive to somewhat negative.
- Certain, specific road schemes, either newly-completed or proposed were clearly going to result in significant redistributions of traffic between important routes.

The initial phase of the work was the updating of the existing GLTM output to 1998 standard. This involved updating the highway network within the Model to include highway network changes which had occurred in the intervening period, for example capacity changes, space reduction and reallocation, traffic calming, pedestrianisation, one-way schemes, traffic bans and parking restrictions. The second phase of the work was to extrapolate to the year 2005: The representation of the network was updated to embody all ongoing and planned network changes which are committed to be operational in 2005. The schemes incorporated can be found in Appendix D.4.2. It should be noted that items in the Local Transport Plan and, in particular proposals for “Park-and-Ride” sites additional to that serving the Hinckley Road (A47 westbound) corridor have not been taken into account.

In updating the TRIPS Model data, an attempt was made to refine the 2005 forecast of origin-destination patterns of movement by dividing the GLTM area into four sub-areas for which differential levels of traffic growth were projected. The traffic growth figures used for forecasting pollution levels in 2005 were derived from the City Council's work in carrying out its responsibilities as a local transport authority under the Road Traffic Reduction Act 1997:-

The City centre	- 5%
The inner suburbs	0%
The outer suburbs	+ 9%
The remainder of the GLTM area	+10%

The extent of these zones is shown in Figure 23.

Clearly the traffic model used has significant limitations:

- The GLTM is a simple, link-based model and cannot represent traffic behaviour at junctions.

- The model is only as good as its underlying assumptions e.g. those made about differential growth factors applicable to different regions of the network to represent the impact of future policies and network changes. The model does not represent every road on the network although these were taken into account for dispersion modelling purposes by means of a separate, aggregated input. Its outputs can only be regarded as indicative for broad, strategic purposes.

For the purposes of comparison, the dispersion models were also run using more pessimistic National Traffic Forecast growth factors, as published by the London Research Centre on behalf of the DETR: These assume an annual traffic growth of 2% over the period of interest. An overall growth over the period up to the end of, e.g., 2005 of 12% was therefore applied across the whole modelled area. This was taken to represent the corresponding "high" case for traffic growth.

In practice, comparative runs of the dispersion models using the traffic flow input data calculated for the "high" and "low" growth cases respectively made little significant difference compared with that made by the changes in vehicle emission factors over the period up to the end of 2005. Because the TRIPS based traffic growth methodology was considered more realistic and detailed in relation to circumstances in the Leicester area, it was adopted as the basis for dispersion modelling input for the Review and Assessment exercise.

(b) Traffic Emission Factors

Because of improvements in vehicle technology and the progressive elimination of older vehicles over time emissions per vehicle are projected to show a considerable improvement, to the extent that predicted increases in the vehicle population will be offset and total mass emissions from motor vehicles will decline up to around 2015 before again increasing. Projections by the Government for future levels of traffic pollutants are discussed in the sections of this Report dealing with individual pollutants.

(i) ADMS Dispersion Model.

The default emissions database within this model were used to calculate traffic emissions. These were derived by CERC from the *Design Manual for Roads and Bridges*.

(ii) AIRVIRO Dispersion Model.

The traffic emission factors compiled by the London Research Centre on behalf of the DETR for the Review and Assessment exercise were used.

(c) Emissions from Rail Traffic

Leicester is situated on the Midland main line from London St. Pancras to Sheffield and the North. Two subsidiary routes, running towards Coalville and Nuneaton make junctions with the main north-south route within or near the City boundary, at Knighton and Wigston Junctions, respectively.

For the purposes of this Review and Assessment, emissions from rail traffic have been treated as negligible and have not been included in the emissions inventory used as input to the dispersion models.

In view of the recent increase in volumes of passenger and freight traffic using the route, this will be kept under review in future rounds of review and assessment.

2.4.5 Interpretation of Modelling Results Using Leicester Emissions Inventory.

It is apparent from the above that there are a number of gaps in the emissions inventory, although these are estimated not to make a critical difference to the modelling outputs. The inventory will be reviewed and updated for use in subsequent refinements of this Review and Assessment.

These omissions, taken in conjunction with the range of optimistic assumptions detailed above, suggest that dispersion modelling predictions using these inputs for the purposes of the Review and Assessment can be regarded as conservative. This encourages us in taking a precautionary stance in terms of modelling error, when delineating modelled exceedances of the air quality Objectives.

2.5 Dispersion Modelling.

2.5.1 General

High quality monitoring equipment is expensive to acquire and to run: Therefore the number of places at which data can be collected is inevitably restricted. Also, even the most sophisticated pollution analyser can only give a “snapshot” of the situation over a particular period of time at one specific location.

Powerful computer-based atmospheric dispersion models are now available and are constantly being developed and refined. These take data about emissions and the weather and predict the distribution of pollutants over space and time in the area being modelled. Leicester City Council is currently using two such models (ADMS-URBAN Version 1.53 and AIRVIRO Version 2.21).

Dispersion models offer considerable advantages: With estimates of the pattern of emissions likely from any given scenario, we can model the resulting pollution picture and compare the predicted outcomes of different development proposals or policy options. Since we are committed to predicting whether national Air Quality Objectives will be attained in future years ranging from 2003 to 2005, this capability is of great value.

Conversely, dispersion modelling is subject to considerable uncertainties: The designers of models make simplifying assumptions about extremely complex real-life situations; collecting emissions inventory information for the model is time-consuming and often itself depends on making assumptions; accurate data may be hard to come by; predicting emissions in the future as situations change introduces further complications; some inputs to the models, e.g. traffic flows, are themselves model outputs, which introduces an extra layer of uncertainty. In other words, the output of a model is only as good as the design of the model and the quality of its input data.

2.5.2 How the models are used.

The methodology of using the dispersion models and interpreting their outputs is outlined in Part 3 of this Report in the Sections dealing with the investigation of individual pollutants. Detailed particulars may be found in Appendix E.

The principal model on which the recommendations made in this Report for Air Quality Management Areas is based is ADMS. Some AIRVIRO runs were made for comparison and validation purposes, when assessing the performance of ADMS.

The ADMS model can be used in two modes:

- It can be run for a particular *receptor point*, to give a detailed data series for that point. The receptor point can be chosen to correspond to a monitoring site, so that the model output can be compared with observed data. This is the basis of validation of the model.

- It can be run to give a *City-wide mapping* of the distribution of a particular pollutant, for example the annual mean. This mode is used for presentational purposes in this Report.

The runs of the model used to predict future concentrations of pollutants in this Report and to assess likely compliance with the Air Quality Objectives were based on meteorological data for the year 1999. This is because by far the most extensive monitoring data was available for this year, following expansion of the Leicester City automatic monitoring network. This was a reasonably "typical" year inasmuch as it did not exhibit exceptional concentrations of certain pollutants such as occur every five to ten years.

Dispersion models are subject to two kinds of error:

- Systematic error, or bias:

This is where the model shows a more or less consistent degree of over- or under-estimation which can be identified and allowed for in interpreting its output.

- Random error:

This is due to scattered errors sometimes higher, sometimes lower than the observed data, due to characteristics of the real world which the simplifying model is unable to take into account.

By comparing the behaviour of the model in receptor point runs with monitoring data for the same period, systematic correction factors were derived for various pollutants. The assumption is made that these relationships will hold approximately true for model predictions of pollutant concentrations in future years, and the derived factors applied to those outputs. In some cases, it was not possible to derive a sufficiently robust validation factor to correct future outputs with any degree of confidence. In any case, the dependence of the process on assumptions about the future behaviour of emission sources will inevitably introduce considerable uncertainties.

Estimates of random error were also attempted for the various pollutants. A standard deviation of error was estimated. This can be applied to model outputs by deciding how many standard deviations of error away from the predicted contour of exceedance of the Objective for a particular pollutant, it is acceptable to say that it is "likely" that Air Quality Management Areas are necessary.

Again, this process met with varying degrees of success with model outputs for different pollutants. Where it is not possible to derive and apply a consistent factor for *systematic* error, there is little point in attempting to superimpose estimates of *random* error on model outputs which do not satisfactorily resemble the observed behaviour of the real world.

Where viable bias and random error factors were calculated, these were applied to adjust the contour-values on City-wide map outputs, which display the raw model predictions for the future distribution of the relevant pollutants. Interpretation of these adjusted maps was then used to draw the boundaries of recommended Air Quality Management Areas, adjusted outwards to "logical", physical boundaries.

It should be noted that it is inherently more difficult to make satisfactory predictions of short-term behaviour of pollutants than it is to model an annual mean value. This is because the model cannot take account of short-term fluctuations in emission source behaviour and weather conditions. Therefore, more confidence can be placed in, for example, a model prediction of an annual mean for nitrogen dioxide than in the number and value of peaks occurring over a year for that pollutant.

These matters are dealt with in more detail in the sections covering the outcomes for individual pollutants and in the Summary and Conclusions Section of this Report (Section 4); a full account of methodology for validation and interpretation of dispersion model outputs may be referred to in Appendix E.

Part 3: RESULTS OF THE REVIEW AND ASSESSMENT

3.0 Changes to the Statutory Guidance.

The first two Stages of the statutory Air Quality Review and Assessment (*Leicester Air Quality Review and Assessment: INTERIM STAGE I / II REPORT, December 1998),* indicated that it was necessary to proceed to the third, most detailed stage with respect to:-

- Carbon monoxide
- Nitrogen dioxide
- Particulates (PM_{10})

The Interim Report also makes a preliminary identification of the significant sources of these pollutants and the areas of Leicester affected.

The issue is complicated by the fact that the statutory Guidance on determining which pollutants proceed as for as Stage 3 has been revised since the completion of Leicester City Council's Stage I / II Report. The tests applied in the revised document are variously more or less conservative for different pollutants. (LAQM.TG4 (00), *Review and Assessment: Pollutant Specific Guidance*) To avoid confusion, this Results chapter is structured according to the outcome of the original Stage I / II exercise and any variations are discussed in the sections on individual pollutants below.

3.1 Review and Assessment of Benzene.

3.1.1 Characteristics and Sources of Benzene

Benzene is a liquid at ambient temperature but readily evaporates. It is a recognised carcinogen and long-term exposure can cause leukaemia. There is no known level below which there is zero risk.

The main atmospheric source of benzene in the UK is petrol, of which it is a constituent. Some benzene passes unburnt through the internal combustion engine and more is formed by combustion of other aromatic components of the fuel. Benzene also evaporates during storage and handling of petrol.

Motor vehicles account for about 67% of total UK emissions with evaporation from mobile sources accounting for around 13% (1995 figures, *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland,* 2000).

3.1.2 The Objective for Benzene

(a) The Objective/Time Weighting

The Objective for benzene is a running annual mean of 16.25 microgrammes per cubic metre or less, to be achieved by 31st December 2003. The choice of an annual criterion reflects the long-term nature of the risk from exposure to ambient concentrations. (*The Air Quality Regulations 2000*, SI 2000 No.928).

(b) Exposure

Due to the predominant sources of benzene, concentrations of will be highest near to heavily trafficked roads and installations where petrol is handled, for example service stations.

The Objective will only be deemed to be breached at locations where people are likely to be exposed non-occupationally near ground level over the averaging period contained in the Objective. (Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality).*

3.1.3 Projections by the Government for Benzene in Leicester.

It is the view of the Government that national policies will deliver the Air Quality Objective for benzene by 2003: Roadside levels, even next to the most busy or congested roads are generally expected to be well below the Objective value. Only localities adjacent to major industrial installations which handle large quantities of benzene should need to progress beyond Stage 1 of the Review and Assessment. (*National Air Quality Strategy* and Guidance Note LAQM.TG4 (00), *Review and Assessment - Pollutant Specific Guidance, para. 3.04*).

3.1.4 Findings of Stage1/2 Review and Assessment.

The following test is prescribed in the statutory Guidance to establish whether the risk of the air quality Objective for benzene being exceeded is negligible. (Guidance Note LAQM. TG4(98), *Review and Assessment: Pollutant Specific Guidance,* which document was in effect at the time of the Stage 1/2 Review and Assessment, although the current LAQM.TG4 (00) gives similar advice):- Existing or prospective industrial processes classified as "Part A" processes or "Part B" processes under the *Environmental Protection Act 1990* and the *Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended)* with the potential to emit significant quantities of benzene.

A review of industrial processes in and around Leicester was coupled with consideration of information held on the relevant statutory registers held by Leicester City Council under the terms of Part 1 of the Environmental Protection Act and an examination of the published Environment Agency industry database. Petrol stations are excluded by the Guidance because developments in the regulation of fugitive emissions from these sites are expected to eliminate them as significant sources of benzene. (LAQM.TG4 (00), para. 3.06).

No existing or proposed industrial processes were identified in the Leicester area with the potential to emit significant quantities of benzene.

3.1.5 Monitoring of Benzene

Full details of the Leicester monitoring network together with a statement of Quality Assurance / Quality Control procedures is given at Appendix B.5.

There is no national monitoring site for benzene in Leicester or Leicestershire. However, data from two passive sampling (diffusion tube) surveys is available and is summarised in the two tables, below.
(Fig. 4).

Table 3.1.5/1: Summary of 1995/96 Annual Mean Benzene Concentrations ($\mu g.m^{-3}$) from the 10-site survey:

Site Type	Mean	Maximum
Background	6.5	6.5
Roadside	6.5	13

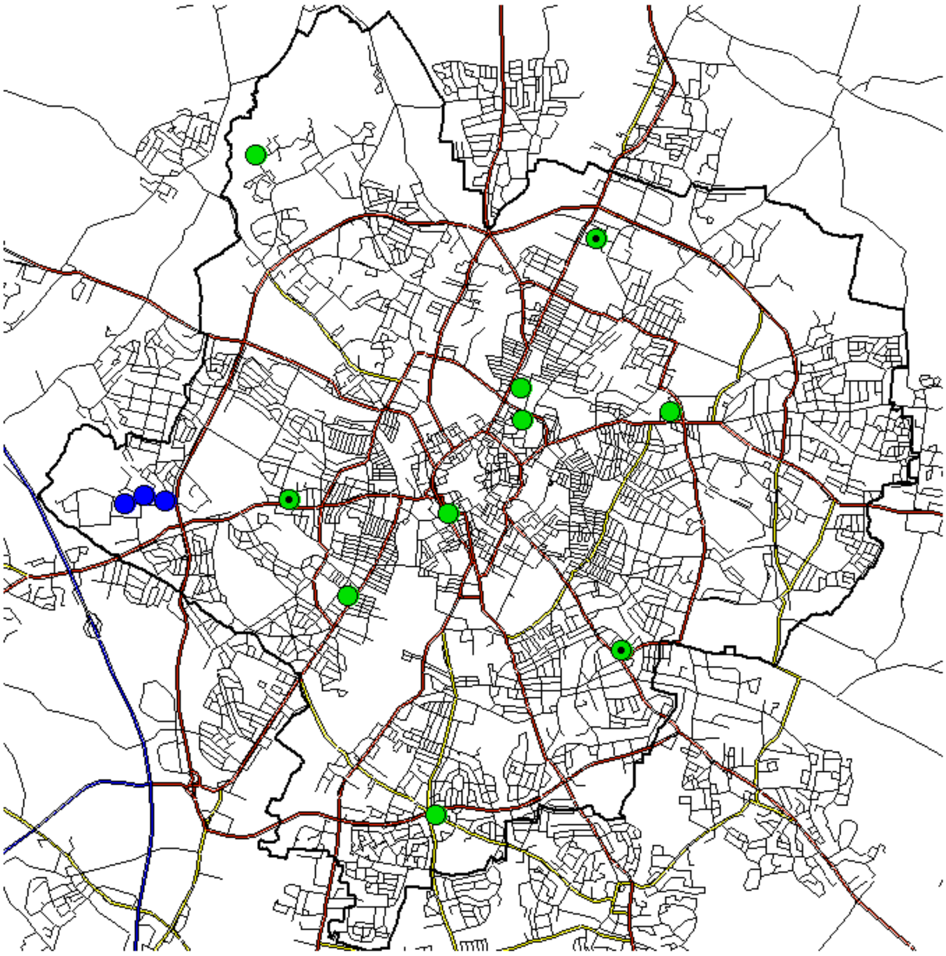


Figure 4
Benzene & BTX Survey Sites

● 1995/96 BENZENE SURVEY SITE
● BTX SURVEY SITE
◉ 1995/96 BENZENE SURVEY & BTX SURVEY SITE

Table 3.1.5/2: Summary of site means (µg.m^{-3}) for 1997/8 “BTX” diffusion tube survey.

Site	**Mar 97 – Mar 98**		**Mar 98 – Oct 98**	
	Mean (μg.m^{-3})	**% Data Capture**	**Mean (μg.m^{-3})**	**% Data Capture**
New Parks Way/Scudamore Road roundabout	4.55	75.0	3.25	75.0
Fulford Road	2.93	91.7	2.28	66.7
Cathkin Close	2.60	75.0	2.60	58.3
1, Meadhurst Road	3.58	91.7	2.93	50.0
5, Saltcoates Avenue	4.23	83.3	3.90	66.7
Regency Hotel, 358, London Road.	3.58	75.0	2.93	66.7

Unfortunately, data capture is poor for the second study due to repeated theft of the diffusion tubes. The maximum of 13 µg.m^{-3} recorded in the first study was at a roadside location on Newarke Street, a road with an annual mean daily traffic flow in excess of 25,000.

It can be seen from available monitoring data that in no case is the statutory Objective value for benzene exceeded and that the conclusions of the Stage 1 / 2 Review and Assessment were fully supported.

3.1.6 Conclusions for Benzene:

(a) **Leicester City Council does not need to proceed to Stage 3 of the Review and Assessment for benzene.**

(b) **No additional action will be required by Leicester City Council to achieve the statutory air quality Objective for benzene.**

3.2 Review and Assessment of 1,3-butadiene.

3.2.1 Characteristics and Sources of 1,3-Butadiene.

1,3-butadiene is a gas at ambient temperatures and is present in trace amounts in the atmosphere. It is known to cause various cancers and there is no known level at which it can be said that there is zero risk.

67% of 1,3-butadiene emitted in the UK comes from petrol engines: Although it is not a constituent of petrol, it is formed from olefines in the fuel, during combustion in the engine. There are significant industrial sources elsewhere in the UK but, so far as Leicester is concerned, the dominant source is motor vehicles.

3.2.2 The Objective for 1,3-Butadiene.

(a) The Objective/Time Weighting

The Objective for 1,3-Butadiene is a running annual mean of 2.25 $\mu g.m^{-3}$ or less, to be achieved by 31st December 2003. The choice of an annual criterion reflects the long-term nature of the risk from exposure to ambient concentrations. (*The Air Quality Regulations 2000*, SI 2000 No.928).

(b) Exposure

The Objective will only be deemed to be breached at locations where people are likely to be exposed non-occupationally near ground level over the relevant averaging period. (Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality*, para. 2.09).

Due the predominant source of 1,3-butadiene, concentrations will be highest near to heavily trafficked roads.

3.2.3 Projections by the Government for 1,3-butadiene in Leicester.

It is the view of the Government that national policies will deliver the Air Quality Objective for 1,3-butadiene: Roadside levels, even next to the most busy or congested roads are generally expected to be well below the Objective value. Only localities adjacent to major industrial installations which handle large quantities of 1,3-butadiene should need to progress beyond Stage 1 of the Review and Assessment. (LAQM.TG4 (00) *Review and Assessment - Pollutant Specific Guidance*, para. 4.04)

3.2.4 Findings of Stage 1/2 Review and Assessment

The test prescribed in the statutory Guidance, to establish whether the risk of the air quality Objective for 1,3-butadiene being exceeded is negligible, is the existence of industrial processes classified as “Part A” processes or “Part B” processes under the *Environmental Protection Act 1990* and the *Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended),* which have the potential to emit significant quantities of 1,3-butadiene. (Guidance

Note LAQM. TG4(98), *Review and Assessment - Pollutant Specific Guidance*, which document was in effect at the time of the Stage 1/2 Review and Assessment, although the current LAQM.TG4 (00) gives similar advice.)

A review of industrial processes in and around Leicester was coupled with consideration of information held on the relevant statutory registers held by Leicester City Council under the terms of Part I of the *Environmental Protection Act* and an examination of the published Environment Agency industry database:

3.2.5 Monitoring of 1,3-butadiene

There is no national monitoring site for 1,3-butadiene in Leicester or Leicestershire. Leicester City Council has not carried out any monitoring within its area for this pollutant species and, so far as is known, no monitoring data is available.

However, it was concluded from the above that the City Council could be satisfied that the air quality Objective for 1,3-butadiene would be met without undertaking any specific monitoring exercise for this pollutant.

3.2.6 Conclusions for 1,3-butadiene:

(a) **Leicester City Council does not need to proceed to Stage 3 of the Review and Assessment for 1,3-butadiene.**

(b) **No additional action will be required by Leicester City Council to achieve the current, statutory air quality Objective for 1,3-butadiene.**

3.3 Review and Assessment of Sulphur Dioxide.

3.3.1 Characteristics and Sources of Sulphur Dioxide.

A gas at normal temperature, sulphur dioxide readily dissolves in moisture and oxidises to sulphuric acid.

Because of its acidic nature, it is irritant when inhaled and high concentrations may cause breathing difficulties. Exposure at high ambient concentrations may provoke asthma attacks.

The principal source of sulphur dioxide is the combustion of sulphur-containing fossil fuels, especially coal. Following the great smogs of the early 1950's, the Clean Air Acts have produced a dramatic reduction in ambient levels of SO_2. In Leicester, which has in its entirety been a Smoke Control Area for over 20 years, levels have fallen by a factor of around 10 since the early 1960's. In addition, there has been the progressive reduction of the statutory maximum sulphur content of diesel fuel.

Nationally, emissions of SO_2 have fallen by 63% since 1970 and 52% since 1980. Currently, emissions are dominated by a few sources: In 1995, 44% of all UK emissions came from just nine power stations. (*National Air Quality Strategy).*

3.3.2 The Objective for Sulphur Dioxide.

(a) Objective/Time Weighting.

The Objective for SO_2 is threefold:

- 266 microgrammes per cubic metre or less, expressed as a 15 minute mean, not to be exceeded more than 35 times a year.
- 350 microgrammes per cubic metre or less, expressed as an hourly mean, not to be exceeded more than 24 times a year.
- 125 microgrammes per cubic metre or less, expressed as a 24 hour mean, not to be exceeded more than 3 times a year.

(*Air Quality Regulations 1997,* SI 2000 No.928).

The reason for adopting the percentile approach to the Objective for sulphur dioxide is that it is acknowledged that there will always be a small number of unavoidable episodes of elevated levels of this species, due to the weather acting in combination with occasional emission events.

(b) Exposure

Given the short averaging time contained in the Objective for sulphur dioxide, the Review and Assessment will focus on any non-occupational near-ground level outdoor location where such short-term exposures are likely.

3.3.3 Projections by the Government for Sulphur dioxide in Leicester.

The most important source of sulphur dioxide in the UK is large, coal-fired power stations. Road traffic contributes less than 2% to the total. In the Government's original view, national policies would deliver the Air Quality Objective for sulphur dioxide, except in areas subject to exceptional emissions from fixed sources and this was reflected in the screening tests. (Guidance Note LAQM. G1(97), *Framework for Review and Assessment of Air Quality*, para. 2.09 and TG4 (98), *Pollutant Specific Guidance*). The revised edition of the *Pollutant Specific Guidance* (TG4 (00)) gives generally similar advice.

3.3.4 Findings of Stage 1/2 Review and Assessment.

The following tests were prescribed in the 1998 statutory Guidance to establish whether the risk of the air quality Objective for SO_2 being exceeded is negligible:

Planned or prospective industrial processes classified as "Part A" or "Part B" processes under the Environmental Protection Act 1990 and the Environmental Protection (Prescribed Processes and Substances) Regulations 1991 *(as amended) with the potential to emit significant quantities of* SO_2 *:-*

A review of industrial processes in and around Leicester and prescribed as "Part A" and "Part B" processes for the purposes of Part 1 of the Environmental Protection Act (and other processes) 1990 was carried out. This was based on Annex 1 and 2 of the *Pollutant Specific Guidance*, which specifies the types of prescribed processes considered to have the potential to emit significant amounts of sulphur dioxide for the purposes of Stage I of the Review and Assessment. This was coupled with consideration of information held on the relevant statutory registers held by Leicester City Council under the terms of Part 1 of the Environmental Protection Act, other relevant files and the local knowledge of enforcing officers. The published Environment Agency industry database was also examined.

Details of the "Part A" processes considered can be found in Appendix A.

All "Part A" processes identified in the preliminary survey as having the potential to be significant emitters of sulphur dioxide were discounted, from consideration of available information. No "Part B" processes were identified. There are no known proposals to establish further processes in or around Leicester which will emit significant quantities of sulphur dioxide.

The presence of a solid-fuel or fuel oil combustion system with thermal power greater than 5 MW:-

There is no solid fuel or fuel oil combustion plant exceeding 5 MW within the Leicester area.

A 1 km by 1km grid square in the UK National Emissions Inventory showing maximum low-level (i.e. domestic combustion and other short-stack) emissions are greater than 25 kg. per hour or 40 tonnes per year, within the City boundary. (Where domestic emissions are the main source of concern, this can be assumed to approximate to 300 houses burning coal in a 1 km. by 1 km. grid square.):-

Leicester City Council carried out a rolling programme of Smoke Control Areas under the Clean Air Acts, which was completed in 1976**.** The combustion of sulphur-bearing fuel in both domestic and industrial premises has therefore been regulated in the entire City for many years. Although legislation this has not been adopted in all neighbouring urban areas, exceedance of this criterion (in any of the forms in which it is expressed) has not been remotely approached in Leicester for some time.

Notwithstanding these conclusions, available monitoring data is for sulphur dioxide is given below in support of them.

3.3.5 Monitoring of Sulphur dioxide.

Full details of the Leicester monitoring network together with a statement of Quality Assurance / Quality Control procedures is given at Appendix B. A full summary of available monitoring data for Sulphur dioxide is given below. Sites at which sulphur dioxide are monitored are shown on Fig. 5.

Table 3.3.5: Exceedances of Statutory AQ Objective*.

Site/location	**Year**	**Max hourly mean**	**Hourly means > 350 μg/m^3 (132 ppb) (24 allowed)**	**Max 24 hour mean**	**24 hr means > 125 μg/m^3 (47ppb) (3 allowed)**	**Max 15 min mean**	**15 min means > 266 μg/m^3 (100 ppb) (35 allowed)**	**Data Capture (%)**
AURN monitoring station	**1994**	364 (137)	**1**	114 (43)	0	564 (212)	**17**	97
	1995	261 (98)	0	88 (33)	0	335 (126)	**5**	97
	1996	149 (56)	0	53 (20)	0	221 (83)	0	96
	1997	223 (84)	0	51 (19)	0	250 (94)	0	96
	1998	253 (95)	0	96 (36)	0	362 (136)	**4**	95
	1999	192 (72)	0	53 (20)	0	314 (118)	**2**	92
LAMS, Marydene Dri.	**1999**	189 (71)	0	75 (28)	0	282 (106)	**1**	66

* Pollutant concentrations in μg.m^{-3} (ppb).

The automatic monitoring sites in Leicester shows intermittent peaks of short duration, which are probably attributable to remote combustion sources, e.g. coal-fired power-stations in the Trent Valley.

The 15-minute Objective is considered to be the most onerous of the three Objectives. (LAQM.TG4 (00), *Pollutant Specific Guidance*, para. 7.05). However, the available monitoring data shows that current conditions in Leicester are well within the Objectives. Given the projected decline in SO_2 emissions between the time of writing and 2004, it can be assumed with confidence that the Objective for sulphur dioxide will be achieved in Leicester.

For the sake of completeness, the results of the national smoke/SO_2 site at New Walk Centre are given in Fig. 6. This illustrates very clearly the overall decline in annual mean concentrations of sulphur dioxide in Leicester since 1976.

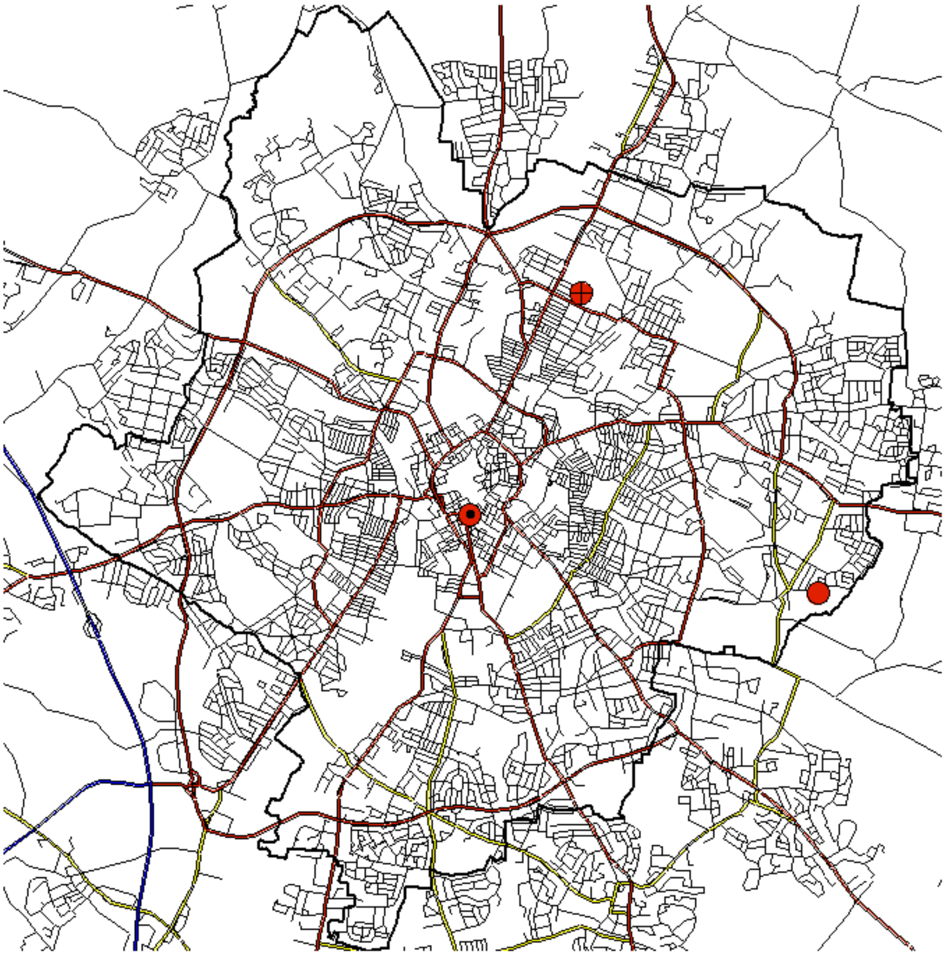


Figure 5
Sulphur Dioxide Monitoring Stations

⊙ AUTOMATIC MONITORING STATION & NATIONAL SURVEY SITE
● AUTOMATIC MONITORING STATION
⊕ AUTOMATIC MONITORING STATION (1997/98)

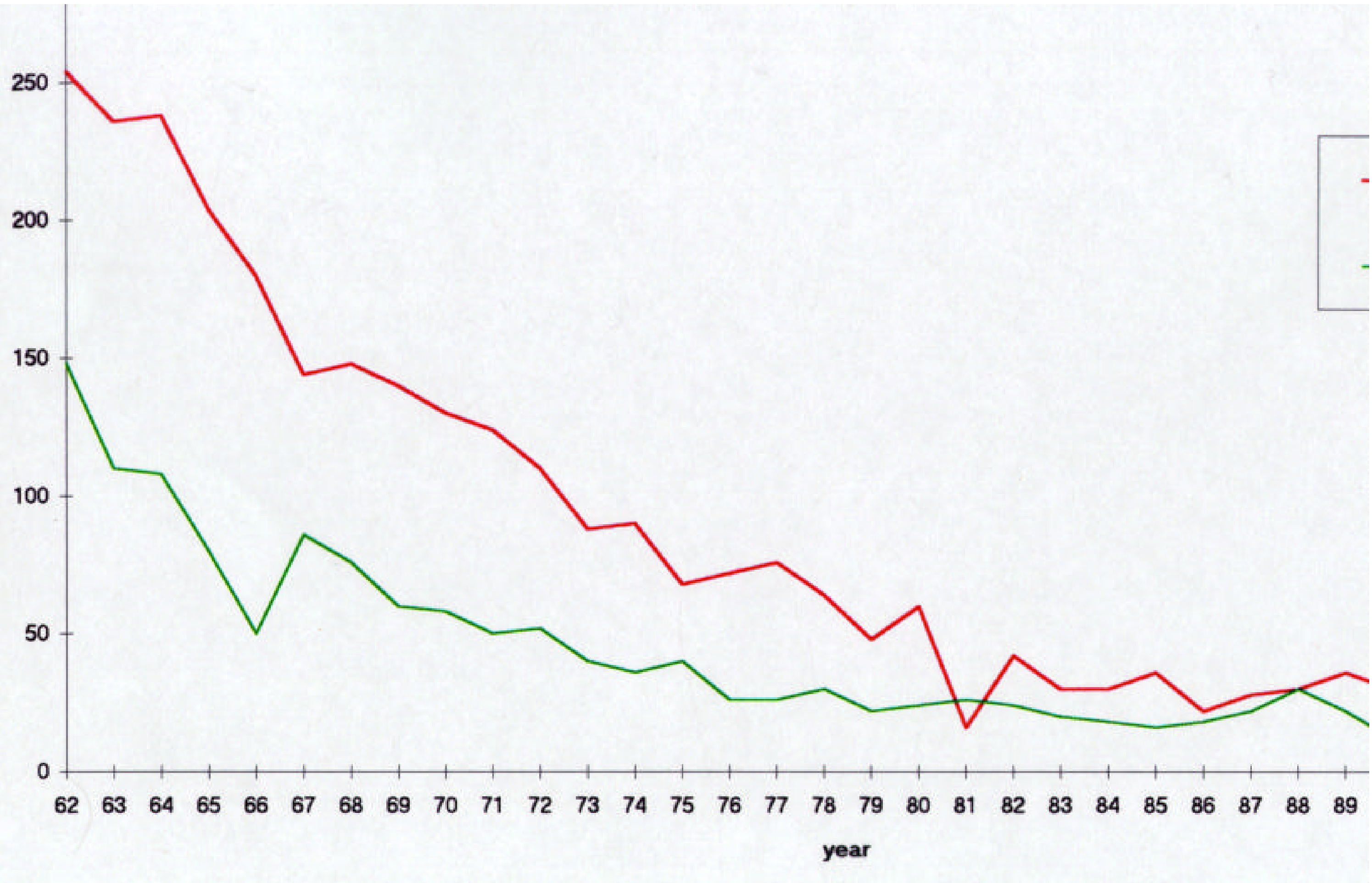


Figure 6

Annual average levels of smoke and sulphur dioxide in Leicester 1962 - 1995.

3.3.6 Conclusions for Sulphur dioxide.

(a) **Leicester City Council does not need to proceed to Stage 3 of the Review and Assessment for sulphur dioxide.**

(b) **No additional action will be required by Leicester City Council to achieve the statutory air quality Objectives for sulphur dioxide.**

3.4 Review and Assessment of Lead.

3.4.1 Characteristics and Sources of Lead.

Lead is a dense, unreactive metal which also occurs widely in its compounds. It is toxic, causing damage to the nervous system, blood, gastrointestinal tract, joints and reproductive system. These effects can be chronic if sufficiently high environmental levels are experienced on a regular basis.

Most atmospheric lead is in the form of fine particles with an aerodynamic diameter of less than 1 micrometre.

Lead is the non-ferrous metal most widely used by industry, both as an element and in compounds.

As the compound tetraethyl lead, it has long been used as an "anti-knock" additive in petrol and this has been the major source of airborne lead in the UK. However, the statutory limits on the lead content of petrol coupled with the phasing out and withdrawal of leaded petrol, have resulted in a steady fall in environmental levels of lead from this source. *(The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000).*

3.4.2 The Objective for Lead.

(a) The Objective/Time Weighting

The Objective set for lead is an annual average is 0.5 microgrammes per cubic metre or less, to be achieved by 31st December 2004, with a further reduction to 0.25 microgrammes per cubic metre by 31st December 2008. This reflects the risk of chronic effects at elevated ambient levels. (The *Air Quality Regulations 2000*, SI 2000No.928).

(b) Exposure

The Objective will only be deemed to be breached at locations where people are likely to be exposed non-occupationally near ground level over the relevant averaging period, e.g. in the vicinity of housing, schools, hospitals etc. (LAQM.G1(00), *Framework for the Review and Assessment of Air Quality,* paras. 2.09-2.11).

3.4.3 Projections by the Government for Lead in Leicester.

It is the view of the Government that existing UK policies, for example the withdrawal of leaded petrol from 1st January 2000, will ensure that levels of lead in air are extremely low and well below the air Quality Objective for lead. The only exception will be in the case of industrial sources which are best dealt with on an individual regulatory basis. There are stated to be only a few sites in the UK which pose any risk of causing localised exceedances of the Objective and none of these is in the vicinity of Leicester. (Guidance Note LAQM. TG4(00), *Pollutant Specific Guidance,* para. 5.05).

3.4.4 Findings of Stage 1/2 Review and Assessment.

Under the requirements of DETR Guidance Note LAQM. TG4(98), *Review and Assessment: Pollutant Specific Guidance*, the factor which governs the progression to the third stage of air quality Review and Assessment is whether Leicester is subject to any existing or prospective industrial processes classified as "Part A" processes or "Part B" processes under the *Environmental Protection Act 1990* and the *Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended)* with the potential to emit significant quantities of lead. (This document was in effect at the time of the Stage 1/2 Review and Assessment, although the current LAQM.TG4 (00) gives similar advice).

Consideration of information held on the relevant statutory registers held by Leicester City Council under the terms of Part I of the Environmental Protection Act and on the published Environment Agency industry database did not identify any industrial processes which had the potential to emit significant quantities of lead. There are no known proposals to establish processes in or around Leicester which will emit significant quantities of lead.

Details of the processes considered can be found in Appendix A.

3.4.5 Monitoring of Lead.

There is no known, recent monitoring data available for lead in the Leicester area.

However, it was concluded from the above that the Council could be satisfied that the air quality Objective for lead would be met without any specific monitoring exercise for this pollutant.

3.4.6 Conclusions for Lead.

(a) **Leicester City Council does not need to proceed to Stage 3 of the Review and Assessment for lead.**

(b) **No additional action will be required by Leicester City Council to achieve the statutory air quality Objectives for Lead.**

3.5 Review and Assessment of Carbon Monoxide.

3.5.1 Characteristics and Sources of Carbon monoxide.

Carbon monoxide is a gas formed by the incomplete combustion of carbon containing fuels. It is toxic through its impairment of the oxygen carrying capacity of the blood and high concentrations in confined spaces can prove fatal.

Environmentally, exposure may exacerbate existing heart-problems.

The main source of carbon monoxide in the UK is road transport which accounts for around 75% of total emissions, 71% being derived from petrol vehicles. *(The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000).*

Transient peaks are also experienced in some areas from remote sources, such as coal-fired power stations.

3.5.2 The Objective for Carbon monoxide.

The Objective for carbon monoxide is 11.6 microgrammes per cubic metre (10 ppm), expressed as a running 8 hour mean, to be achieved by 31st December 2003. The choice of an 8 hour averaging time reflects the acute effects of carbon monoxide, operating over a number of hours of exposure at ambient concentrations. (The *Air Quality Regulations2000*, SI 2000 No.928).

Since the main environmental source of carbon monoxide is motor traffic, concentrations tend to be highest near busy roads and fall away rapidly with increasing distance from the carriageway.

The Objective will only be deemed to be breached at locations where the Standard is exceeded for 8 hours or more and where people are likely to be exposed non-occupationally near ground level over the same period. (Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality,* paras. 2.09-2.11).

Areas of significant exposure are likely to be ones where people reside (i.e. in the vicinity of housing, schools, hospitals etc.), which are close to heavily trafficked roads.

3.5.3 Projections by the Government for Carbon monoxide in Leicester.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (2000) provides the following information on carbon monoxide:

Analysis of data nationally shows that, in general, the maximum running 8-hour means will occur at roadside and kerbside sites, except during exceptional episodes such as that caused by a prolonged atmospheric temperature inversion in 1991.

Carbon monoxide is measured at 61 sites of the National Automatic Urban Network (1999). Statistical analysis of trends at sites with at least 5 years' satisfactory data shows a statistically significant downward trend at 8 of these sites, although Leicester is not one of them. This does not necessarily prove that a long-term trend will not ultimately be demonstrable, it merely indicates that this cannot be satisfactorily demonstrated from the available data.

An assessment of carbon monoxide concentrations likely to result from current national policies has been carried out (Stedman and Linehan, 1999). Roadside concentrations have been projected both for typical meteorology and for years with extreme meteorological conditions, such as the poor dispersion conditions experienced in some UK cities in the winter of 1991. No road links are expected to have concentrations greater than 10 ppb even under such extreme conditions.

Government projections for transport emissions of carbon monoxide are shown in Fig. 7. (*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000).*

Similarly, Guidance Note LAQM.TG4 (00) *Review and Assessment- Pollutant Specific Guidance* states that ongoing reductions in vehicle emission due to the EC Auto-Oil programme will result in the air quality Objective for carbon monoxide being achieved by 2003 even at roadside locations; only local authorities with significant stationary sources in their area should need to progress beyond the first stage of Review and Assessment.

This advice is at variance with that given in the previous edition of the DETR Guidance, LAQM. TG4 (98), *Review and Assessment: Pollutant Specific Guidance*, where lower thresholds for road traffic flows were given.

3.5.4 Findings of the Stage 1/2 Review and Assessment.

Following the requirements of DETR Guidance Note LAQM. TG4 (98), *Review and Assessment: Pollutant Specific Guidance*, the following tests were prescribed for the need to progress to the third stage of air quality Review and Assessment with respect to carbon monoxide. (This document was in effect at the time of the Stage 1/2 Review and Assessment, although the current LAQM.TG4 (00) gives revised advice, see below):

No current or prospective industrial source was identified as being significant, according to the criteria laid down in Guidance Note LAQM. TG4(98).

Data on traffic flow for the City of Leicester and the surrounding County was available from the results of runs of the TRIPS Model. Four road links were identified within Leicester which had annual average daily traffic flows greater than 50,000 vehicles. (Fig. 8)**.**

- Burleys Way (Inner Ring Road) between its junction with St. Margarets Way and its junction with Belgrave Gate (Burleys Flyover).
- Vaughan Way between its junction with Saint Nicholas Circle and its junction with Saint Margarets Way.
- Saint Georges Way between Queen Street and Southampton Street.
- London Road between Conduit Street and Granby Street (Waterloo Way junction, outside London Road Railway Station).

In addition, other roads were identified outside the boundaries of the City but in sufficiently close proximity possibly to exert a significant influence:

- The M1 for its full extent from Junction 22 (A50) to Junction 20. (Both the northbound and the southbound carriageways separately satisfy this criterion).
- The M1 Junction 21 Approach from its junction with the M1 (Junction 21) to its junction with Narborough Road South (A5460) (Fosse Park roundabout).

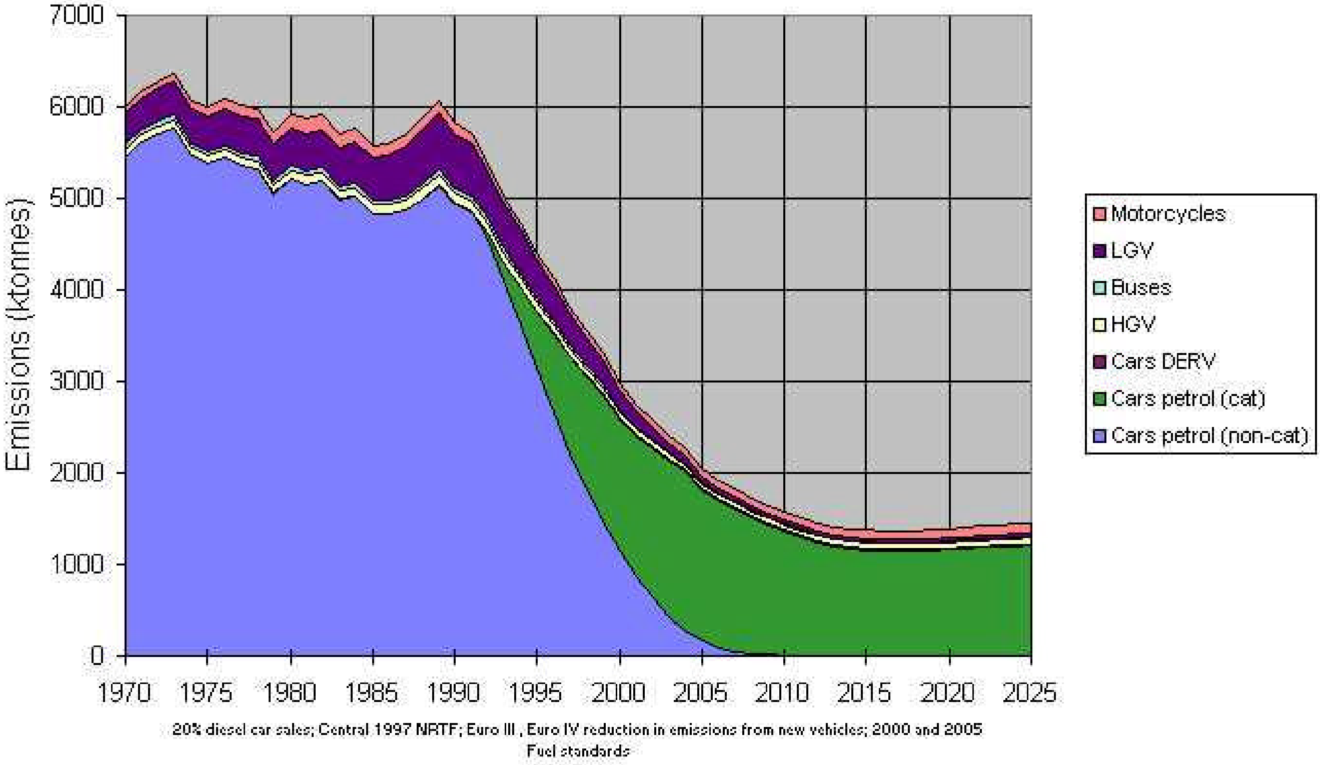


Figure 7

UK urban road transport emissions of carbon monoxide, 1970 - 2025.

(Source: *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, DETR, January 2000.)

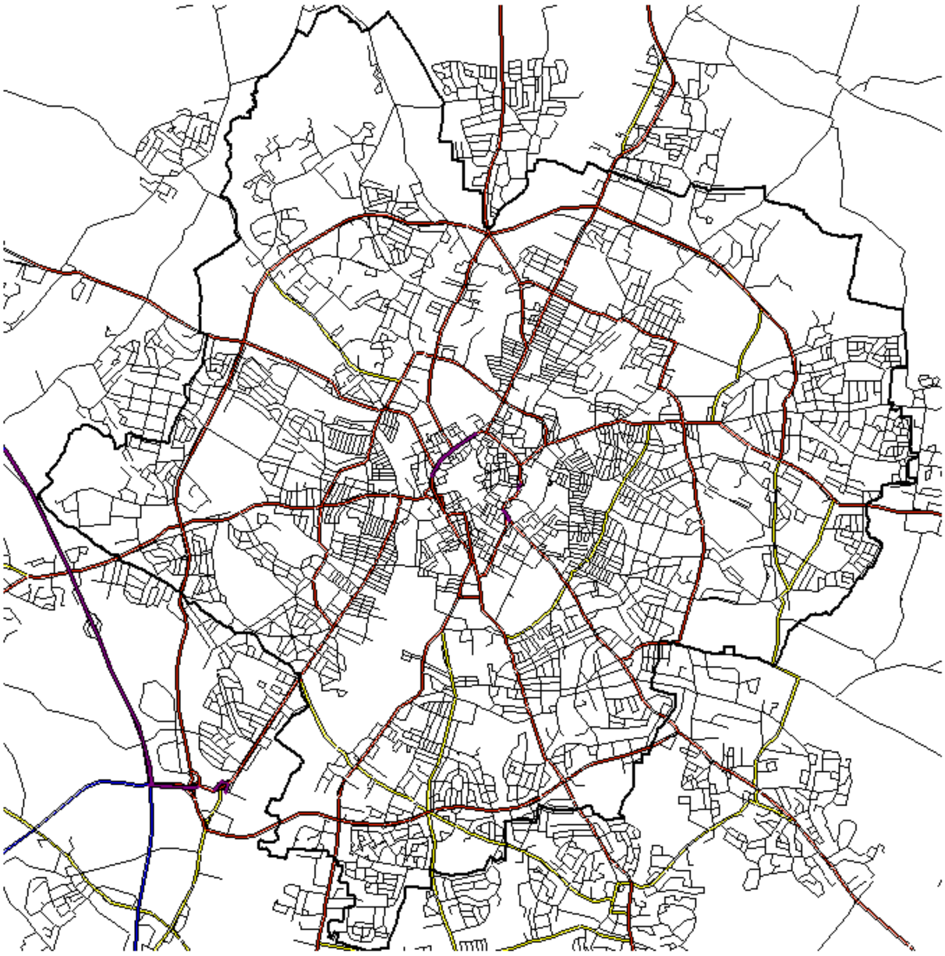


Figure 8

Roads with Daily Traffic Flow >50,000 Vehicles per Day

Therefore, on the basis of the advice given in Guidance Note LAQM. TG4(98), there was sufficient evidence of major road sources of carbon monoxide to justify proceeding beyond Stage 1 of the Review and Assessment.

However, this advice has been revised in DETR Guidance, LAQM. TG4(00), Review and Assessment: Pollutant Specific Guidance, where less onerous thresholds for road traffic flows are prescribed:

- Single carriageway roads where daily average flow exceed 80,000 vehicles.
- Dual carriageway roads where the daily average flow exceeds 120,000 vehicles
- Motorways where the daily average flow exceeds 140,000 vehicles.

On the basis of the revised Guidance, it would not have been necessary in the case of Leicester to proceed to Stage 3 of the Review and Assessment with respect to carbon monoxide.

Nonetheless, as certain monitoring and modelling work had been carried out on carbon monoxide, the results are presented below for completeness.

3.5.5 Findings of interim Stage 3 Review and Assessment investigations.

(a) Monitoring of Carbon Monoxide.

(i) Automatic Sites.

Full details of the Leicester monitoring network together with a statement of Quality Assurance / Quality Control procedures is given at Appendix B. (See Fig. 9).

The AURN site at the Leicester City Council offices at New Walk Centre, in the centre of Leicester. Data is available from its commissioning at the beginning of 1994. The Leicester City Council’s equivalent, relocatable unit (“LAMS”), has been situated at various locations around Leicester.

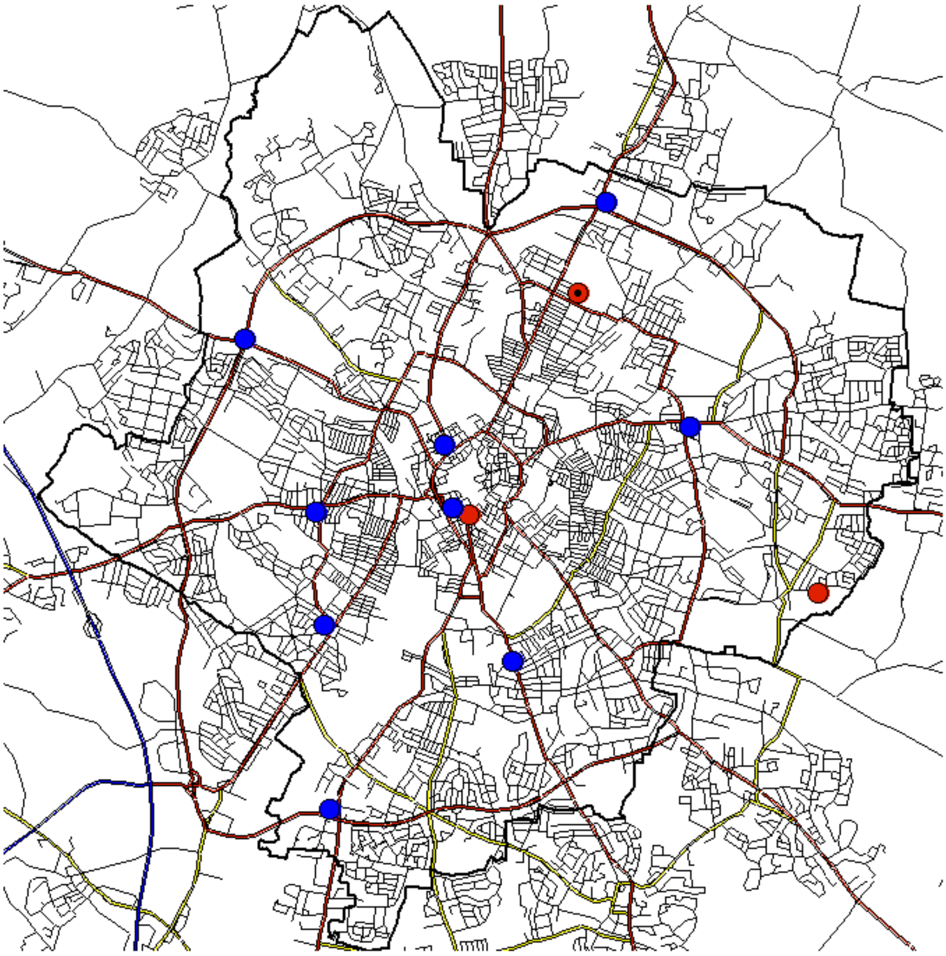


Figure 9
Carbon Monoxide Monitoring Sites

● AUTOMATIC MONITORING STATION
⊙ AUTOMATIC MONITORING STATION (1997/98)
● ROAD-SIDE POLLUTION MONITOR

Table 3.5.5/1: Exceedances of the Air Quality Objective:

Site	Site type	Year	Annual Mean mg.m^{-3} (ppm)	Max running 8hr average mg.m^{-3} (ppm)	Exceedances	Data Capture (%)
AURN Council Offices, Welford Place	**City centre background**	**1994**	0.7 (0.6)	6.8 (5.9)	**0**	95
		1995	0.6 (0.5)	9.2 (7.9)	**0**	96
		1996	0.6 (0.5)	5.0 (4.3)	**0**	94
		1997	0.7 (0.6)	5.8 (5)	**0**	95
		1998	0.7 (0.6)	3.7 (3.2)	**0**	94
		1999	0.7 (0.6)	2.8 (2.4)	**0**	94
LAMS, Harrison Rd	**Urban background**	**1997/8**	0.6 (0.5)	5.3 (4.6)	**0**	98
LAMS, Marydene Dri.	**Suburban / semirural**	**1999**	0.4 (0.3)	1.5 (1.3)	**0**	80

It can thus be seen that no exceedances of the Objective have been observed and that it has not even been closely approached at these sites.

(ii) Roadside Pollution Monitors.

Leicester City Council also has access to the data from a network of electro-chemical Roadside Pollution Monitors (RPM's). These do not fully meet the criteria laid down in the Guidance for accuracy and precision. The prescribed criteria for QA/QC and calibration in connection with Stage 3 monitoring are not met and the percentage data capture is also poor. (LAQM.TG1 (00) *Monitoring Air Quality, paras. 5.9 – 5.15*). A full description of the electro-chemical monitors and a discussion of these issues can be found in Appendix B.

Nonetheless, available data is given below to give a broad impression of conditions prevailing at a number of kerbside sites. The tabulated numbers of exceedances of the Objective should be treated with caution, for the reasons given and, in any case, it is in the nature of these devices to be situated where exposure is not an issue.

Table 3.5/2: Roadside Pollution Monitor Data

Ppm:

RPM Site	1997			1998			1999		
	Annual mean	Max 8hr rolling mean	Exeed-ances	Annual mean	Max 8hr rolling mean	Exeed-ances	Annual mean	Max 8hr rolling mean	Exeed-ances
Melton Rd/ Troon	2.0	12.9	13	2.6	9.9	0	2.4	11.4	5
Welford Rd/ Oakland Rd	0.5	5.2	0	1.8	7.4	0	1.6	6.7	0
Soar Valley Way/ Lutterworth Rd.	1.0	8.9	0	3.9	25.7	357	2.5	9.6	0
Hinckley Rd/ Woodville	1.5	8.8	0	1.5	6.5	0	1.5	6.4	0
Uppingham/ Coleman	2.5	8.5	0	3.0	10.7	9	2.5	11.1	15
Vaughan Way/ St Margarets	1.8	11.2	5	1.3	14.0	8	1.6	8.3	0
Narborough Rd/ Fullhurst Av	0.9	3.6	0	0.5	3.8	0	0.6	3.3	0
Newarke Street				1.6	8.3	0	1.7	7.0	0
A50/ New Parks Way	0.9	5.9	0	0.8	8.0	0	0.7	6.4	0

Mg.m^{-3} :

RPM site	1997			1998			1999		
	Annual mean	Max 8hr rolling mean	Exeed-ances	Annual mean	Max 8hr rolling mean	Exeed-ances	Annual mean	Max 8hr rolling mean	Exeed-ances
Melton Rd/ Troon	2	15	13	3	11	0	3	13	5
Welford Rd/ Oakland Rd	1	6	0	2	9	0	2	8	0
Soar Valley way/ Lutterworth	1	10	0	5	30	357	3	11	0
Hinckley Rd/ Woodville	2	10	0	2	8	0	2	7	0
Uppingham/ Coleman	3	10	0	3	12	9	3	13	15
Vaughan Way/ St Margarets	2	13	5	2	16	8	2	10	0
Narborough Rd/ Fullhurst Av	1	4	0	1	4	0	1	4	0
Newarke Street	0	0		2	10	0	2	8	0
A50/ New Parks Way	1	7	0	1	9	0	1	7	0

(b) Air Quality Modelling of Carbon Monoxide.

The Guidance Note LAQM.TG4 (00), *Pollutant Specific Guidance* indicates that emissions of carbon monoxide are likely to drop significantly by the end of 2003 and that, unless there are major stationary sources, there will be no difficulty in achieving compliance with the relevant Objective. (Para. 2.04).

If modelling and monitoring of current concentrations of carbon monoxide show no exceedances, then, in view of this, dispersion modelling of the future situation should not be necessary. (LAQM.TG3 (00), *Selection and Use of Dispersion Models,* para. 7.13).

Similarly, where predicted future concentrations of carbon monoxide are "well below" the Objective values, there can be confidence that the Objective is unlikely to be exceeded, even if the model accuracy is only within +/- 50%. In this case, provided that the dispersion model used has been appropriately validated elsewhere, further work on model validation may not be necessary.

Nonetheless, since under the terms of the original (1998) technical Guidance carbon monoxide was deemed appropriate to take forward to Stage 3 of the Review and Assessment, some future modelling and validation work was performed.

The original Objective for carbon monoxide specified an achievement date of 2005 and modelling was carried out to assess this. In view of the revised Stage 1 assessment criteria, it was not considered necessary to carry out further modelling to assess the position in 2003. Nonetheless, the limited modelling and validation work performed is summarised below, for the sake of completeness. Full details of methodology are provided in Appendix E.4.1.

Dispersion modelling was carried out using the ADMS Model and comparison with monitoring data showed under-prediction in excess of 50%. Therefore, a correction factor was estimated from comparison of modelled with observed data.

The RPM data did not meet appropriate QA/QC criteria, especially with respect to data capture, so it was not used for model validation. Only two urban background monitoring sites were available for validation, Leicester Centre AUN and Marydene Drive. Because of this limitation, the comparison was carried out by examining the respective percentile distribution of the data and a quadratic relationship was derived. It was assumed that this relationship would hold approximately true for 2005 and it was used to correct the modelled values.

The corrected model output for 2005 comfortably met the Objective although it should be borne in mind that the available monitoring data for validation represents urban background locations. While this is more likely to be representative of typical exposure, it does not show conditions at a “worst case” roadside location.

Nevertheless, there is sufficient margin between the corrected output and the Objective for 2003 to allow some confidence in our findings that exceedances for carbon monoxide are unlikely. This is reinforced by future predictions for road traffic, which indicate that levels of carbon monoxide are likely to decrease further by 2003.

3.5.6 Conclusions for Carbon Monoxide:

(a) **Air quality monitoring has not revealed any instances of the Air Quality Objective level being exceeded in Leicester to date at sites where exposure is relevant. Emissions of carbon monoxide are projected by the Government to fall significantly by 2003.**

(b) **Limited air quality modelling suggests that the Air Quality Objective will be achieved across the whole of the City in 2003.**

(c) **It is unlikely that the air quality Objective criterion for carbon monoxide will be breached at locations where people are exposed over the relevant period (8 hours).**

3.6 Review and Assessment of Nitrogen Dioxide.

3.6.1 Characteristics and Sources of Nitrogen dioxide.

Nitrogen dioxide is a toxic gas, reddish-brown in bulk. In elevated environmental concentrations, it exacerbates respiratory conditions.

In addition to being harmful in its own right, NO_2 is implicated in the cycle of atmospheric ozone chemistry and indirectly in global warming.

Nitrogen dioxide (NO_2) and nitric oxide (NO) are included together as oxides of nitrogen ("NOx"), which are produced by all combustion processes. Usually, NO predominates initially but then reactions take place in the atmosphere with oxidants such as ozone (O_3) to produce NO_2.

This secondary formation of a large proportion of NO_2 complicates the prediction of levels: Prevailing concentrations depend upon the proportion of NO_2 to NO found in the initial emission and on the availability of atmospheric oxidants.

It is estimated that road traffic accounts for 46% of total UK emissions, the electricity generating industry for 22% and other industry and commerce for around 12%. *(The Air Quality Strategy for England, Scotland, Wales and Northern Ireland;2000).* Moreover the local impact of traffic emissions may be greater than that of large industrial sources because the emissions take place at low level.

Thus, while emissions from stationary combustion plant, boilers etc., are significant in Leicester, road traffic will be the major source.

3.6.2 The Objective for Nitrogen dioxide.

There are two Objectives for nitrogen dioxide:

- 200 microgrammes per cubic metre or less, when expressed as an hourly mean, not to be exceeded more than 18 times a year; to be achieved by 31st December 2005.

- 40 microgrammes per cubic metre or less, when expressed as an annual mean; to be achieved by 31st December 2005.

(The *Air Quality Regulations 2000*, SI 2000 No.928).

The annual Objective can clearly be deemed to be breached at any location where persons are reasonably likely to be exposed non-occupationally near ground level over the averaging period, e.g. areas of housing. (Guidance Note LAQM. G1(00), *Framework for the Review and Assessment of Air Quality,* paras. 2.09-2.11).

3.6.3 Projections by the Government for Nitrogen dioxide in Leicester.

(a) General

The Government has estimated that, although emissions are likely to fall, the air quality Objective for nitrogen dioxide will not be delivered by national measures alone, in the case of sites in close proximity to major roads. (*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland;2000);* LAQM.TG4 (00), *Pollutant Specific Guidance,* paragraph 6.09-6.10, from which the information in Section 3.6.3 are drawn). Since the main source of nitrogen dioxide in Leicester is motor traffic, concentrations will therefore tend to be highest near to very busy or highly congested roads. (Fig. 10)..

The annual Objective for Nitrogen dioxide has been shown to be more stringent than the hourly Objective. If the annual Objective is achieved, then it is very likely that the hourly Objective will also be achieved. Conversely, to demonstrate breaches of the hourly-based Objective, the test of exposure is less onerous. (*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland;2000* para. A71; Guidance Note LAQM.TG4 (00), *Pollutant Specific Guidance* para. 6.09).

(b) Trends

UK annual emissions of NO_x have declined in recent years: For example, total emissions have fallen by 31% between 1990 and 1997. Predicted urban road transport emissions of NO_x show a steady fall from a peak around 1990, bottoming out around 2015, when the increase in vehicle numbers is predicted to halt the fall due to improved technologies penetrating the vehicle population. (*The Air Quality Strategy for England, Scotland, Wales and Northern Ireland;2000*).

Table 3.6.3/1: Predicted Emissions of NO_x from Urban Road Transport

Year	Emission (kilotonnes)
1990	458.21
2000	260.19
2005	162.37
2010	117.43
2015	105.74

Nitrogen dioxide has been measured at many sites of the National Automatic Urban and Rural Network for several years. Statistical analysis of trends at sites with at least 5 years' satisfactory data shows a statistically significant downward trend at 13 sites, although Leicester is not one of them. This does not necessarily prove that a long-term trend will not ultimately be demonstrable, it merely indicates that this cannot be satisfactorily demonstrated from the available data.

Where there *is* a decline in NO_x values, the corresponding trend of decline in NO_2 levels would be expected to be proportionally smaller. This is because the $NO_2 : NO_x$ ratio is non-linear over increasing concentrations. Since the availability of atmospheric oxidant may constrain the formation of secondary NO_2 from emitted NO, the ratio tends to fall with increasing concentrations of NO_x.

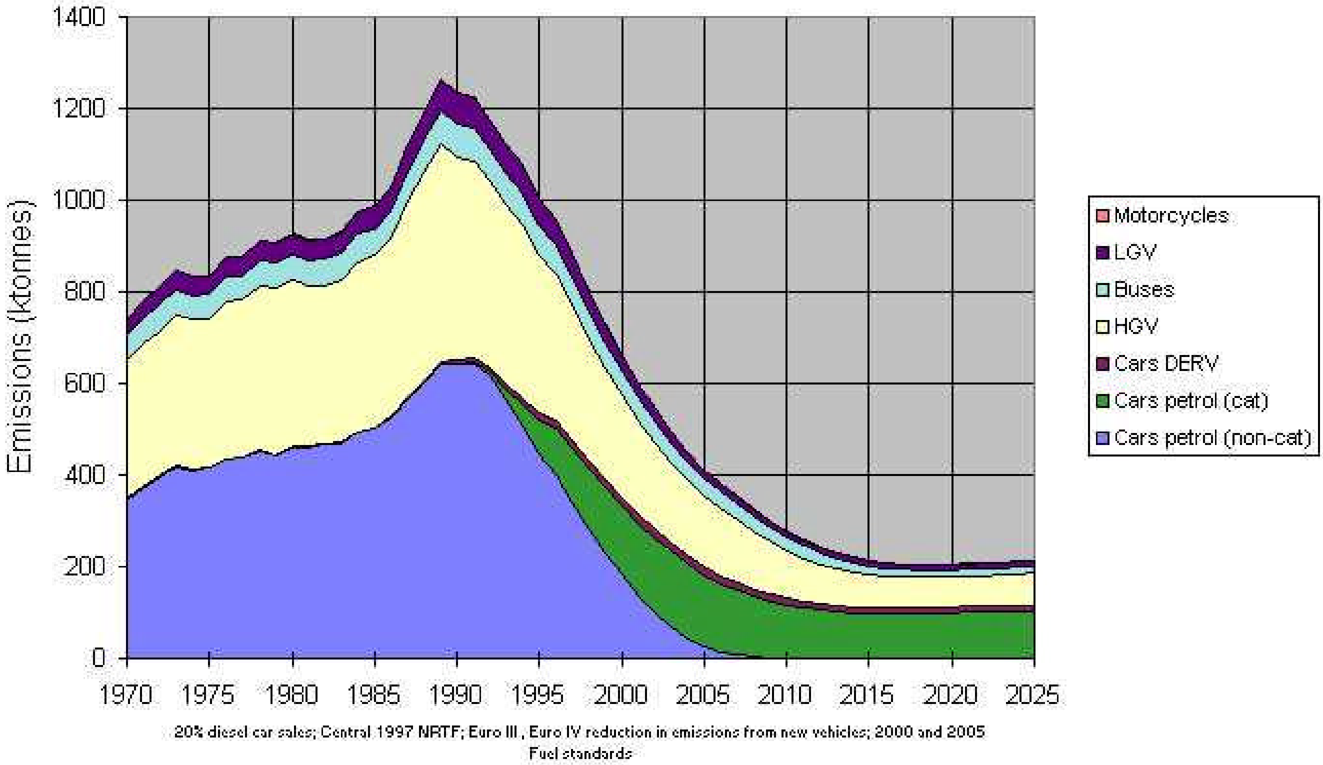


Figure 10

UK annual urban road transport emissions of NO_X, 1970 - 2025.

(Source: *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, DETR, January 2000.)

(c) Annual Means

The annual mean at the Leicester AUN site for 1998 was 40 µg.m^{-3} , with a 99.8th percentile value of 109 µg.m^{-3} (equivalent to 18 hourly exceedances of this value in the year).

Projected annual means for the Leicester AUN site have been calculated, using 1996 and 1997 meteorology datasets:

Table 3.6.3/2: Current and projected annual means for the Leicester AUN site [µg.m^{-3}(ppb)]:

Measured, 1996	**Measured, 1997**	**Projected, 2005 (1996 met. Data)**	**Projected, 2005 (1997 met. Data)**
42 (22)	42 (22)	29 (15)	29 (15)

(d) Roadside/Kerbside Levels

National modelling of major urban roads in the UK has been performed by calculating a projected "roadside enhancement" for each site, derived from projected traffic emissions and adding this to the projected background for the area. This method of modelling does not provide the focussed predictions that ADMS-URBAN can, however their results have been compared.

This has identified 761 road links where, with existing policies, roadside or kerbside breaches of the air quality Objective for Nitrogen dioxide may occur in 2005. Of these, 495 are in greater London and 26 are in Leicester City Council’s area. The links identified correspond to the inner ring road and some of the radial routes out of the city.

In addition a number of other scenarios were considered for the future. This modelling indicated that in Leicester, Southgates Underpass and Vaughan Way would still exceed the air quality standard of 40 µg/m^3 after a 30% reduction in traffic emissions.

Table 3.6.3/3 Projected annual means for road links.

Road number	**Road name (corrected from NETCEN report)**	**Extent of Road link**	**Predicted annual mean NO_2 2005 mg.m^{-3} (ppb)**	**DETR link ID number**
A594	Southgates Underpass	Oxford Street – Highcross Street jcn.	53.7 (28.1)	48489
A594	Vaughan Way	Highcross Street jcn.– Saint Margarets Way jcn.	50.2 (26.3)	56464

3.6.4 Findings of Stage 1/2 Review and Assessment.

Following the requirements of DETR Guidance Note LAQM. TG4 (98), *Review and Assessment: Pollutant Specific Guidance*, the following summarises the factors relating to progression to the third stage of air quality Review and Assessment with respect to nitrogen dioxide. (This Guidance was in force at the time of the Stage 1 / 2 Review and Assessment, but the amended advice given in LAQM.TG4 (00) would also have led to a similar outcome).

- One or more existing or planned roads with a projected daily traffic flow of greater than 20,000 in 2005:-

  64 road links were identified within Leicester which had annual average daily traffic flows greater than 20,000 vehicles. In addition, around 12 road links were identified outside the boundaries of the City but in sufficiently close proximity to exert a significant influence. These links are listed in Appendix A and shown in Fig. 11.

- Annual mean urban background in 1996 of greater than 30ppb (57 $\mu g.m^{-3}$):-

  Annual background levels of NO_2 for 1996 were taken from the DETR website provided for the purpose. This source estimates levels to be in the range 20 - 30 ppb with the higher values occurring in the centre of the City.

- An indication through measurement of existing sources acting in combination to exceed a current annual mean concentration of 30 ppb:-

  While being inconclusive at the time of the Stage 1 / 2 Review, monitoring evidence suggested the likelihood of annual means of nitrogen dioxide of 30 ppb (57 $\mu g.m^{-3}$) being exceeded near certain busy roads: No actual annual means were then recorded in excess of this value but it should be noted that these data were acquired at sites characterised as “background” sites; alternatively, there was data for NO_2 relating to near-road sites at which persons may be exposed over the relevant average periods and which was suggestive of exceedance of the “30 ppb test” (specified in LAQM.TG4 (98), *Pollutant Specific Guidance*, para. 6.6). More extensive monitoring data subsequently became available; this is discussed in the section on monitoring of nitrogen dioxide in connection with Stage 3 of the Review and Assessment, below.

- Planned or prospective industrial processes classified as “Part A” or “Part B” processes under the *Environmental Protection Act 1990* and the *Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended)* with the potential to emit significant quantities of NO_2 :-

  A review of industrial processes in and around Leicester and prescribed as “Part A” and “Part B” processes for the purposes of Part I of the Environmental Protection Act (and other processes) 1990 was carried out. This was based on Annex 1 and 2 of LAQM.TG4 (98), *Pollutant Specific Guidance*, which specified the types of prescribed processes considered to have the potential to emit significant amounts of nitrogen dioxide for the purposes of Stage 1 of the Review and Assessment. Consideration was also given to information held on the relevant statutory registers held by Leicester City Council under the terms of Part I of the Environmental Protection Act, the published Environment Agency industry database, other relevant files and the local knowledge of enforcing officers. No current or prospective industrial source was identified as being significant, according to the criteria laid down in Guidance Note LAQM. TG4(98). Details of the sites considered are given at Appendix A.

In terms of the screening tests prescribed for nitrogen dioxide in the statutory Guidance, Leicester City Council was required to proceed to Stage 3 of the Review and Assessment.

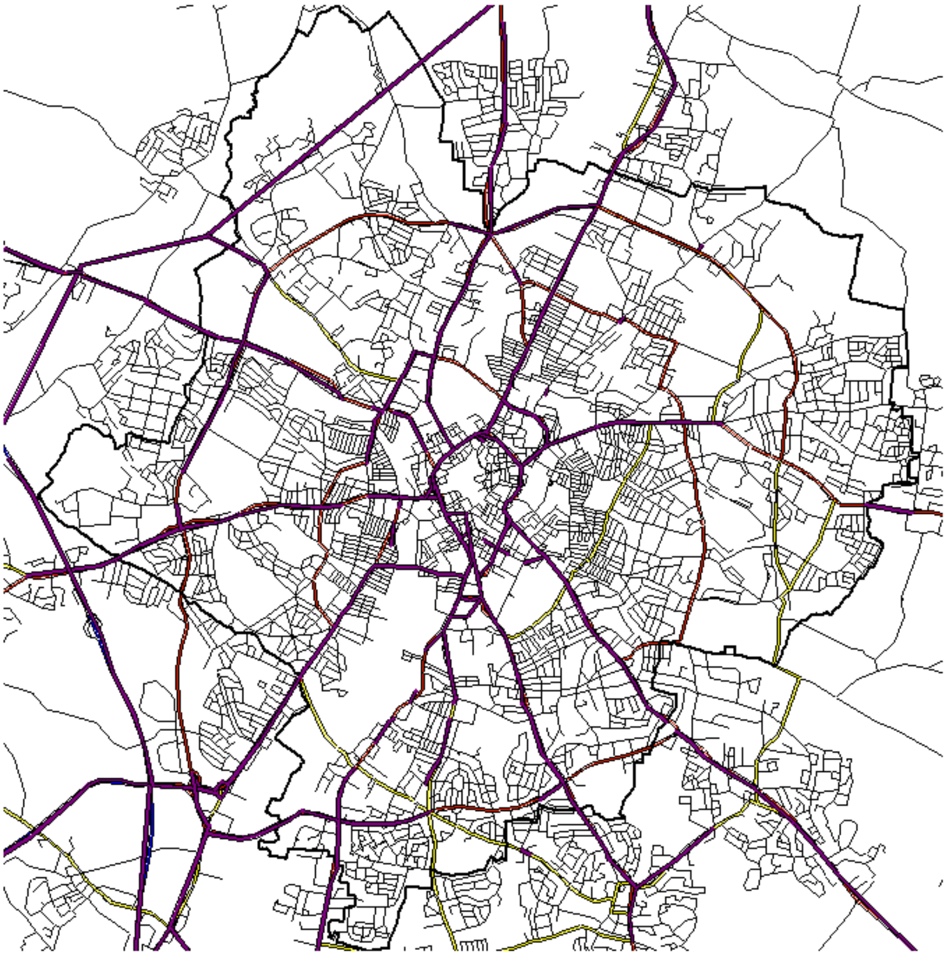


Figure 11

Roads with Daily Traffic Flow >20,000 Vehicles per Day

ROADS WITH >20,000 VEHICLES PER DAY

3.6.5 Findings of the Stage 3 Review and Assessment.

(a) Monitoring of Nitrogen dioxide.

(i) Monitoring Techniques, Locations and Quality Assurance.

Full details of the Leicester monitoring network together with a statement of Quality Assurance / Quality Control procedures is given at Appendix B.

(ii) Passive Monitoring (Diffusion Tubes).

Diffusion tubes are a relatively crude method of monitoring nitrogen dioxide, with poor accuracy and precision. However, they are inexpensive and so can be deployed at a relatively large number of sites. These can be seen at Fig. 12.

Diffusion tubes typically give an integrated or “average” value for the nitrogen dioxide to which they have been exposed over about one month. They therefore are incapable of registering fine detail such as short-term pollution episodes of a few hours’ or days’ duration. For this reason, they cannot be used to give a direct indication of whether the hourly Standard for nitrogen dioxide has been exceeded, although statistical methods exist for estimating particular percentile values for the dataset from annual mean values.

Diffusion tube monitoring can be grouped under various exercises:

- Long-term monitoring at 10 sites (Table 3.6.5/1).
- Monitoring background levels to assess the impact of the proposed Enderby power station (not built) (Table 3.6.5/3)

- Monitoring to assess the impact of the Belgrave corridor highway scheme. (Table 3.6.5/3).
- Sites affiliated to the national diffusion tube network (Table 3.6.5/4).

However, individual diffusion tube determinations can be averaged over a calendar year to estimate whether the annual Standard has been exceeded (shown in bold type):-

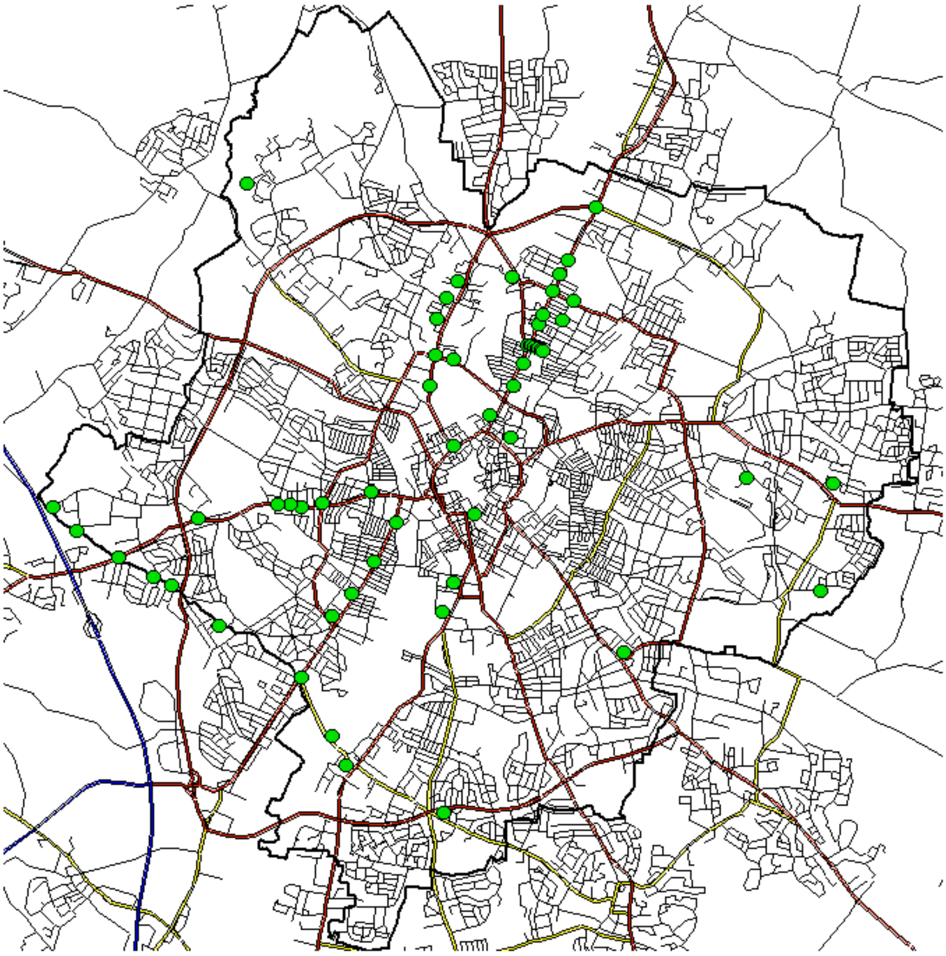


Figure 12
Nitrogen Dioxide Diffusion Tube Sites

● NO2 DIFFUSION TUBE SITE

Table 3.6.5/1 Ten Permanent Sites

Site		**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
		Mean ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)	**Mean** ($\mu g/m^3$)
1	EMEB, Rawdykes Rd.	**42**	**52**	**48**	**42**	32	31	32
2	1 Meadhurst Road *	40	40	38	36	27	29	29
3	3, Copeland Ave.	**42**	40	40	40	31	34	31
4	86, Blackthorne Dri.	31	31	31	31	23	27	38
5	Melton Rd, Police Stn.	38	40	38	40	36	**42**	**46**
6	138, Uppingham Rd.	**50**	**44**	**44**	38	31	40	40
7	Upper Wharf St. Matthews	**50**	**50**	**53**	**46**	40	31	**42**
8	Regency Hotel, London Rd.	**42**	**44**	40	38	29	40	38
9	3, Stonesby Ave.	**42**	**44**	**44**	40	27	36	34
10	New Walk Centre	**53**	**63**	**57**	**53**	42	**48**	**46**
	Mean (all sites)	**42**	**46**	**44**	40	31	36	38

*7 Dunster Street up to 1995

Table 3.6.5/2: Braunstone area study

Diffusion Tube Site		**Mean (Apr 96 - Mar 97)** (μg/m^3)	**Mean (Apr 97 - Apr 98)** (μg/m^3)
16	Middleton St.	38	38
17	Braunstone Lane East	34	34
19	Main St	38	21
20	376 Braunstone Lane	**46**	31
21	438 Braunstone Lane	40	27
22	Hinkley Rd./Braunstone Lane roundadbout	**44**	40
23	Wembley Road	**50**	38
24	Ratby Lane	**44**	**48**
25	Narborough Rd/Fulhurst Ave	34	34
26	267 Narborough Rd.	38	38
27	Upperton Rd./ Narborough Rd.	**48**	38
28	Narborough Rd./ Hinckley Rd.	40	40
	Mean (all sites)	**42**	36

Table 3.6.5/3: Belgrave Corridor study

Site		**Mean** (μg/m^3) **May 1998 – Dec 1998**	**Mean** (μg/m^3) **1999**
11	316 Loughborough Rd.	**53**	**55**
12	Beaumont Leys La./Abbey Lane Junc.	40	**48**
13	182 Abbey Lane	31	**42**
14	320 Abbey Lane	32	**46**
16	South of Belgrave flyover	40	**57**
17	North of Belgrave flyover	**53**	**57**
19	Sandia Bros, Belgrave Rd.	**65**	**50**
20	Melton Rd/Loughboro' Rd Junc.	**61**	**59**
21	Melton Rd/Broadhurst St Junc.	38	**46**
22	Melton Rd/Checketts Rd Junc.	**57**	**59**
23	Melton Rd/Lanesboro' Rd Junc.	**46**	**55**
24	Melton Rd/Troon Way Junc.	**61**	**46**
25	St Margarets Way/Abbey Park Rd Junc.	**57**	**69**
29	75 Abbey Park Rd.	36	**42**
30	new B&Q, Abbey Lane	36	**46**
31	St Margarets Way/Vaughan Way Junc.	**67**	**63**
32	Melton Rd/Doncaster Rd Junc.	**50**	**48**
33	5 Doncaster Rd.	36	**44**
34	17 Doncaster Rd.	38	40
35	31 Doncaster Rd.	32	32
36	47 Doncaster Rd.	34	**44**
37	63 Doncaster Rd.	36	40

Table 3.6.5/4: National Network Sites (μg/m^3).

Site		1998	1999
AEA 1	83 Aylestone Road	**46**	**52**
AEA 2	482 Uppingham Road	27	32
AEA 3	86 Blackthorne Drive	29	25
AEA 4	Marydene Drive	27	25

It can be seen from this data that, given the limitations of the technique, there is considerable evidence of exceedance of the annual Objective criterion for nitrogen dioxide, especially at sites near busy roads.

(iii) Automatic Monitoring.

Monitoring data for nitrogen dioxide is available at a number of sites in Leicester. Full descriptions of the sites and Quality Assurance procedures are given at Appendix B. The location of the sites can be seen in Fig. 13.

Hourly Air Quality Objective

Table 3.6.5/5: Exceedances of the Hourly Air Quality Objective (bold type).

Site	Year	Maximum hour (ppb)	Maximum hour (mg/m^3)	Exceedances	Data Capture (%)
AURN Council Offices, Welford Place	**1994**	97	185	0	96
	1995	106	**203**	**1**	96
	1996	72	138	0	96
	1997	126	**241**	**1**	96
	1998	87	166	0	94
	1999	70	134	0	97
LAMS, Harrison Rd.	**1997/98**	79	151	0	95
LAMS, Marydene Drive	**1999**	57	109	0	77
Saffron Lane	**1997**	77	147	0	76
	1998	49	94	0	83
	1999 (jan-feb)	60	115	0	100
Bassett Street	**1997 (apr - dec)**	84	160	0	59
	1998	76	145	0	38
	1999	83	159	0	89
Imperial Avenue	**1998 (sep-dec)**	70	134	0	81
	1999	160	306	**49**	89
Abbey Lane	**1998 (nov - dec)**	76	145	0	98
	1999	248	474	**69**	95
Melton Road	**1998 (nov - dec)**	84	160	0	93
	1999	185	353	**48**	72
Glenhills Way	**1999 (may - dec)**	95	181	0	78

It can be seen that the Objective criterion was exceeded in 1999 at the Imperial Avenue, Abbey Lane and Melton Road sites. Data capture in some cases can be seen to be less than the 90% which is required by the Guidance. Conversely, this may mean that the data are conservative in the number of exceedances indicated because episodes of high levels of nitrogen dioxide may have been missed.

All of these sites are at back-of-pavement situations next to main roads having daily average vehicle flows in excess of 25,000. There are no fixed sources of Nitrogen dioxide to account for the very high peaks observed at these locations. There is therefore a presumption that they are attributable to emissions from heavy, congested traffic, in combination with prevailing weather conditions.

The Imperial Avenue and Abbey Lane sites are located in line with the facades of houses adjacent to the road at this point. Residential property is situated within 30 metres of the Melton Road Site. The Imperial Avenue and Melton Road sites are also in busy shopping areas. These can therefore be considered as situations of actual current exposure to these levels of nitrogen dioxide.

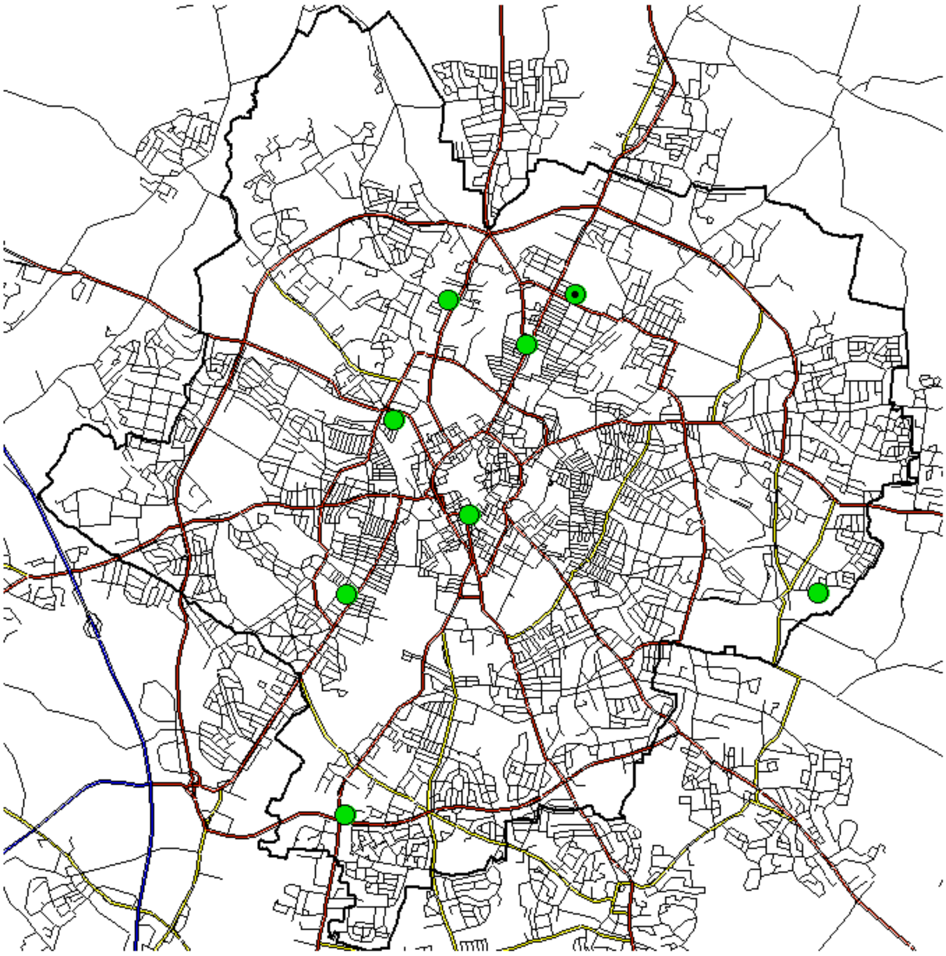


Figure 13
Nitrogen Dioxide Monitoring Stations

● AUTOMATIC MONITORING STATION

⊙ AUTOMATIC MONITORING STATION (1997/98)

Annual Air Quality Objective

Table 3.6.5/6: Exceedances of the Annual Objective (bold type).

Site	Year	Annual Mean (ppb)	Annual Mean (mg/m^3)	Data Capture (%)
AURN Council Offices, Welford Place	**1994**	23	**44**	96
	1995	23	**44**	96
	1996	22	**42**	96
	1997	21	40	96
	1998	21	40	94
	1999	22	**42**	97
LAMS, Harrison Rd	**1997/98**	15	29	95
LAMS, Marydene Drive	**1999**	12	23	77
Saffron Lane	**1997**	20	38	76
	1998	19	36	83
	1999 (Jan-Feb)	20	38	100
Bassett Street	**1997 (May-Dec)**	16	31	59
	1998	20	38	38
	1999	21	40	89
Imperial Avenue	**1998 (Sep-Dec)**	28	**54**	81
	1999	39	**75**	89
Abbey Lane	**1998 (Nov-Dec)**	29	**55**	98
	1999	25	**48**	95
Melton Road	**1998 (Nov-Dec)**	33	**63**	93
	1999	33	**63**	72
Glenhills Way	**1999 (May-Dec)**	36	**69**	78

It can be seen that exceedances of the Objective value have occurred at the Leicester AURN background site. Additionally, substantial exceedances are currently occurring at the Imperial Avenue, Abbey Lane, Melton Road and Glenhills Way roadside sites. It should be noted that a data capture of 90% is required by the Guidance for Stage 3 Review and Assessment and that some sites in some years fail to attain this. However, this is of more significance in demonstrating compliance with the Objective value than in indicating exceedance, since the data are thereby conservative.

These are all sites at which residential exposure over the averaging period of the Objective is possible, particularly in view of the magnitude of the exceedances, i.e. the distance from the respective roads before which the annual level decays to below the Objective value will be correspondingly great.

(b) Air Quality Modelling of Nitrogen dioxide.

Dispersion modelling was primarily carried out using the ADMS model, version 1.53, although comparisons were made for validations puposes with the outputs of AIRVIRO, version 2.21. A full description of the model and the correction/validation techniques outlined below are given in Appendix E.4.2. The emissions inventory used is detailed in Appendix D.

(i) Adjustments to the Model

In running the model and interpreting the model outputs, various factors are taken into account:-

Atmospheric Chemistry.

A large part of the nitrogen dioxide (NO_2) in the air is emitted as nitric oxide (NO), which then reacts with oxidants such as ozone to form nitrogen dioxide. This is a complex process and the relative proportion of the two species can vary greatly at any one time. The relative proportion of nitrogen dioxide tends to be lower during high pollution episodes because the available oxidant has been "used up". The ADMS model is designed to take into account these atmospheric chemical processes.

Background Adjustment.

There will always be a background of nitrogen dioxide which originates outside Leicester. This does not figure in the local emissions inventory used in the model. Therefore its average value has to be estimated and added on to the predictions of the model.

Adding the value of a "suburban" background resulted in gross over-predictions by the model. This could be demonstrated because current monitoring data for suburban background sites in Leicester did not show exceedances of the annual mean criterion, whereas the model did. Since emissions of nitrogen oxides are predicted to decline substantially by 2005, this is clearly unlikely. It was considered that some of the nitrogen dioxide monitored at this site was accounted for by sources included in the emissions inventory, i.e. pollutant was being "double counted" and inflating the predicted level.

Therefore, a background was adopted based upon the 1999 annual mean for the nearest rural national network monitoring site, at Ladybower. (See Appendix E.4.2.2)

Systematic Error.

Systematic error or *bias* is the tendency of a model to over- or under-predict in a consistent way. A correction factor is estimated by calculating the average ratio for all receptor sites:

[monitored annual mean / modelled annual mean]

It was found that the model under-predicted for sites close to major roads and over-predicted for more distant sites. The degree of error bore a good correlation with distance from the highway. It was found that the ADMS and AIRVIRO models agreed remarkably closely in their behaviour in this respect.

It is not practicable for the model to map levels of a pollutant with degrees of correction varying constantly with distance from major roads but it was observed that sites could be conveniently grouped into two sets, each exhibiting a relatively small range of systematic error, and a mean correction factor calculated for each:

Table 3.6.5/7: Aggregated annual mean corrections for roadside receptor-points

Description of site	Distance from kerb	Approximate correction factor to model output
"Roadside"	< 10 metres	1.5
"Background"	10 metres or more	0.9

The data has been used to estimate the distance at which the transition between “roadside” and “background” situations occurs. This has been done with a small sample of sites using data for only one year but it shows very clearly the differences in the way in the models perform with respect to sites less than about 10 metres from a major road and sites at greater distances. This analysis agrees with the demarcation suggested in the Guidance (LAQM.TG4 (00), para. 6.32).

It has then been assumed that the model will behave in roughly the same way with respect to conditions obtaining in 2005 and these ratios applied to the model output, according to this differentiation of the receptor points.

Random Error.

Models also show *random error* . Using a method set out in the the NSCA Guidance-Note “*Air Quality Management Areas: Turning Reviews Into Action*, (Part 2”), a value for the standard deviation of the error was estimated. It approximated to 2 $\mu g.m^{-3}$ (1 ppb).

The map output of the model for 2005 is plotted with contours arranged in increments of one standard deviation, so that zones with increasing or decreasing probability of exceeding the annual Objective criterion can be read off relative to the contour on the map representing the criterion value.

In view of the uncertainties of the modelling process, and taken in conjunction with a number of conservative inputs adopted, it was decided to adopt a precautionary stance and recommend Air Quality Management Areas based on a error of minus two standard deviations.

(ii) The Hourly Objective

It is difficult to model short term variations in nitrogen dioxide levels accurately, due to wide and rapid fluctuations of pollutant levels near to major roads

Receptor point runs of the ADMS model for 1999 were analysed and systematic and random error estimated. (See Appendix E). It is not practicable to apply these corrections to a model map output for 2005 because peak hours for concentrations of nitrogen dioxide do not coincide at different receptor sites, depending on wind direction.

The principal source of nitrogen dioxide in Leicester is traffic emissions. Kerbside levels decay to the prevailing background level within a short distance of the highway. The Guidance indicates that, where the significant source is traffic emissions and there are no major local fixed emissions, the annual mean Objective is more stringent than the 1-hour Objective. Where the annual Objective is achieved, it is unlikely that the 1-hour Objective will be breached. Thus, the ruling factor in determining the maximum extent of any areas of failure to meet the Objectives for nitrogen dioxide is likely to be exceedances of the annual criterion, i.e. it can be assumed that any exceedances of the 1-hour Objective will be subsumed within predicted areas of exceedance of the annual mean Objective (LAQM.TG3 (00), *Review and Assessment: Selection and Use of Dispersion Models*, paras. 7.21-7.22). (LAQM.TG4 (00), para. 6.09; 6.32).

This consideration, which is supported by the analysis of monitoring and modelling data presented in Appendix E, considerably eases the task of determining the boundaries of areas of exceedance: As a check on the model outputs for hourly nitrogen dioxide, these values were also estimated from annual mean model runs. (See next Section).

(iii) The Annual Mean Objective

The outputs of the ADMS model, taking account of all these factors, are displayed on the accompanying maps of annual mean levels of nitrogen dioxide. Fig.14 shows the current (2000) position. Two maps are shown for 2005 (units in microgrammes per cubic metre):-

Figure 15.

This map shows the raw model output calculation of annual mean values of nitrogen dioxide for 2005, with the addition of the previously-described background correction. Predicted exceedances of the annual mean Objective are shown as red zones.

To show the extremes of model behaviour at background and at roadside sites, the outcomes of factoring the basic model output by 0.9 and 1.5, as described above, were examined:

Figure 16.

This map shows the same model output with a correction for the estimated "background" systematic error applied. (A factor of about 0.9) The map can be used to delimit the approximate outer boundaries of the zones of exceedance of the annual mean Objective, which centre on the main road network. It must be borne in mind that this map is only estimated to hold true at distances greater than about 10 metres from major roads, (i.e. roads having daily mean vehicle flows in excess of about 20,000). At lesser distances, concentrations of nitrogen dioxide will tend to be higher.

The random error is also incorporated in this map because the contours are arranged in increments of one standard deviation (approximately 2 $\mu g.m^{-3}$). Thus zones of progressively decreasing probability of exceedance can be read off in steps of one standard deviation, starting with the contour showing the actual Objective value. (40 $\mu g.m^{-3}$). In view of the uncertainties of modelling and the number of conservative assumptions built into the process, it is recommended that a precautionary approach is taken and the contour of minus 2 standard deviations (the yellow zones on the map) is adopted as an approximate basis for outlining Air Quality Management Areas.

However it will be noted that the areas outlined in yellow on this map are virtually identical with those outlined in red (Objective criterion, 40 $\mu g.m^{-3}$ contour) on the map of the raw model output (Fig. 15). For the sake of simplicity, Figure 14 will be used within this Report: This map therefore forms the basis for the delineation of areas of failure to meet the annual Objective for nitrogen dioxide.

If the values for nitrogen dioxide concentrations predicted in the model output are multiplied by the estimated systematic model error estimated for sites within about 10 metres of the busiest roads (about 1.5), the whole City is shown as failing to meet the annual mean Objective for nitrogen dioxide, with levels in the range 40-76 $\mu g.m^{-3}$ (21-40 ppb).

We know from, albeit limited, monitoring data that the annual mean criterion is being met currently at suburban sites. We also know that emissions of oxides of nitrogen are predicted to fall across the UK between now and 2005. This calculation clearly, therefore, over-estimates future levels of nitrogen dioxide at locations more than, perhaps, 10 metres from major roads, (i.e. roads having daily mean vehicle flows in excess of about 20,000). However, it indicates that people will be

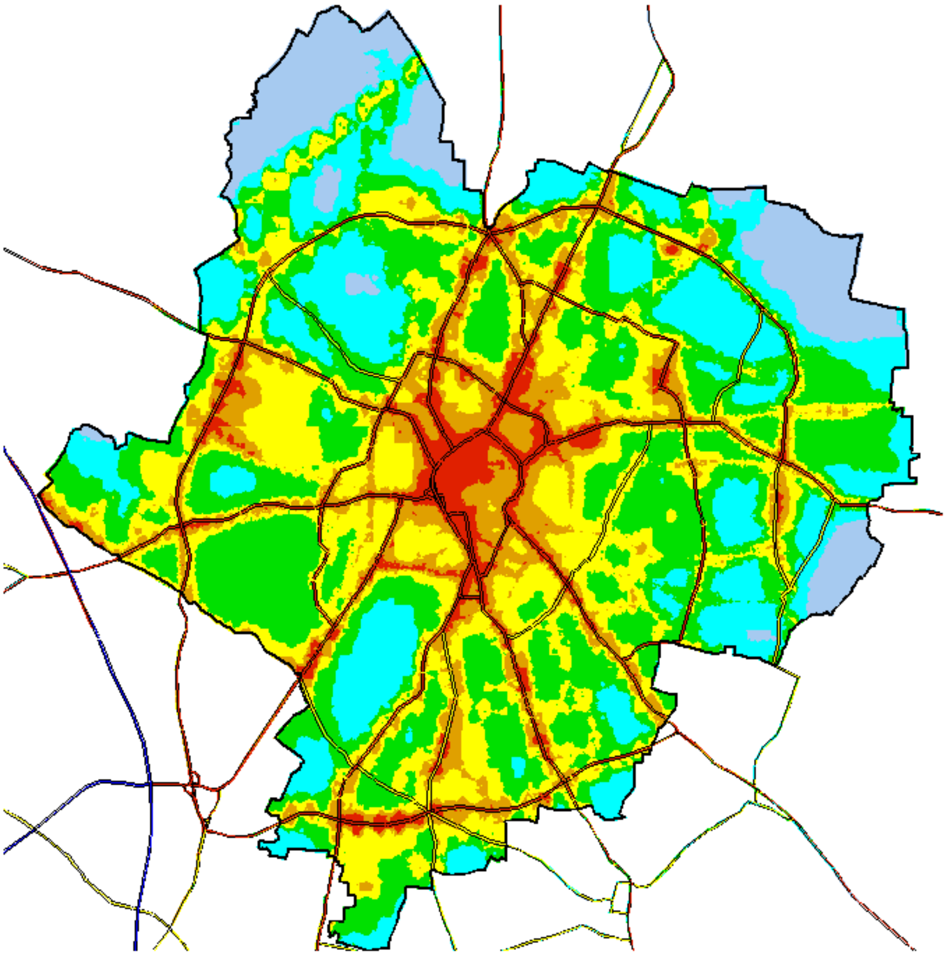


Figure 15
Nitrogen Dioxide 2005

Predicted annual mean concentration of nitrogen dioxide.

	NO2 ppb	(ug/m3)
⬜	0 - 15	(0 - 28.6)
🟦	15 - 17	(28.6 - 32.5)
🟦	17 - 18	(32.5 - 34.4)
🟩	18 - 19	(34.4 - 36.3)
🟨	19 - 20	(36.3 - 38.2)
🟧	20 - 21	(38.2 - 40.1)
🟥	21 - 27	(40.1 - 51.6)

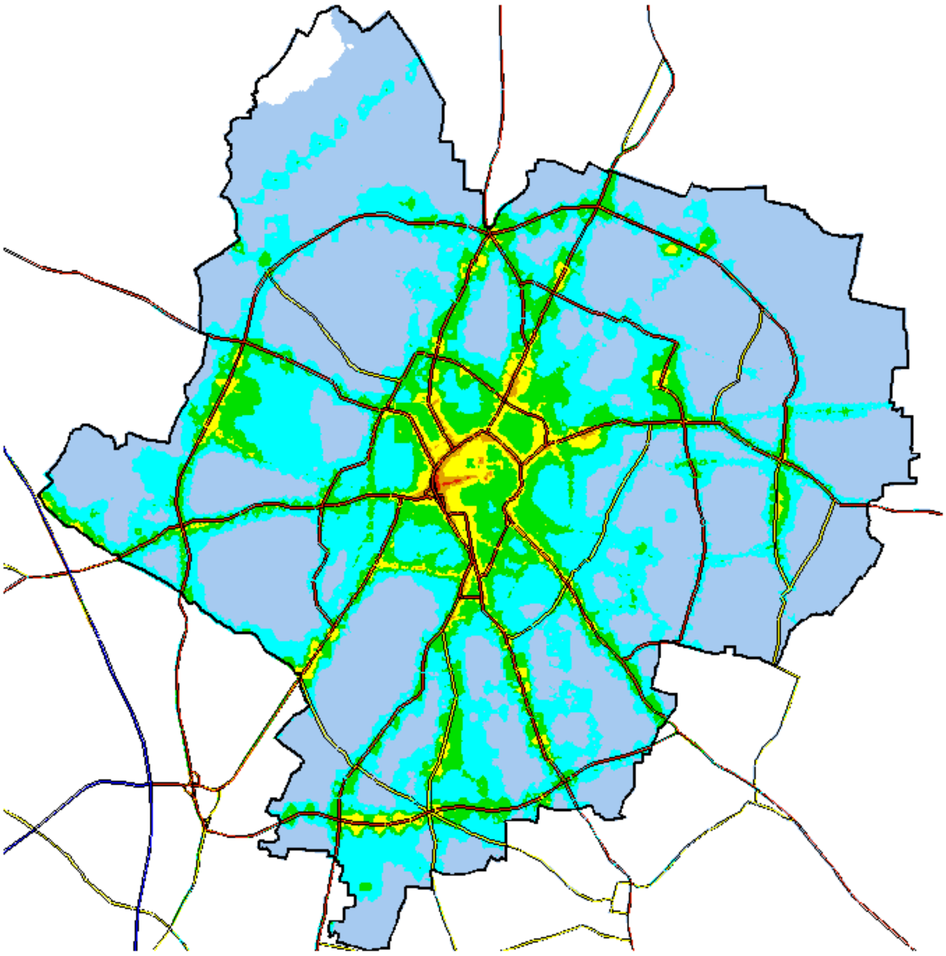


Figure 16
Nitrogen Dioxide 2005 (Corrected)

Predicted annual mean concentration of nitrogen dioxide with a validation correction factor (0.9) applied.

NO2 ppb		(ug/m3)
⬜	0 - 14	(0 - 26.7)
🟦	14 - 17	(26.7 - 32.5)
🟦	17 - 18	(32.5 - 34.4)
🟩	18 - 19	(34.4 - 36.3)
🟨	19 - 20	(36.3 - 38.2)
🟧	20 - 21	(38.2 - 40.1)
🟥	21 - 24	(40.1 - 45.8)

exposed to higher levels of nitrogen dioxide at locations within about 10 metres of such major roads than are implied by Figs. 15 and 16.

The Guidance suggests that, at roadside sites where traffic emissions are the only significant concern, it can be assumed that the 99.8th percentile of hourly means (approximating to 18 exceedances per year) will not exceed 3.5 times the annual mean value. It can therefore be roughly estimated that, where the annual mean exceeds 57 µg.m^{-3} (30 ppb), at locations less than about 10 metres from major roads, people might be exposed to levels of nitrogen dioxide exceeding the 1-hour Objective. (LAQM.TG4 (00), para. 6.32). This is reinforced by observed data indicating that, at some roadside sites in Leicester, this empirical relationship does not hold true and is, in fact conservative: The measured 98th percentile of hourly means exceeds the annual mean by considerably more than a factor of 3.5:

1999 Monitoring data for Roadside Sites (µg.m^{-3}).

Table 3.6.5/8: Comparison of estimated and observed 99.8th percentile values

Site	Observed 99.8th percentile	Observed annual mean X 3.5
Abbey Lane	321	168
Melton Road	263	221

Roadside NO_2 levels fall away to the prevailing urban background value at about 20-30 metres from the centre of the highway. Similarly, concentrations have been shown to decrease rapidly above ground floor level. Thus, people living above ground floor level, for example in upper-floor flats, will not be exposed to concentrations corresponding to measured or predicted roadside or kerbside values.

Comparison with Government Projections for Annual Nitrogen Dioxide Concentrations.

The Air Quality Strategy for England, Scotland Wales and Northern Ireland (2000) (Table A25, page A146), gives projections of annual mean concentrations of nitrogen dioxide at the Leicester AUN site. These are based upon “An Empirical Model for Estimating Roadside Nitrogen Dioxide Concentrations in the UK” (AEAT-4291, Stedman, Bush and King, 1999). Levels are predicted based upon the observed data for a “good” and a “bad” year for average levels of nitrogen dioxide (1996 and 1997, respectively). Similar material is presented in “Site Specific Projections of NOx and NO_2 Concentrations for the UK”. (AEAT-5850 Issue 2, Stedman, 1999) and the projections for the Leicester AUN site are shown in graphical form in Fig. 17. These projections are set out in Table 3.6.5/9, below.

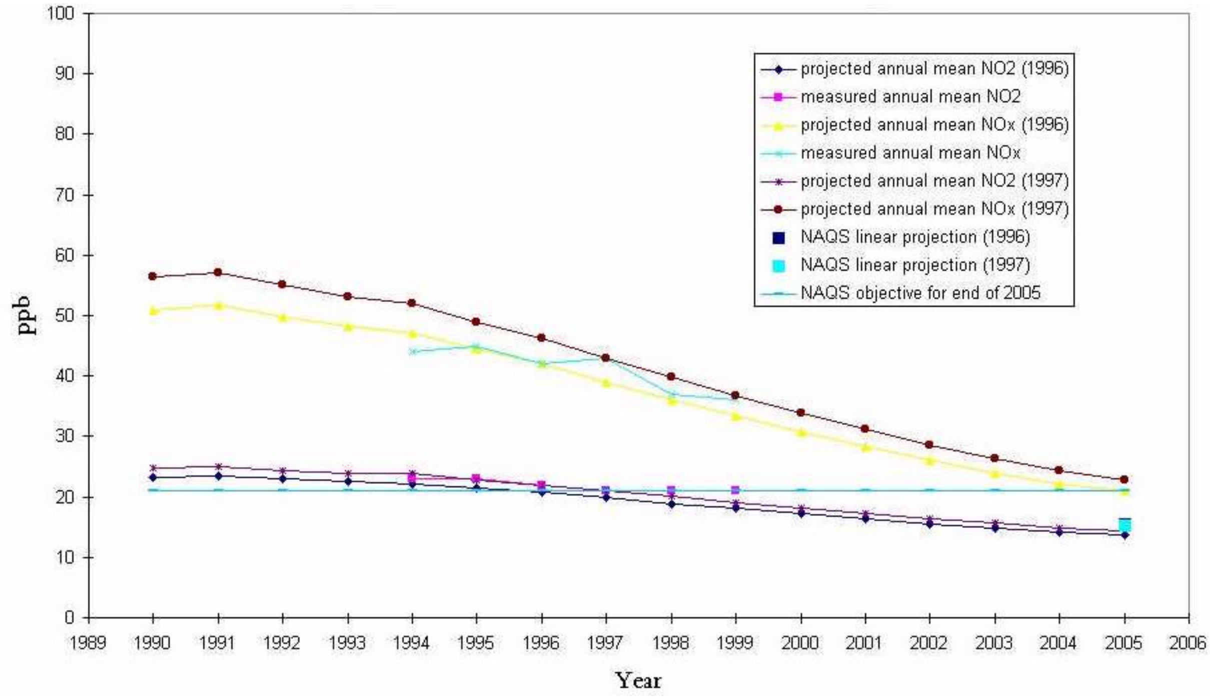


Figure 17

Comparison of measured NOX and NO2 concentrations at Leicester Centre with projections based on both 1996 and 1997 monitoring data.

(Source: *Site Specific Projections of NO_X and NO_2 Concentrations for the UK*, AEAT Report 5850 Issue 2, Stedman, 1999.)

Table 3.6.5/9: Comparisons of national and local modelling with observed data

Nitrogen dioxide Annual means Leicester Centre	**1994**	**1995**	**1996**	**1997**	**1999**	**2005**
Measured, Leicester AUN	44 (23)	44 (23)	42 (22)	40 (21)	42 (22)*	
Stedman, Bush & King, projected					34-36 ** (18-19)	29 (15)***
ADMS prediction (validation factor = 0.9)					38 (20)	36.7 (19.2)

Values in $\mu g.m^{-3}$ (ppb)
Unratified data.
** Estimated from graph. (Stedman).
*** Same value obtained using 1996 and 1997 observed data.

It will be noted that the corrected ADMS prediction for 2005 is somewhat in excess of that projected by Stedman, Bush and King. However, the observed (unratified) value for the Leicester AUN site for 1999 is also greater than that predicted for 1999 by this methodology. The latter is already, therefore, under-predicting annual mean levels for this site by about 3-4 ppb for 1999. Inspection of the annual mean data for the AUN site for the last few years (q.v.) certainly shows no clear downward trend since 1996.

Thus, corrected predictions from the ADMS model depart significantly from the Government's initial projections. However, on the basis of the evidence to date, Leicester's local predictions seem to justify at least as much confidence.

3.6.6 Conclusions for Nitrogen dioxide.

(a) **There will be widespread failure to achieve the annual mean Objective for nitrogen dioxide in zones centring on the major road network (roads having average flows greater than about 20,000 vehicles per day), as shown in Figure 15 (red contour).**

The declaration of Air Quality Management Areas is required in all areas where this exceedance coincides with areas containing, schools, hospitals, housing and other residential accommodation at or near ground level.

These areas of exceedance will determine the maximum extent of Air Quality Management Areas: Any areas of exceedance of the one-hour Objective for nitrogen dioxide (and the two Objectives for PM_{10} *particulates- see Section 3,7) will be subsumed within them.*

(b) **People within about 10 metres of major roads (roads having average flows greater than about 20,000 vehicles per day) are likely to be exposed to higher levels of nitrogen dioxide than are implied by Figure 15. It is estimated that areas of failure to achieve the one-hour Objective for nitrogen dioxide may occur in these zones.**

Exposure in these areas of exceedance will extend to short-term exposure, for example for people visiting shops and leisure facilities.

3.7 Review and Assessment of PM_{10} Particulates.

3.7.1 Characteristics and Sources of PM_{10} Particulates.

PM_{10} particulates differ from the other pollutants discussed in this Report in that they are not a single substance. Particulate matter in the atmosphere is composed of a wide range of materials of various origins.

This pollutant is defined by particle size and not by its chemical nature. This is because it is necessary to look at the size fraction of particles most likely to be deposited in the lung. "PM_{10}" approximates to particles up to 10 µm (millionths of a metre) in size: In practice, a size-specific sampling inlet is used which collects 50% of 10 µm aerodynamic diameter particles, more than 95% of 5 µm aerodynamic diameter particles and less than 5% of 20 µm aerodynamic diameter particles. *[Thoracic convention, E_T ,as defined in ISO 7708:1995(E): "Particle size fraction definitions for health-related sampling".]*

In recent years, a clear association has been established between respiratory or cardiovascular ill-health and exposure to fine atmospheric particles. The precise mechanism whereby adverse effects occur has not been identified with certainty, although considerable research is in progress and various theories have been advanced.

Studies have suggested that the smaller fractions of airborne particulates, for example $PM_{2.5}$ (particles up to 2.5 µm aerodynamic diameter) are of greater significance for morbidity and mortality. (Expert Panel on Air Quality Standards).

Further, there is some evidence of a good correlation between even finer fractions, e.g. $PM_{0.1}$ (particles up to 0.1 µm aerodynamic diameter) and ill-health. Particle numbers and/or surface area may be a significant factor. It has been demonstrated that, while this fraction accounts for only 1% of the total mass of a sample of atmospheric $PM_{2.5}$, it might account for almost three-quarters of the total number of particles.

Accordingly, it is possible that there may, in the relatively near future be changes in the indicators by which airborne particulates are assessed. However, this Report will confine itself to PM_{10} , for which a statutory Objective is prescribed and which is widely measured, in accordance with the statutory Guidance governing air quality Review and Assessment.

As indicated above, particulate matter is derived from a wide range of sources: it can be primary or secondary, man-made or natural in origin. Recent investigations suggest that PM_{10} particulates can be roughly divided into three categories:-

- Fine, "*Primary*" particulates to a large extent comprise those derived from incomplete combustion in motor vehicle engines or stationary combustion plant. Much, but not all of this material is likely to be of fairly local origin, although such particles can be transported over large distances under appropriate meteorological conditions.

- Fine, "*Secondary*" particulates consist largely of ammonium sulphate, ammonium nitrate and secondary organic aerosols. Sulphates and nitrates form from industrial and traffic emissions of sulphur dioxide and oxides of nitrogen in two ways:

    ◊ Homogeneous nucleation: Coalescence of the gaseous species particles.

    ◊ Heterogeneous nucleation: Adsorption of gaseous species onto an existing particle.

  These complex processes also involve sunlight and the presence of agricultural ammonia particles and sea-salt particles.

Such aerosols take time to form and can be transported over considerable distances, in particular from sources in continental Europe. There is therefore a tendency for elevated levels of secondary particulates to be associated with a prevailing easterly wind. In particular, 1996 experienced longer than usual periods of easterly winds associated with markedly elevated levels of what were demonstrated to be secondary particulates of the kind described.

- "*Coarse*" particles include a variety of natural and anthropogenic material, e.g. wind-blown dust and biological matter such as spores.

[*Source Apportionment of Airborne Particulate Matter in the United Kingdom*, Report of the Airborne Particles Expert Group, January 1999; *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000*].

Episodes of high particulate levels will predominantly feature either primary or secondary particles, depending on the type of weather conditions which have caused high concentrations to occur:

Table 3.7.1: Particle characteristics typical of different weather conditions

Episode Type	**Weather Conditions**	**Predominant Source of Fine PM_{10}**
Primary (winter)	Stable conditions, low wind velocity. Cold, possibly foggy, mornings.	Primary: Dark sooty emissions from diesel vehicles, with volatile organic component.
Secondary (summer)	Prolonged high pressure, high temperatures over several days. Easterly wind from continental Europe.	Secondary: Large volatile component (ammonium nitrate).

3.7.2 The Objective for Particulates

The Objective for PM_{10} particulates was revised in early 2000 and comprises two levels:

- A maximum annual mean of 40 $\mu g.m^{-3}$.
- A maximum 24-hour mean of 50 $\mu g.m^{-3}$, with up to 35 exceedances allowed per year (approximating to the 90th percentile).

The relevant date for compliance with these criteria is the end of 2004. The revised Objective has been shown to be somewhat less onerous than the existing, statutory Objective for particulates. *(The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000).*

There were two, related reasons for the revision of the Objective.

- Changes in the state of scientific knowledge about the nature and behaviour of pollutants.
- The need to harmonise UK legislation with the somewhat different requirements of binding EC legislation, in the form of the Air Quality Daughter Directive (AQDD).

In particular, as indicated above, it is now appreciated that a significant proportion of particulates are of remote, secondary origin and are therefore not susceptible to local control. For example, modelling of a scenario in 2005 in which *all* urban traffic emissions were eliminated indicated that there would still be widespread exceedances of the 1997 Objective for particulates. *(The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2000,* para. 238). In terms of what can be accomplished by local or national measures, the 1997 Objective for particulates was therefore considered to be unrealistic.

3.7.3 Projections by the Government for Particulates in Leicester.

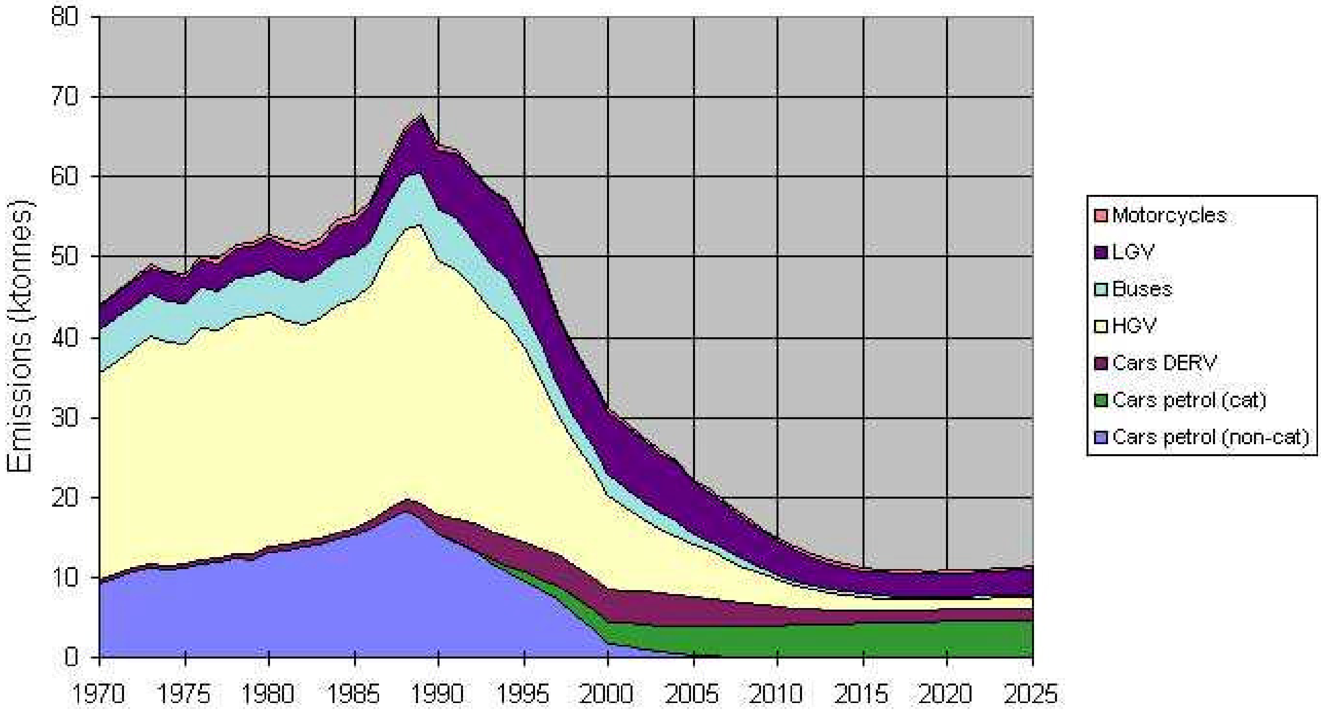
It is important to distinguish between the different components of atmospheric particulates when projecting changes between the time of writing and 2004. Because primary and secondary particles have different origins, their reduction is influenced by different sets of national and EC policies. Coarse particles will remain largely unaffected. The key issue in Leicester will be primary traffic emissions in close proximity to highly congested major roads.

Overall, national emissions of PM_{10} particulates fell by 36% between 1990 and 1997 and the road transport contribution decreased by 30% between 1991 and 1997. Between 1995 and 2005 road transport emissions of primary PM_{10} are projected by the DETR to fall from 23.49 kilotonnes to 11.08 kilotonnes (53 %). (See Fig. 18, (*Air Quality Strategy for England, Scotland, Wales and Northern Ireland,* 2000)).

Table 3.7.3: Annual means for the Leicester Centre AUN site are as follows ($\mu g.m^{-3}$)

Year	Annual Mean
1994	21
1995	20
1996	22
1997	20
1998	18
1999	16

In comparison, Government estimates set the annual mean for 2005 at the Leicester AUN site at 18 $\mu g.m^{-3}$, using 1996 (“worst case”) meteorological data and at 16 $\mu g.m^{-3}$, if 1995 (“typical”) weather data is applied.



20% diesel car sales; Central 1997 NRTF; Euro III , Euro IV reduction in emissions from new vehicles; 2000 and 2005 Fuel standards

Figure 18

UK urban road transport primary emissions of PM10 particulates, 1970 - 2025.

(Source: *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, DETR, January 2000.)

3.7.4 Findings of Stage 1/2 Review and Assessment.

Following the requirements of DETR Guidance Note LAQM. TG4(98), *Review and Assessment: Pollutant Specific Guidance*, the following summarises the prescribed tests governing progression to the third stage of air quality Review and Assessment with respect to PM_{10} particulates. (This Guidance was in force at the time of the Stage 1 / 2 Review and Assessment, but the amended advice given in LAQM.TG4 (00) would also have led to a similar outcome):

Annual average regional background due to secondary particles is currently greater than 8mg.m^{-3}.

Annual average regional backgrounds of PM_{10} particulates due to secondary particulates were abstracted from the DETR website provided for the purpose. This source estimates these levels to be of the order of 11 μg.m^{-3}.

Indication by the UK National Atmospheric Emissions Inventory that annual emissions from low-level dispersed sources (including road traffic) are greater than 10 tonnes in any single 1 km. by 1 km. grid square or an average of 5 tonnes in several adjacent grid squares.

The National Atmospheric Emissions Inventory shows emissions of particulates in excess of 10 tonnes in several of its 1 kilometre grid squares lying within the Leicester City Boundary.

One or more planned or existing roads with a projected annual average daily traffic flow greater than 25,000.

Data on traffic flow for the City of Leicester and the surrounding County was available from the results of runs of the TRIPS Model.

52 road links within the City of Leicester have been identified as having a current annual average daily traffic flow greater than 25,000. In addition, around 13 road links were identified with current annual average daily flows greater than 25,000, which, although outside the boundaries of the City of Leicester, are considered to be likely to have an air quality impact by virtue of their importance and close proximity. These links are detailed in Appendix A. (See Fig. 19).

Planned or prospective industrial processes classified as "Part A" or "Part B" processes under the Environmental Protection Act 1990 and the Environmental Protection (Prescribed Processes and Substances) Regulations 1991 (as amended) with the potential to emit significant quantities of PM_{10} particulates.

A review of industrial processes in and around Leicester and prescribed as "Part A" and "Part B" processes for the purposes of Part I of the Environmental Protection Act (and other processes) 1990 was carried out. This was based on Annex 1 and 2 of the *Pollutant Specific Guidance*, which specifies the types of prescribed processes considered to have the potential to emit significant amounts of PM_{10} particulates for the purposes of Stage I of the Review and Assessment.

This was coupled with consideration of information held on the relevant statutory registers held by Leicester City Council under the terms of Part I of the Environmental Protection Act, other relevant files and the local knowledge of enforcing officers. The published Environment Agency industry database was also examined. Details of the processes considered can be found in Appendix A.

The five “Part A” processes identified in the preliminary survey as having the potential to be significant emitters of PM_{10} particulates were discounted, from consideration of available information. No “Part B” processes were identified.

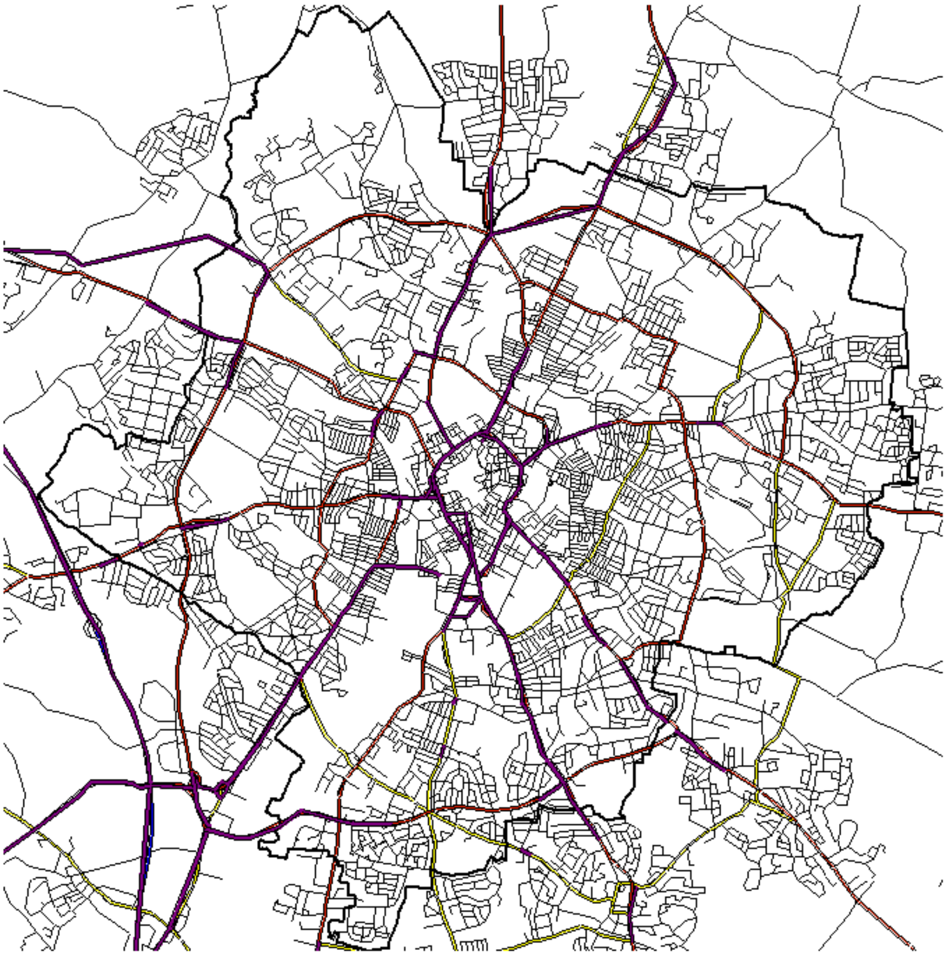


Figure 19

Roads with Daily Traffic Flow >25,000 Vehicles per Day

There are no known proposals to establish further processes in or around Leicester which will emit significant quantities of PM_{10} particulates.

The presence of any industrial process which emits significant quantities of dust in the form of PM_{10} particulates from uncontrolled or fugitive sources within the plant.

No processes in this category were identified.

The *Pollutant Specific Guidance* states that the approach for Stage 1 of the Review and Assessment is of an interim nature, pending the results of further research and no methodology is prescribed for Stage 2.

Leicester contains numerous roads which meet the Stage 1 criteria for further and better investigation. There is evidence from monitoring data of current breaches of the relevant Air Quality Objective.

In terms of the screening tests prescribed for PM_{10} particulates in the statutory Guidance, Leicester City Council was required to proceed to Stage 3 of the Review and Assessment.

3.7.5 Findings of Stage 3 Review and Assessment.

(a) Monitoring of Particulates.

(i) Monitoring Techniques, Locations and Quality Assurance.

Full details of the Leicester monitoring network together with a statement of Quality Assurance / Quality Control procedures is given at Appendix B

(ii) Automatic Monitoring Sites.

There are two types of equipment in use in Leicester:

- The Tapering Element Oscillating Microbalance ("TEOM")
- The Beta Attenuation Monitor ("BAM").

Full descriptions of the sites and the equipment, together with Quality Assurance procedures, are given at Appendix B. (See Fig. 20).

As indicated above, the current Objective for particulates is designed to harmonise UK legislation with the EC Air Quality Daughter Directive. This specifies the gravimetric *European Reference Method* of measurement, which differs in important respects from the Tapering Element Oscillating Microbalance (TEOM) method which has been standardised in the UK AURN scheme from its inception. The Expert Panel on Air Quality Standards (EPAQS) based their original recommendations for an air quality Standard on measurements made with the latter technique and these recommendations were subsequently adopted as the now superseded UK air quality Objective value.

Recent work has indicated that the TEOM system under-estimates particle mass compared to other techniques. This is because the TEOM method pre-heats sampled air to eliminate interference from water. In doing so it evaporates and so fails to collect the volatile component of the particulates sampled. This volatile, *secondary* component has been shown represent a significant, and varying, proportion of the total mass present.

The Airborne Particle Expert Group (APEG) recommended, as an interim measure that, when assessing compliance with the current criterion, TEOM readings should be multiplied by 1.3. (Report of the Airborne Particles Expert Group, *Source Apportionment of Airborne Particulate Matter in the United Kingdom,* January 1999, Section 6.1). This advice has been incorporated in LAQM.TG4 (00), *Pollutant Specific Guidance* (para. 9.7). As discussed in Appendix B.2.2.4, this is an over-simplification of the complex relationship between the results obtained by the two techniques: There is probably no stable relationship between the two, as conditions at a given point advect varying proportions of primary and secondary particulates from various sources to the receptor. However, for the purposes of this Report, this approximation is used for analysis of TEOM data.

Because the instrument does not pre-heat the inlet air, the data from BAM technique probably at least have a reasonably linear relationship with those which would be obtained by the European Reference Method for particulates. For the purposes of this Report, the data from BAM equipment is reported without any correction being applied.

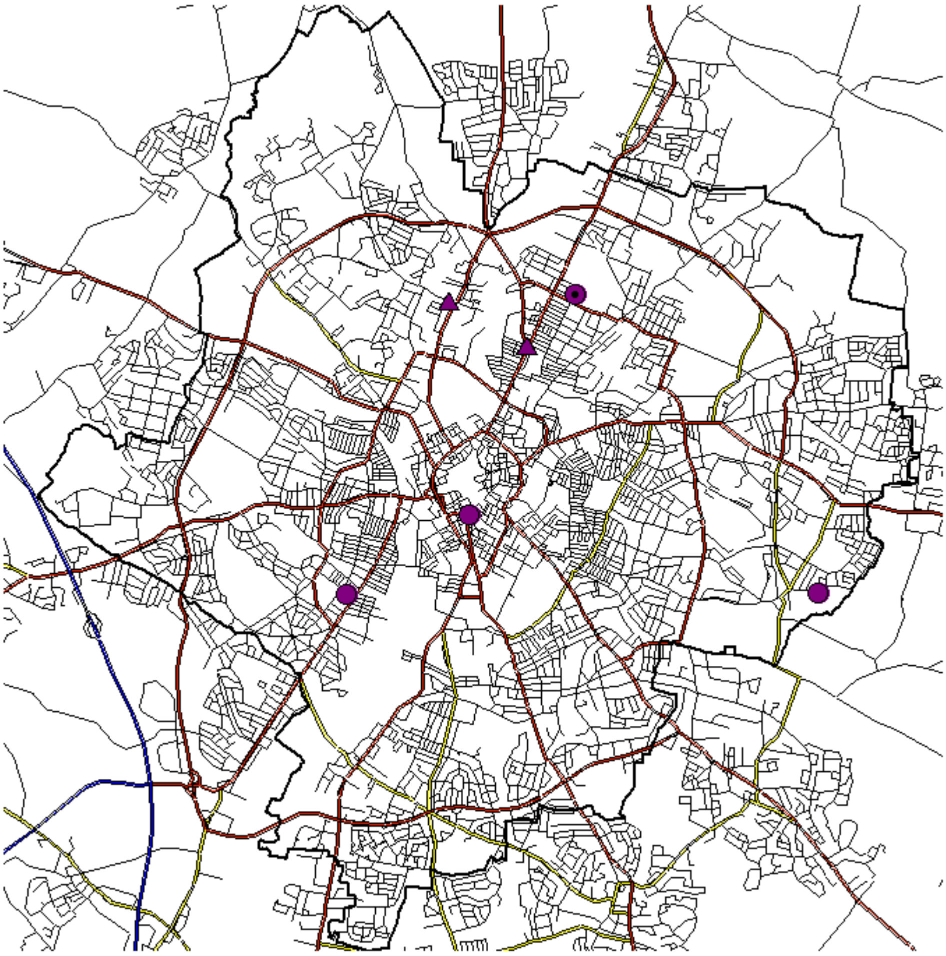


Figure 20
PM10 Particulates Monitoring Stations

● AUTOMATIC MONITORING STATION (TEOM)

▲ AUTOMATIC MONITORING STATION (BAM)

⊙ AUTOMATIC MONITORING STATION (1997/98) (TEOM)

In considering the data presented below, these considerations should be borne in mind when making comparisons between sites using the TEOM and BAM techniques.

Table 3.7.5/1: Annual Means.

Method/ Correction factor	Site	Year	Annual Mean mg/m^3	Data Capture (%)
TEOM	**AURN Council Offices, Welford Place**	**1994**	21	93
		1995	20	97
		1996	22	96
		1997	20	97
		1998	18	95
		1999	16	96
	LAMS, Harrison Rd	**1997/98 (Mar-Apr)**	21	99
	LAMS, Judgemeadow Sch.	**1999**	16	76
	Imperial Avenue	**1998 (Sep-Dec)**	25	80
		1999	42	89
TEOM X 1.3	**AURN Council Offices, Welford Place**	**1994**	28	93
		1995	26	97
		1996	27	96
		1997	26	97
		1998	22	95
		1999	21	96
	LAMS, Harrison Rd	**97/98 (Mar-Apr)**	27	99
	LAMS, Judgemeadow Sch.	**1999**	21	76
	Imperial Avenue	**1998 (Sep–Dec)**	26	80
		1999	**55**	89
BAM	**Abbey Lane**	**1999**	37	92
	Melton Road	**1998 (Oct-Dec)**	40	94
		1999	37	91

Table 3.7.5/2: 24 hour means

	Site/location	Year	Maximum 24 hour Mean mg/m^3	24 hour means >50
TEOM	AURN Council Offices, Welford Place	1994	65	6
		1995	64	4
		1996	84	13
		1997	58	3
		1998	74	4
		1999	42	0
	LAMS, Harrison Rd	97/98 (Mar-Apr)	76	8
	LAMS, Judgemeadow Sch.	1999	42	0
	Imperial Avenue	1998 (Aug-Dec)	51	1
		1999	99	72

TEOM x 1.3	AURN Council Offices, Welford Place	1994	84	30
		1995	84	14
		1996	109	23
		1997	76	21
		1998	96	14
		1999	55	5
	LAMS, Harrison Rd	97/98 (Mar-Apr)	99	21
	LAMS, Judgemeadow Sch.	1999	55	2
	Imperial Avenue	1998 (Sep–Dec)	66	8
		1999	129	**180**

BAM	Abbey Lane	1999	118	**61**
	Melton Road	1998 (Oct-Dec)	87	20
		1999	117	**61**

It can be seen that the 24-hour mean Objective criterion was exceeded in 1999 at the Imperial Avenue, Abbey Lane and Melton Road sites. The annual mean criterion was exceeded at Imperial Avenue.

All of these sites are at back-of-footway situations next to main roads having daily average vehicle flows in excess of 25,000. It is observed that the TEOM filter at the Imperial Avenue site regularly needs changing at fortnightly rather than monthly intervals due to heavy particulate loading. There are no obvious fixed sources of particles to account for the very high transient peaks observed at these locations. There is therefore a presumption that they are attributable to emissions from heavy, congested traffic, in combination with prevailing weather conditions. It will be noted from the preceding section that these sites are also affected by elevated levels of nitrogen dioxide, which tends to reinforce the view that traffic emissions play an important part in conditions at these locations.

The Imperial Avenue and Abbey Lane sites are located in line with the facades of houses adjacent to the road at this point. Residential property is situated within 30 metres of the Melton Road Site. These can therefore be considered as situations of actual current exposure to these levels of particulates. The Imperial Avenue and Melton Road sites are also in busy shopping areas.

Air Quality Modelling of Particulates.

Modelling was primarily carried out using the ADMS model, version 1.53. Full details of the dispersion model used and the validation techniques discussed in this Section can be found in Appendix E.4.3. Details of the emissions inventory used are in Appendix D.

The inventory used by the model will account for emissions of primary particles but not for the secondary and coarse components. A background correction to account for these was therefore be applied, using measurements of rural sulphate, as detailed in Appendix E.

The model was run using 1999 meteorological data, since this was the year for which data from the largest number of monitoring sites was available for the purposes of validation. 1999 is considered to be a reasonably "typical" year, i. e. it was not a year in which prevailing weather conditions imported unusual quantities of particulates from continental Europe, like 1996. Since such "atypical" years occur only every 5-10 years, it was felt that this was a reasonable and conservative assumption.

The 24-hour mean Objective for particulates is likely to be more onerous than the annual mean standard. I. e. areas of exceedance of the latter are unlikely to exist outside areas of exceedance of the former: It is, in effect, the ruling factor in determining the extent of areas of failure to meet the Objectives for particulates. Unfortunately, it is inherently difficult to model short-term values of particulates due to day-to-day variations in concentration and composition of PM_{10} . (LAQM.TG4 (00) para. 8.09 ff.)

The model was used to generate predictions for sites with particulate analysers so that the model outputs could be compared with observed data. (See Fig. 21). Due to constraints of resources and time, the model input could not be adjusted to take account of the change in the Objective deadline year for particulates from 2005 to 2004. As can be seen from Figure 21, the model did not successfully predict the distribution of particulates observed in current monitoring data. Although the annual mean model output map shows concentrations of particulates to be slightly elevated in proximity to major roads, the difference compared to background situations is very small (3 $\mu g.m^{-3}$ at most) and is considerably less than the observed data would lead us to expect concerning the behaviour of particulates in the real world.

The modelling was further complicated because two different monitoring techniques, TEOM and BAM are in use in Leicester and it is difficult to make comparisons between their outputs. This means that it is not satisfactory to use data from both types of site together to estimate modelling error. Full details of each monitoring technique and a discussion of the problems in comparing the data produced by them are given in Appendix B.

Attempts were made to derive a systematic error correction for the model output by calculating a mean of the ratios between the monitored annual mean value and the modelled value for each receptor site. This indicated not only that the predicted levels exhibited large degrees of error but also that the error varied over a very wide range between sites. The ratio between monitored and modelled values varied from 1.7 to as much as 4.8, with a standard deviation over the three TEOM sites of 1.37. I. e. the model was grossly but inconsistently under-predicting. At best, the predicted value was only around 59% of the observed data; at worst, it was around 21%.

Taking this in conjunction with difficulties in making comparisons between different monitoring techniques, it has therefore not proved possible to derive a satisfactory systematic correction factor for the model.

An empirical method is provided in the Guidance for estimating the 90th percentile concentration of PM_{10} (approximating to 35 days of exceedance per year) from the annual mean. (LAQM.TG4 (00), Figure 8.1). However, since the future annual means cannot be calculated with any certainty for the

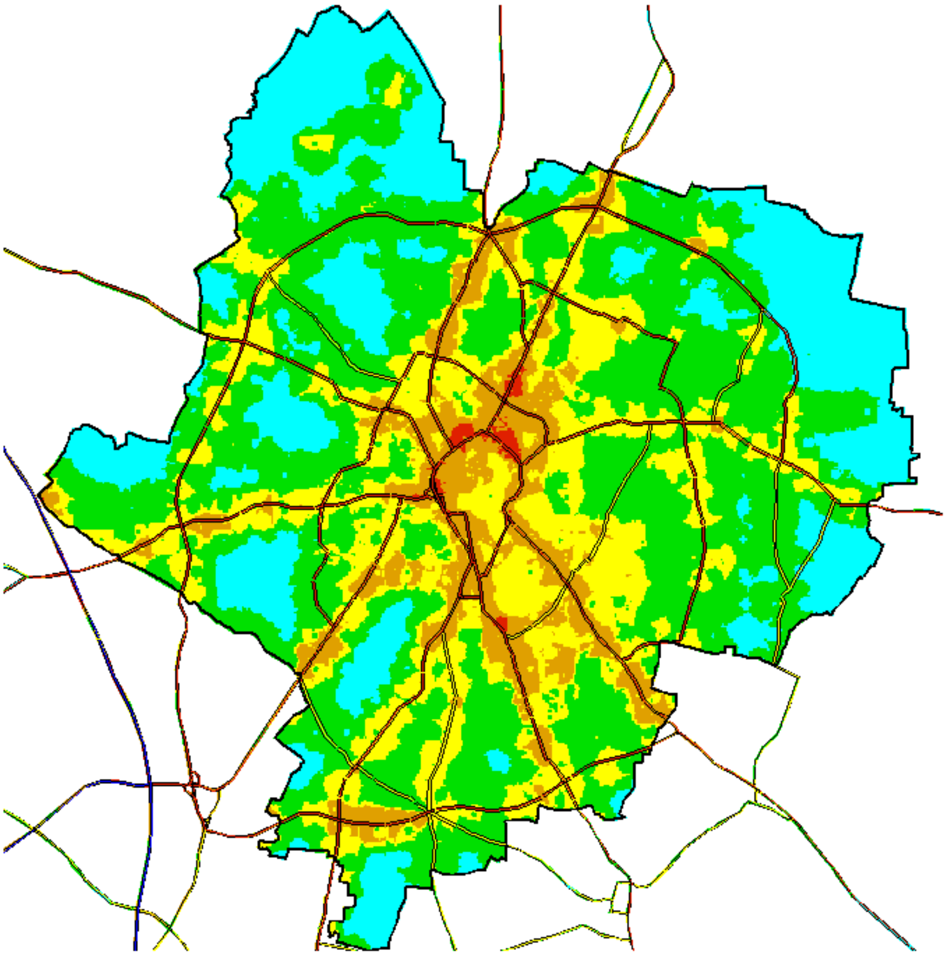


Figure 21
PM10 Particulates 2005

Predicted annual mean concentration of PM10 particulates.

PM10 ug/m3
⬜ 0 - 9
🟦 9 - 9.25
🟦 9.25 - 9.5
🟩 9.5 - 9.75
🟨 9.75 - 10
🟧 10 - 10.5
🟥 10.5 - 12

reasons already explained, there is little point in compounding this uncertainty by applying a rough, empirical factor to these outputs.

3.7.6 Conclusions for PM_{10} Particulates.

As previously discussed, particulates consist of three components, “primary”, “secondary” and “coarse”. Near busy roads, much of the primary component will come from traffic exhaust emissions. Levels of the three components will be influenced by different factors between now and 2004: Primary particles will reduce with new legislation governing vehicle emission standards and to the extent that traffic flows at a given point are reduced. Secondary particles will be influenced by controls on emissions of their precursors, e. g sulphur dioxide emissions from power generation, much originating at a great distances from Leicester. The coarse component is largely uncontrolled and so can be expected not to change. In addition, it is known that the “roadside enhancement” of the particulate burden contains a quantity of particulates re-suspended by the movement of traffic. This may be roughly equal in mass to the primary, traffic emissions recorded at the roadside and is unlikely to change without large reductions in traffic volumes. (APEG Report and LAQM.TG4 (00), para. 8.83).

The evidence from monitoring shows large current roadside exceedances of the Objective criteria for particulates. Since the significant source of particulates in these situations is emissions from road traffic, as it is for nitrogen dioxide, it is argued that any localised exceedances of the Objective criterion will be subsumed within areas identified as being likely to experience failure to meet the annual Objective for nitrogen dioxide. The ruling factor for determining the maximum extent of Air Quality Management Areas is thus the extent of exceedances of the annual mean Objective for nitrogen dioxide.

The significance of these conjectured exceedances for particulates will subsequently be of more importance for *policy* because people living in very close proximity to major roads may suffer exposure to high levels of particulates.

Some measures to reduce emissions of, and exposure to, nitrogen dioxide will also have a beneficial impact on levels of particulates. However, this will only be to the extent that *primary* particulate emissions can be reduced, since this is the only component susceptible to local control.

There is a number of issues to be resolved with respect to particulates:-

- The size fraction and chemical nature of particles responsible for ill-health.
- Appropriate monitoring technique and a satisfactory way of comparing data from different techniques.
- The role and amount of the re-suspended component of particulates near to busy roads.
- The reasons for the large error in the dispersion modelling.

Research is in progress on some of these issues on a national basis and further guidance will be issued by the DETR. It is proposed to focus in more detail on particulates in roadside situations within Leicester’s Air Quality Management Areas during the next round of Review and Assessment, in the light of this research.

For the present, it is concluded that:

(a) Failures to achieve the 24-hour mean (and perhaps the annual mean) Objectives for PM_{10} particulates may occur in close proximity to the major road network. However, any areas of exceedance will be subsumed within Air Quality Management Areas declared on the basis of exceedances of the annual Objective for nitrogen dioxide.

(b) These exceedances will be significant for persons residentially (or analogously) exposed.

(c) Due to the uncertainties of the modelling undertaken, it is NOT proposed to declare Air Quality Management Areas specifically on the basis of the Review and Assessment of PM_{10} particulates at the present.

(d) Some of the remedial measures appropriate for nitrogen dioxide will also have a beneficial effect on levels of particulates, although a large proportion of particulates (imported) are not susceptible to local control. Conversely, it is possible that some measures could have an adverse effect on particulate concentrations (e. g. significant increases in diesel emissions). Therefore, designated Air Quality Management Areas and the consequent Review and Assessment of air quality carried out under Section 84 of the Environment Act will take account of local sources of particulates.

(e) Further research is needed at national and at local level on particulates.

Part 4: SUMMARY AND CONCLUSIONS

4.1 The Main Conclusions

Air quality will improve significantly in Leicester between now and 2005 due to the combined effects of City Council and national policies. The main residual problem will relate primarily to nitrogen dioxide emissions from traffic: This will occur in situations in which people are exposed in close proximity to the major road network.

In the light of the Review and Assessment of air quality detailed in this Report, it is the opinion of the Leicester City Council that:-

The statutory Objectives for the following pollutants WILL be met by the respective prescribed dates:-

Benzene
1,3-butadiene
Lead
Sulphur dioxide
Carbon monoxide.

The annual statutory Objective for Nitrogen dioxide will NOT be met by the prescribed date, in some areas of the City.

It has not been possible to predict with certainty but it is considered likely that the hourly statutory Objective for nitrogen dioxide and both of the Objectives for PM_{10} particulates may NOT be met, at some situations very close to major roads, (within about 10 metres of roads having an average daily flow in excess of about 20,000).

It is considered that the maximum extent of exceedances of the air quality Objectives will be governed by areas of exceedance of the annual mean Objective for nitrogen dioxide. This is subject to the proviso that persons in close proximity to major roads may be subjected to levels of nitrogen dioxide and particulates considerably greater than are implied by the method used to determine the maximum areas of exceedance.

Subject to consultation, it is therefore proposed that the Leicester City Council designate Air Quality Management Areas in accordance with the areas identified on the map issued in conjunction with this Report: "Leicester City Council Review and Assessment of Air Quality, Stage 3, 2000: Proposed Air Quality Management Areas." (Fig. 1).

The key factor in all identified cases of locations where the statutory air quality Objectives will not be met is traffic emissions from the busiest roads in the City. Policy should therefore be directed toward the minimisation of the impact of these emissions.

4.2 Confidence in Conclusions.

There are many uncertainties in the Review and Assessment process: Emissions inventories are inevitably incomplete and based on simplifying assumptions. Predicted emissions inventories for future years are even more problematic: We cannot be certain how optimistic or pessimistic projected levels of activity and emission factors may be. Pollutant levels vary considerably from year to year with prevailing weather conditions; selection of annual different sets of meteorological data for model input therefore makes significant differences to predictions. Some of the inputs to the dispersion model are themselves model outputs, which have their own uncertainties. Apart from input data, models contain inherent simplifications and errors in predicting what is an enormously complex situation. The methodologies used for validation of the dispersion models and correction of future predictions are inevitably crude.

There are inevitably a few anomalies in the model inputs, due to constraints of time. Appropriate allowances have been made in interpreting the model output and framing proposals for Air Quality Management Areas.

Taking all of these considerations together with the overall uncertainties of predicting the future, this exercise cannot claim to have done more than to identify the major sources of the key pollutants and mapped out the approximate areas over which they will exceed the statutory Objectives by the prescribed dates.

Since the outcome of the Review and Assessment may have major implications for policy and future expenditure, it appeared reasonable to adopt a prudent approach. Notwithstanding this, significant sources of pollution have been identified which will cause extensive failures to meet the air quality Objectives and which therefore require action to protect human health.

These conclusions have been reached despite a number of reasonable but conservative assumptions built into the process, either due to constraint of circumstances or by conscious choice. This therefore gives Leicester City Council confidence in the predictions on which the recommended Air Quality Management Areas are based:

- Emissions inventory:

  This embodies a number of conservative features:-

  ▫Traffic growth estimates have been adopted which, while being realistic, are more complex and, in some areas, somewhat lower than the across-the-board 2% per year growth factor proposed in the Guidance.

  ▫Vehicle emission factors provided by the Government are used by Leicester City Council but are considered to be somewhat optimistic and not supported by trends in observed air quality monitoring data up to the present.

  ▫A number of area inputs, (e.g. gas usage by areas of private sector housing), while not being considered significant for the outcome, have, perforce been omitted from the inventory due to constraints of time and resources and non-availability.

- Background corrections for dispersion modelling:

  Rural rather than urban values of background have been adopted: In particular, the background correction applied to the annual mean predicted values for Nitrogen dioxide, which is the ruling factor in determining the extent of AQMA's, is taken from rural monitoring.

- Systematic correction factors for dispersion modelling:

  These have been found to cover a range from substantially positive to substantially negative, in proportion to distance from major highways. The negative level of correction typical of "background" sites has been applied in order to determine the extent of failure to achieve the annual mean Objective for Nitrogen dioxide, which is the ruling factor. This is done with the proviso that much higher levels may be experienced where exposure exists in very close proximity (< 10 metres) to busy roads. These are, in any event subsumed into the wider areas of exceedance and the main implication of is not for the definition of AQMA's but for subsequent policy.

- Meteorological inputs to dispersion modelling:

  Some years are atypical inasmuch as the weather conditions lead to higher than average levels of a particular pollutant for that year. Examples are 1996 for PM_{10} particulates, when an unusual prevalence of easterly air flows imported more particulates from continental Europe, and 1997, where the monitoring data for Leicester shows exceptional peaks of nitrogen dioxide. Such conditions may only be expected to occur once every five to ten years and consideration must be given to their relevance to defining AQMA's, with their implications for policy.

  In Leicester, dispersion model runs were, perforce, performed using meteorological data for 1999, since this was the only year for which monitoring data was available at a large number of Supplementary Credit Approval-funded sites, which could provide satisfactory model validation. Relatively speaking, 1999 represents a "typical" year for the key pollutants.

These matters will be carefully reviewed and, if appropriate, adjusted as appropriate during subsequent rounds of air quality Review and Assessment.

4.3 Determination of Air Quality Management Areas.

For the reasons explained in this Report, *"Setting AQMA boundaries will not be an exact science and local authorities will not be able to rely solely on empirical data for this"* (Guidance Note LAQM.G1 (00), *Framework for Review and Assessment of Air Quality,* para. 4.03).

The Objective exceedance with the widest extent is that caused by failure to meet the annual mean Objective for Nitrogen dioxide in 2005. This therefore becomes the ruling factor in delineating AQMA's and all other exceedances are likely to be subsumed within this zone. This is true for the hourly Objective for Nitrogen dioxide and the annual and 24-hour Objectives for PM_{10} particulates.

Where Air Quality Management Areas are declared, the first step is a further, more focussed Review and Assessment. (Environment Act, Section 84). In addition, the general process will be repeated at least once by the end of 2003. Leicester City Council's extensive real time monitoring network will allow trends in air quality to be followed and progress towards meeting the Objectives evaluated: Review and assessment of air quality is essentially an iterative process, whereby current techniques, data and the conclusions drawn from them will be progressively refined. Section 83 (2) of the Environment Act allows Air Quality Management Areas to be varied in the light of changing circumstances.

A more or less precautionary approach can be taken to applying estimates of modelling error to the drawing of boundaries. Air Quality Management Areas may be influenced by factors far beyond their boundaries and subsequent Action Plans will reflect this. In addition, the areas of exceedance identified have been adjusted outwards to logical, clearly-identifiable boundaries, when outlining Air Quality Management Areas.

The Order declaring AQMA's for Leicester is a legal document and the boundaries must be exactly defined. It is clearly both imprecise and unreasonable to the occupier to draw up AQMA boundaries dividing the curtilages of individual properties and the statutory Guidance allows adjustment of the defined area to include "logical" boundaries. It is also suggested that AQMA's so defined should cover an area greater, not smaller, than that suggested by the empirical data. (Guidance-note LAQM.G1, *Framework for Review and Assessment of Air Quality,* para. 4.03) Therefore Leicester City Council has adjusted the boundaries of recommended AQMA's are to align with features clearly identifiable on Ordnance Survey mapping, e. g. the nearest appropriate-

- Administrative boundary.
- Centre-line of a road, river etc.
- Property boundary-line.

Similarly, where "hotspots" of pollution have been identified, for example closely-spaced junctions or busier stretches along a major highway corridor, these have been combined within a larger AQMA zone covering the whole area. (LAQM.TG4 (00), para. 4.04).

Thus, the end-product of this Review and Assessment of Leicester's air quality is a simple map of the City with a single line showing the proposed AQMA. However, the steps by which this has been arrived at can be clearly traced back. In addition, this is, of course subject to statutory consultation and comments on how the areas have been drawn up are welcome during the consultation period:

Scheme of conversion of modelling outputs into AQMA’s:

Raw model output (E.g. Fig. 15).

Corrected model output (E.g. Fig 16).

Correction to suitable logical boundaries

Presentation of recommended AQMA's

Adjustment of AQMA's in the light of consultation

4.4 The Next Stages

4.4.1 Procedural Steps.

Following publication of this Report, Leicester City Council is required by Section 83 of the Environment Act to declare Air Quality Management Areas (AQMA's), based upon those areas where there is a predicted failure to meet any of the air quality Objectives. The statutory Guidance states that such areas should be designated within four months of completion of the Stage 3 Review and Assessment presented in this Report.

Section 84 (2) of the Environment Act 1995 then requires the City Council to prepare a time-based Air Quality Action Plan (AQAP), aimed at securing compliance with the Objectives. The aim should be to go to public consultation on the Action Plan within 9-12 months of designation of AQMA's and to have the Action Plan in place within 12-18 months of designation. The Action Plan must be time-based, although no specific deadlines are set.

The DETR's "suggested deadlines" for completion are detailed below:

June 2000*	Completion of Review & Assessment and submission of draft report to statutory consultees.
October 2000* (Within 4 months of AQ R & A report)	Completion of final report after consultation and formal designation of any Air Quality Management Areas (AQMAs)
November 2001 (Within 9-12 months of AQMA designation)	Completion of a more detailed review within AQMAs and preparation of a draft Action Plan for consultation.
May 2002 (Within 12-18 months of designation)	Action Plan should be in place.
December 2003	Completion of a second full Review & Assessment

* DETR recognises the difficulties in achieving these deadlines and has indicated that completion by December 2000 will be acceptable.

It can be seen from this Report that the key air quality issue in Leicester is that of emissions from motor vehicles. Therefore, appropriate policy objectives for the prospective Leicester City Council Air Quality Action Plan will be framed in terms of measures directed toward minimising exposure of the population to elevated levels of the identified traffic pollutants. The next step will be a further, detailed Review and Assessment of air quality in the Air Quality Management Areas, as is required by Section 84 of the Environment Act. This will run in tandem with the formulation of the Action Plan and both processes will also be subject to full, public consultation. The Council is well placed, with its air quality monitoring network and dispersion models, to assess progress toward the air quality Objectives and to evaluate different policy options.

Leicester City Council already has a broad environmental policy framework improvement in place. A comprehensive Air Quality Strategy was launched in 1998, which is cross-referenced to the key documents summarised below. These interlock with each other and provide a policy base on which the Air Quality Action Plan can be constructed.

It has not been possible at this stage to include an evaluation of the impact of many of these strategies now "in the pipeline" in the present Review and Assessment. The Action Plan will not necessarily imply a radical policy shift but will, to a large extent be integrated with the existing policy package. Nonetheless, their application will need to be reviewed carefully and in detail in relation to the Air Quality Management Areas. A matrix is presented in Section 4.4.3 of possible, generic policy options, as a starting point for this evaluation process.

The focus of the Review and Assessment Report is the impact of local air pollution emissions on the well-being of the population of Leicester: There are also pressing global sustainability and climate issues. In most cases, policy objectives relating to the two will be complementary: For example, reduction in the consumption of carbon based fuels will benefit programmes to reduce emissions of greenhouse gases. In a few cases, the respective policy analyses may point in different directions: An example is in the field of vehicle fuel policy. Diesel engines are relatively fuel-efficient but may emit greater volumes of nitrogen dioxide and particulates on our roads than other automotive options; conversely, electric vehicles may be virtually pollution-free at the point of use but the losses in generation and transmission of the electricity used to re-charge their batteries may result in relative global inefficiency. Again, the existing policy base will need to be re-assessed in order to establish priorities and to ensure that these are being pursued in the most appropriate way.

4.4.2 Existing Council Policies.

(a) The Strategic Direction.

Leicester City Council has an ongoing commitment to Integrity and Sustainability: This Strategic Direction is summarised in four core aims:

- Environmental Quality
- Economic Prosperity
- Social Justice
- Cultural Diversity

Apart from Environmental Quality, the other aims will not be neglected: Some disadvantaged groups are more likely to be exposed to adverse air quality, as inspection of the proposed Air Quality Management Areas reveals (Fig. 1).

(b) Leicester's Community Plan.

This document, which is essentially a compact between the different stakeholders in Leicester, is currently undergoing consultation. It details a number of goals in relation to the environment and in particular that *"to ensure that national…air quality standards are met, and increase awareness and understanding of air quality issues"*. In addition, it states a number of other policy goals relevant to this Report:

- *To slow and reverse the growth of car travel in Leicester.*
- *To increase the role and usage of public transport.*
- *To encourage cycling and walking.*
- *To encourage a partnership approach to pollution control between public bodies, industry and the community.*
- *To ensure that the Planning system protects and enhances the environment.*
- *To create a healthy living environment with good quality air…and housing… .*

(c) City of Leicester Local Plan (CLLP).

The Plan, which is currently under revision, is the principal land-use planning policy document which helps to guide and support development in the City. It complements the Leicester, Leicestershire and Rutland Structure Plan which comprise the relevant elements of the Development Plan for the City.

With primacy now being given to sustainability the integration of air quality and pollution issues into policy formulation will be a feature of the replacement Local Plan. At the heart of this are proposed three strategic policies:

- Scrutiny of development proposals in the Air Quality Management Area taking into consideration the requirements of the Air Quality Action Plan. This is also part of a general pollution policy.

- Reduction of energy consumption through transport and access linkages.

- Integrating Planning and Transport:-

  Developing sustainable forms of transport linkages; locating developments in most accessible locations and established centres; improvements to walking, cycling and public transport networks; promotion of mixed use developments; requirements for transport assessments and travel plans for large scale developments.

A sustainability appraisal of the policies of the draft plan has been undertaken. Each policy has been appraised against a set of Factors which include 'air quality' and 'transport mode'.

(d) Central Leicestershire Local Transport Plan (LTP).

Leicester City Council and Leicestershire County Council submit a joint bid for funds to improve local transport in “central Leicestershire” The Central Leicestershire Package Area has recently been extended to reflect more accurately the Leicester travel to work catchment area. The total population of the area is around 525,000, of whom approaching 300,000 live in the City. The first Local Transport Plan covers a five-year period from 2001 to 2006 and guidance issued by the DETR makes it clear that the Plan should take account of Local Air Quality Management issues.

The overarching strategy of the LTP is integration within and between types of transport and with land-use planning. Elements are included which interlock with Local Air Quality Management as well as with social inclusion, regeneration and other, wider aspects of Government policy.

The main priority is to improve local bus services, including the provision of more “Park and Ride” sites, and to improve safety for vulnerable road users, in particular cyclists and pedestrians.

(e) Leicester Local Agenda 21 (LAG 21) Action Plans.

This document reflects the City Council's role as a partner with other stakeholders in securing world-wide sustainable development. It sets out a vision for the future, guiding principle and supporting aims and main targets. These include:

- To improve air quality and achieve national air quality objectives by the year 2005.
- To extend the air quality monitoring network.
- To develop air quality modelling systems as a policy tool in relation to air quality, transport and land use planning.
- To reduce emissions from industry, transport and other sources in the City.
- To improve local air quality information systems and increase awareness and understanding of air quality issues.
- To encourage a partnership approach to pollution control involving public authorities, local industry and the community as a whole.

(f) Leicester City Council Eco-Management and Audit Scheme (EMAS) Manual.

This document defines the City Council's own standards of behaviour in relation to the environment. The Manual:-

- States the Council's Environmental Policy.
- Sets out Environmental Objectives and Targets.
- Provides a Register of the Council's environmental effects.
- Provides a Register of environmental legislation with which the Council must comply.
- Provides a Register of internal policies and international commitments.
- Sets out a management system and key tasks.

One environmental target is to reduce emissions of fleet vehicles by 2002, as follows:

- Sulphur dioxide by 98%.
- Total hydrocarbons by 42%.
- Nitrogen oxides by 12% of April 1997 levels.

4.4.3 Policy Objectives.

Emissions from road traffic are the key air quality issue in Leicester. Therefore, in order to improve air quality in the AQMA's, attention should be paid to the following variables:-

A. Numbers of vehicles flowing past critical points in the City. (Locations where people are exposed to excessive concentrations of traffic pollutants in AQMA's, over the relevant averaging periods).
B. Vehicle/miles within the LTP area.
C. Emissions per vehicle/mile.

Appropriate generic strategies to achieve each of these can be tabulated as follows:

Strategy	A	B	C
Transport modal shift	v	v	
Elimination of unnecessary travel / transport	v	v	
Redistribution of traffic flows	v		
Reduction in free-flowing traffic speeds			v
Reduction in congestion / queueing			v
Reduction in old / poorly-maintained vehicles in all / part of the area			v
Promotion of appropriate automotive technologies in all / part of the area			v
Avoidance of development where relevant exposure can occur in close proximity to major roads.	v		

The specific, existing strategies below can be evaluated against this matrix and modified or expanded as necessary.

4.4.4 Current Strategies for Improving Air Quality:

The following strategies can be identified from the City Council policies summarised above:-

- Encouraging modal shift (public transport, cycling and walking rather than car use).
- Reduction in the need to travel.
- Redistribution of traffic flows.
- Reduction in free-flowing traffic speeds.
- Reduction in traffic congestion.
- Reduction in old and poorly maintained vehicles.
- Promotion of cleaner automotive technologies.

- Reduction in nitrogen dioxide emissions from Council vehicle.

- Energy conservation measures.

- Regulation of emissions from industrial processes.

- Health Promotion, Information and Education.

- Avoiding sensitive development in close proximity to the major road network.

- Improvements in air quality monitoring and modelling capabilities. E.g. SCA approval for 2000-1 for two additional nitrogen dioxide monitoring stations in AQMA's.

4.4.5 Potential Additional Strategies.

It is not intended to pre-empt the public consultation stage or the further consultation on the Air Quality Action Plan. However, in order to act as a starting-point for the forthcoming public debate, the following links with existing policies could be tentatively put forward as part of the Action Plan. The list is no way meant to be definitive or exhaustive:

- Implementation of measures contained in the LTP which have not been taken into account in this Review and Assessment because they are not currently certain to be implemented or because their impact on air quality cannot be precisely quantified, e.g:

- Provision of additional park and ride sites.
- Public transport improvements.

- Introduction of traffic management strategies specifically focussed on reducing congestion and emissions (without causing problems elsewhere!).

- Reduction of speed limits on roads within AQMA's for air quality as well as safety reasons.

- Declaration of Low Emission Zones (LEZ's).

- Encouraging local improvements in vehicle emissions:

    - ◊ Publicity and education.
    - ◊ Partnerships with business etc.
    - ◊ Implementation of statutory roadside vehicle emissions testing powers (proposed for local authorities within AQMA's).

- Improvements in capability in order to refine future air quality predictions:

    - ◊ Air quality monitoring.
    - ◊ Emissions inventories.
    - ◊ Dispersion modelling.
    - ◊ Traffic modelling.

APPENDIX A: Additional Information Relating to the Stage 1 and 2 Review and Assessment, December 1998.

A.1 Nitrogen Dioxide: Survey of road links with current or projected annual average daily flows greater than 20,000.

Roads within Leicester City boundary with flows greater than 20,000 vehicles per day:

St Margarets Way between Vaughan Way and Abbey Lane.

Abbey Lane between St Margarets Way and Red Hill Circle.

Blackbird Road between Abbey Lane and A50 Woodgate.

Fosse Road North between A50 Groby Road and Henley Road.

Groby Road between Blackbird Road and Medina Road.

A50 Northgate/Woodgate between Sanveygate and Bassett Street.

Hinckley Road between Westcotes Drive and City Boundary.

New Parks Way between Hinckley Road and Scudamore Road.

New Parks Way between Park View and Groby Road Roundabout.

Groby Road between Brading Road and City Boundary.
King Richards Road between Fosse Road North and Narborough Road North.

St Augustine Road between Narborough Road North and St Nicholas Circle.

Narborough Road North between King Richards Road and New Park Street.

Narborough Road North between Braunstone Gate and Westcotes Drive.

Narborough Road between Upperton Road and City Boundary (Braunstone Lane).

Upperton Road between Narborough Road and Eastern Boulevard.

Walnut Street between Eastern Boulevard and Aylestone Road.

Aylestone Road between Infirmary Road and entrance to Transco.

Aylestone Road between Lansdowne Road and Grace Road.

Aylestone Road between Park Hill Drive and St James Drive.

Aylestone Road between Middleton Street and Soar Valley Way.

Lutterworth Road between Soar Valley Way and City Boundary.

Saffron Lane between Aylestone Road and Knighton Lane.

Saffron Lane between Grace Road and Burnaston Road.

Soar Valley Way between Lutterworth Road and City Boundary.

Glenhills Way between Lutterworth Road and Saffron Lane.

Asquith Way between Aberdale Road and Welford Road.

Welford Road between Newarke Street and City Boundary.

Counting House Road between Almond Road and Freemans Common Road.

Freemans Common Road between Counting House Road and Aylestone Road.

Almond Road between Welford Road and Aylestone Road.

St Nicholas Circle.

Southgates Underpass.

Southgates between St Nicholas Circle and Oxford Street.
Oxford Street between Southgates and Infirmary Road.

Infirmary Road between Oxford Street and Aylestone Road.

Newarke Street between Southgates and Welford Road.
Carlton Street between Welford Road and Oxford Street.

Waterloo Way between Welford Road and St Georges Way.

Regent Road between King Street and Granville Road.

Granville Road between London Road and Regent Road.

London Road between St Georges Way (Railway Station) and City Boundary.

St Georges Way between Waterloo Way and St Matthews Way.

St Matthews Way between St Georges Way and Burleys Flyover.

Burleys Flyover.

Burleys Way between Burleys Flyover and St Margarets Way.

Vaughan Way between St Nicholas Circle and St Margarets Way.

Humberstone Road between St Georges Way and Uppingham Road.

Uppingham Road between Humberstone Road and Scraptoft Lane.

Uppingham Road between Downing Drive and City Boundary.

Glenfrith Way between Groby Road and Anstey Lane.

Anstey Lane between Glenfrith Way and City Boundary.

Dysart Way between Humberstone Road and Belgrave Circle.

Belgrave Gate between Orchard Street and Belgrave Flyover.

Belgrave Flyover.

Belgrave Road between Belgrave Flyover and Melton Road.

Melton Road between Belgrave Road and City Boundary.

Catherine Street between Stubbs Road and Ulverscroft Road.

Loughborough Road between Checketts Road and Thurcaston Road.

Red Hill Way between Halifax Drive and Red Hill Circle/ Watermead Way.

Watermead Way between Red Hill Circle and Melton Road.

A6 Loughborough Road between Red Hill Circle and City Boundary.

Gipsy Lane between Catherine Street and Barkby Road.

Humberstone Lane between Troon Way and Barkbythorpe Road.

Roads with current annual average daily flows greater than 20,000 vehicles per day, which, although outside the boundaries of the City of Leicester, are considered to be likely to have an air quality impact by virtue of their importance and close proximity:

A46 Leicester Western Bypass.

Newarke Road / Syston Bypass (A607), northwards from the City boundary.

The A50, Groby Road, westwards beyond the City boundary.

The A50 southwards beyond the City boundary (Leicester Road, Wigston etc.)

The A6 northwards beyond the City boundary.
The A6 south-eastwards beyond the City boundary (Leicester Road, Oadby etc.)

Lubbesthorpe Way (A563) (southern end).

Narborough Road South (A5460)

M1 Junction 21 Approach and Narborough Road South roundabout.

Fosse Park Avenue.

M1.

M69.

A.2 PM10 Particulates: Survey of road links with current or projected annual average daily flows greater than 25,000.

Roads with current annual average daily traffic flow greater than 25,000 were identified as follows:.

St Margarets Way between Vaughan Way and Ravensbridge drive.

Abbey Lane between Abbey Park Road and Red Hill Circle.

Blackbird Road between Abbey Lane and Parker Drive.

Blackbird Road between Anstey Lane and Devonshire Road.

Fosse Road North between Groby Road and Tudor Road.

Hinckley Road between New Parks Way and Gooding Avenue.
Hinckley Road at Golf Course Lane.

King Richards Road between Glenfield Road and Narborough Road North.

St Augustine Road between Narborough Road North and St Nicholas Circle.

Narborough Road North between King Richards Road and New Park street.

Narborough Road between City Boundary (Braunstone Lane East) and Upperton Road.

Upperton Road between Narborough Road and Eastern Boulevard.

Walnut Street between Eastern Boulevard and Burnmoor Street.

Soar Valley Way between Lutterworth Road and City Boundary.

Glenhills Way between Lutterworth Road and Wootton Rise.

Asquith Way between Aberdale Road and Welford Road.

Welford Road between Newarke Street and City Boundary.

London Road between Railway Station and Victoria Park Road.

London Road between Holmfield Road Sandown Road.

London Road between Stoughton Road and City Boundary.

Saffron Lane between Knighton Lane East and Knighton Lane.

Saffron Lane between Heathcott Road and The Fairway.

Aylestone Road between Infirmary Road and Saffron Lane.

Counting House Road between Almond Road and Freemans Common Road.

Freemans Common Road between Counting House Road and Aylestone Road.

St Nicholas Circle.

Southgates between St Nicholas Circle and Oxford Street.

Oxford Street between Southgates and Infirmary Road.

Infirmary Road between Oxford Street and Aylestone Road.

Newarke Street between Southgates and Welford Road.

Carlton Street between Welford Road and Oxford Street.

Waterloo Way between Welford Road and St Georges Way.
St Georges Way between Waterloo Way and St Matthews Way.

St Matthews Way between St Georges Way and Burleys Flyover.

Burleys Flyover.

Burleys Way between Burleys Flyover and St Margarets Way.

Vaughan Way between St Nicholas Circle and St Margarets Way.

Humberstone Road between St Georges Way and Mornington Street.

Dysart Way between Humberstone Road and Freehold Street.

Belgrave Gate between Burleys Way Roundabout and Belgrave Flyover.

Belgrave Flyover.

Belgrave Road between Belgrave Flyover and Loughborough Road.

Uppingham Road between Freeman Road North and Scraptoft Lane.

Loughborough Road between Red Hill Circle and City Boundary.

Watermead Way between Red Hill Circle and Melton Road.

Melton Road between Troon Way and City Boundary.

Glenfrith Way between Glenfrith Close and Anstey Lane.

Anstey Lane between Glenfrith Way and City Boundary.

New Parks Way between Aikman Avenue and Groby Road Roundabout.

Groby Road between Groby Road Roundabout and (New Parks Way) and City Boundary.

Almond Road between Welford Road and Aylestone Road.

Southgates Underpass.

Roads with current annual average daily flows greater than 25,000 vehicles per day, which, although outside the boundaries of the City of Leicester, are considered to be likely to have an air quality impact by virtue of their importance and close proximity:

A46 Leicester Western Bypass.

M1 Junction 21 Approach and Narborough Road South roundabout.

Fosse Park Avenue.

M1

M69.

Newarke Road / Syston Bypass (A607), northwards from the City boundary.

A50 Groby Road, Westwards beyond the City boundary.

Narborough Road South (A5460).
Soar Valley Way.

A6 northwards from the City boundary.

The A6 south-eastwards from the City boundary (Leicester Road, Wigston etc.)

The A50 southwards from the City boundary (Leicester Road, Oadby etc).

Lubbesthorpe Way (Southern End).

A.3 Summary of Industrial Sources of the Specified Pollutants.

Tabulation of industrial sites regulated under Part I of the Environmental Protection Act 1990 and identified in Annexes 1 and 2 of the *Pollutant Specific Guidance* as meriting preliminary investigation as significant sources of the relevant pollutants. (See Fig. 22). All sources eliminated from consideration.

Table A3/1: Summary of IPC processes

Process	**Company**	**Address**	**Description**	**Sch.1***	**Emissions**	**OS grid reference**
Organic Chemicals	Bostik Ltd	Abbey Park Road	Pilot plant	4.2A (D)	Benzene 1,3-Butadiene NO2 PM10 SO2	SK 588059
	Bostik Ltd	Ulverscroft Road	Process 1: Polyester/Polyurethane adhesives	4.2A (D)	Benzene 1,3-Butadiene NO2 PM10 SO2	SK 622073
			Process 2: Polyamide manufacture	4.2A (D)	Benzene 1,3-Butadiene NO2 PM10 SO2	SK 622073
	Organic Specilalities	104 Cannon Street	Organic Chemical Manufacture	4.2A (D)	Benzene 1,3-Butadiene NO2 PM10 SO2	SK 622073
Halogens	G.C.Metals	53 Wellington St	Small scale recovery of Au/Ag by dissolving scrap in HCL/Nitric acid mix.	4.4A (F)	NO2 SO2	SK 590039
Inorganics	G.E. Lighting	Melton Road	Light bulb manufacture: -low pressure sodium lamps -tungsten filament production	4.5A (D)	CO Pb SO2 NO2 PM10	SK 605081
Rubber	Metalastik	Evington Valley Road	Anti-vibration mounts Automotive hose	6.8	1,3-Butadiene	SK 610037

*Section of Schedule 1 of the *Environmental Protection (Prescribed Processes and Substances) Regulations* (as amended).

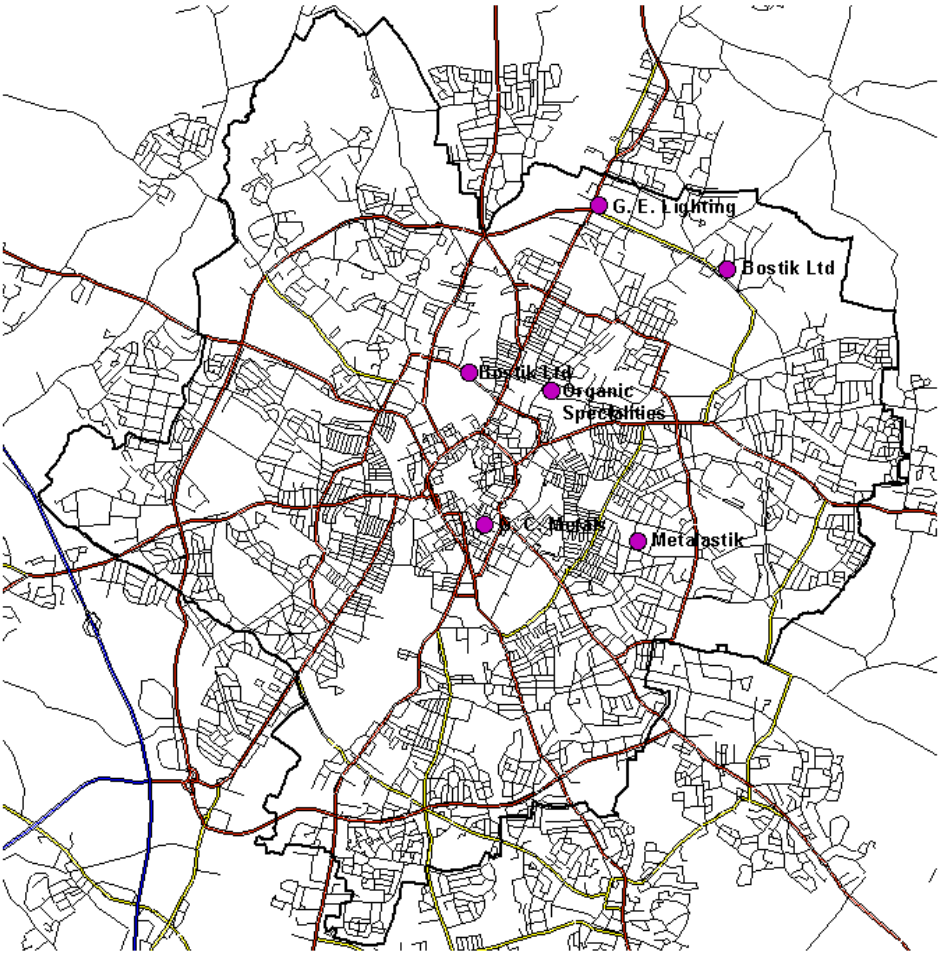


Figure 22

EPA Authorised Potential Sources of Pollutants of Interest

● EPA Authorised Processes

APPENDIX B: The Monitoring Network: Description of Methods and Quality Assurance/Quality Control.

B.1 The Leicester AUN site.

The Leicester Centre Urban Background monitoring site, to which reference is made in this Report, forms part of the DETR national air quality network and is managed under contract by Leicester City Council.

It is located at grid reference SK 587 041 and its position is shown on Fig 3.

The station contains automatic analysers calibrated to a high standard which measure oxides of nitrogen (NO and NO_2), sulphur dioxide, carbon monoxide, PM_{10} particulates and ozone.

The data is transmitted to a central point for validation and used in databases, public and national bulletins.

Protocols for operation, calibration and data management are nationally recognised and well-documented. This information, together with details of matters such as principles of operation of the analysers is readily available in the technical manuals and reports listed in Appendix G 4 (*References, Technical*) below; readers requiring further detail are referred to those documents.

It should also be noted that this material forms much of the basis of the operation of the Leicester City Council automatic monitoring sites described below.

B.2 Leicester City Council Automatic Monitoring Sites.

B.2.1 Site Locations.

The table below shows the current position and the site locations are also shown on Fig. 3.

Table B.2.1:

Site (Grid Ref.)	**Site Category (kerb distance, m.)**	**Start Date (End date)**	**Pollutants Measured**					**Fortnightly Manual Gas Calibration**
			CO	**NO_2**	**0_3**	**SO_2**	**PM_{10}**	
Bassett St. SK 577 054	Roadside (11.8) [from Woodgate (A50)]	Apr 1997		**x**				Yes (from Sept 1998)
Saffron La. SK 585 019	Roadside (2.5)	Jan 1997 (Feb 1999)		**x**				No
Imperial Ave. SK 572 030	Roadside (3.3)	June 1998		**x**			**x**	Yes (from Oct 1999)
Abbey La. SK 558 068	Roadside (8.0) [From Abbey Lane}	Sept 1998		**x**			**x**	Yes (from Sept 1998)
Melton Rd SK 595 063	Roadside (2.5)	Sept 1998		**x**			**x**	Yes (from Sept 1998)
Glenhills Way SK 570 001	Roadside (3.8)	May 1999		**x**				Yes (from May 1999)
LAMS Marydene Drive SK 633 030	Suburban 380 [approx.]	Oct 1998	**x**	**x**	**x**	**x**	**x**	Yes (from Oct 1998)
Mobile Air Quality monitoring Station	Mobile Van	June 2000	**x**	**x**			**x**	Yes (from June 2000)

"**x**" indicates species monitored.

The Leicester Air Quality Monitoring Station ("LAMS") is a relocatable unit containing equipment equivalent to that contained in the Leicester Centre AURN site.

Issues relating to the quality of data from this unit are discussed below.

B.2.2 Quality Assurance/Quality Control.

B.2.2.1 General

The following notes apply to the Leicester City Council automatic monitoring sites as currently operated. There is a body of historical data from the relocatable Leicester Air Quality Monitoring Station ("LAMS") which does not conform to these protocols in all respects. Also, although most deployments were for a period of, typically, 3-6 months, there is a full year of data from its deployment at Rushey Mead School, Harrison Road during 1997 and 1998.

Notwithstanding this, it is felt that these data are sufficiently robust and well-correlated with data from the Leicester Centre AURN site to be used for the purposes of the Stage I/II Air Quality Review and Assessment.

B.2.2.2 Quality Assurance/Quality Control.

(a) Site Selection

There are eight air quality monitoring stations located around the City of Leicester. Six of these are fixed point stations (including the AUN), one is a mobile station which has previously been moved around the city every 6-12 months, and the eighth is a recently purchased mobile air quality monitoring van. All of the monitoring stations contain automatic real-time analysers that produce high resolution measurements (15 minute to hourly averages). Therefore the measurements can be compared directly to the air quality standards for each pollutant.

The air pollutants monitored in Leicester are: carbon dioxide, sulphur dioxide, oxides of nitrogen, ozone and PM_{10} particulates. The combination of pollutants measured at each site varies and is shown in the above Table, together with other site details. The locations are a combination of urban background, roadside and suburban sites and have been selected because they have been identified as the most likely to have air quality problems and be broadly representative of population exposure. A combination of model simulations, traffic flow data and passive tube data were used to identify these possible hotspots.

(b) Equipment Selection

Even though the operating principle used to monitor each pollutant is based on the most accurate and proven analytical technique for the pollutant measured, the equipment type at each site varies. Therefore to maintain uniform operating standards and measurement methods, only analysers that have been type tested and approved by NETCEN (the QA/QC unit of the DETR) for use in the DETR Network, have been selected. This ensures the intercomparability of data from different sites even when the equipment type varies (but see Appendix B2.2.4 concerning particulate analysers).

(c) Equipment service and Maintenance

A service agreement is in place for each analyser. If the analysers malfunction an engineer is called out immediately to minimise data loss. Also, every six months the manufacturer's recommended service is carried out together with preventative maintenance checks and reviews of the entire system and its operation. When each site is visited for the fortnightly calibration, the filters are changed, the

PM_{10} inlets cleaned and the equipment performance is verified by checking the internal instrument parameters.

(d) Calibration

The NO_x, SO_2, and CO analysers perform an internal automatic daily two point calibration (zero / span) to check for analyser malfunction. The zero check is made by air being passed through a chemical scrubber within the analyser to remove the pollutant. Within the NO_x and SO_2 analysers, span checks are made by internal permeation tubes that release a known concentration of NO_2 and SO_2. The CO analysers do not contain an internal permeation tube. Instead, a known concentration of CO is released from a cylinder of compressed CO gas connected to the analyser. The ozone analysers use a UV lamp to produce ozone which is an integral part of the analyser. These daily calibrations can be checked remotely and used to identify analyser malfunction, but cannot be used to scale ambient data.

To check the equipment response and scale the data, a manual two point calibration is carried out fortnightly. A zero check is made as above and a span check is made by passing accurately predetermined concentrations of SO_2, CO, NO and NO_2 gases through the analysers from connected compressed gas cylinders. The compressed gases used are of known concentration which are traceable to National Standards. During high pollution episodes, calibration is avoided to avoid important data losses.

At the moment, performance audits and intercalibrations are not carried out at any of the monitoring sites (except for the AUN). Accuracy of the data for each site (prior to installation of gas calibration) cannot be fully demonstrated in terms of comparability with AUN sites but “best practice” was used at each site with much of the AUN QA/QC procedure followed. The data is therefore robust and well-correlated with AUN data and can still provide valuable indicative information about the extent of pollution incidents.

(e) Accuracy and Precision

> **Accuracy** is defined as *“the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value.”*
>
> **Precision** is *“the closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions.”*

The accuracy and precision of air pollution measurements depends on many factors throughout the entire measurement chain. Calculating values for these is complex and not within Leicester City Council’s scope. However, these values have been estimated for the AURN by NETCEN. The values have been determined from calibration chains and from “in service” and “in laboratory” measured instrument characteristics.

As many aspects of the AURN QA/QC procedures are mirrored in Leicester’s Air Quality Monitoring QA/QC procedures, the same values for the accuracy and precision have been applied to measurements made in Leicester.

The estimates for the AUN (to within 2 standard deviations) are given below:

Table B.2.2: Performance data for monitoring

Pollutant	**Accuracy Estimate for AUN (2s)**	**Accuracy Objective in LAQM.TG1 (00)**	**Precision (2s) Estimate for AUN**	**Data Capture Objective In LAQM.TG1**
SO_2	± 10%	± 15%	± 1.2ppb (3.2 µg/m^3)	90%
CO	± 8%	± 15%	± 0.6ppm (0.7 mg/m^3)	90%
NO	± 10%	± 15%	± 2.5ppb (3.1 µg/m^3)	90%
NO_2	± 10 - 11%	± 15%	± 3.5ppb (6.7 µg/m^3)	90%
O_3	± 11%	None	± 2.0ppb (4 µg/m^3)	None
PM_{10}	Unknown	± 25%	± 4µg/m^3	90%

Based on the above estimates, NETCEN have suggested an accuracy of ± 10% as a good working figure when assessing any air quality data. All data from our monitoring stations quoted in this report are presented with the data capture figure which can be compared to the objective in LAQM.TG1 (00).

B.2.2.3 Data Management, Validation and Ratification

(a) Data Collection and Validation

Raw data (15 minute averages except for BAM PM_{10} analysers which give hourly data) is collected remotely from the analysers via modems controlled by the monnet software from SEIPH. Data is collected every 6 hours and checked each weekday morning. During this check, data is either flagged as valid or excluded if the analyser is malfunctioning or performing a calibration. Unexplained gaps in the data are investigated (by a site visit if necessary) and reported to the appropriate contract service engineer for investigation.

After each fortnightly calibration the scaling factors are entered into the "MONNET" software and the data is automatically scaled using these factors on collection. Copies of the raw data are kept in a database in case of queries.

(b) Data Ratification.

Every three months, the collected data is reviewed during the ratification process.

The processed data is inspected manually to check if it contains unusual or unlikely measurements, taking into account:

- Analyser history / characteristics.
- Calibration factors: Drift; negative or out of range data.
- "Spikes" in data.
- Characteristics of monitoring site.

- Effects of meteorology.
- Time of day / year.
- Relationship between different pollutants.
- Results from other sites.

Any obviously high or low values are removed, on the basis of experience of these factors for each site. Data is eliminated which has been coded by the analysers as bad data.

Once the data has been checked then a program is run which interpolates between calibration factors. This smoothes out the scaling factors between each calibration. The final data can then be analysed, either in a spreadsheet or by using queries to calculate statistics from the SQL database.

The data from 1999 presented in this report was collected by an older program and parsed into "MONNET" and then scaled as mentioned above. All data presented in this report is fully validated.

B.2.2.4 Issues in the Interpretation of Particulate Data from TEOM (Tapering Element Oscillating Microbalance) and BAM (Beta Attenuation Monitor) Instruments.

Two sites were installed Leicester in 1998 which use Beta Attenuation Monitoring ("BAM") equipment to measure particulates. Unlike the EC Reference Method, the BAM technique is not directly gravimetric but infers mass from the ability of particulates to attenuate Beta radiation. The mass of PM_{10} deposited on a filter substrate every 50 minutes is calculated from the known mass absorption coefficient of beta particles passed through the collected material.

Although this equipment is type-approved for installation in AURN sites, there are difficulties in making comparisons with data collected both by the TEOM system and the European Reference Method:

The BAM instrument does not pre-heat sampled air to a constant temperature whereas the TEOM does, with the aim of eliminating interference from particle bound water: It is now known that a significant and variable fraction of particulates is volatile: The TEOM therefore under-records compared to instruments which sample at around ambient temperature because the volatile component is not captured. The relationship between the two responses is not linear because, in the case of non-pre-heating instruments, the proportion of volatilisation will vary with ambient temperature and relative humidity.

The South East Institute of Public Health (SEIPH) has published a survey in which the responses of different particulate monitors is compared and to which the present discussion is indebted. (South East Institute of Public Health, *Particulate Monitor Comparison, Marylebone Road,* David Green, June 1999). This study compared instruments running simultaneously both at one location and at different, comparable sites. Although it is acknowledged that further work is needed, the relevant main conclusions were as follows:

Marked differences were noted between the results from TEOM and BAM sites in the Greater London area, the latter often exceeding the former by as much as 100%. The largest deviations appeared to coincide with a change in the direction of the wind to easterly.

The recorded values from the BAM, while being higher than those from the comparative gravimetric method used in the trials, showed a relatively uniform difference in percentage terms over the entire range of measured values. Conversely, the differences between the TEOM and the gravimetric method tended to vary with gravimetric mass of particulates.

A secondary (summer) pollution episode, during anticyclonic conditions accompanied by an easterly air-flow across the country, was analysed. Under these conditions, secondary particles imported from the continent would be expected to be the predominant form.

The differences between BAM and TEOM results were not constant but attained their highest values in the early morning. This time of day would experience lower temperatures, low wind speeds and high relative humidities. Since secondary particles are hydroscopic, they will increase in mass at these times giving higher readings with BAM instruments. On the other hand, TEOM instruments will volatilise and therefore miss some of this secondary component due to their higher sampling temperature.

In comparison, a run of primary (winter) pollution episodes was also examined. Temperature inversion and very low wind speed allowed traffic pollution to accumulate at ground level. Under these conditions, local, primary emissions would be expected to predominate and, indeed levels of PM10 were seen to vary closely with nearby traffic flow. Because particulates from this source are non-volatile, the BAM and TEOM rose and fell together and there was uniformity in the percentage differences between the results from the two instruments. I.e., in contrast with secondary episodes, there was a more or less linear relationship between the response of two techniques during episodes of this type. Clearly, in practice, the linear and non-linear responses will often be superimposed, depending on the relative proportions of primary and secondary particles present.

In summary, the relationship between BAM and TEOM results for the same period was found to be complex and dependant upon the composition of the prevailing particulates, in particular the proportion of volatile components that were not measured by the TEOM. This in turn depended on the meteorological conditions driving a particular pollution incident. Comparisons between the two methods will be more reliable during winter (primary) particulate episodes than during summer (secondary) episodes. During relatively low prevailing levels of particulates, the relationship will depend on several variables, e.g. temperature, relative humidity, wind speed and direction, traffic flow; it will be correspondingly complex and difficult to analyse.

It is presumed, for the reasons given, that similar considerations will apply to the relationship between TEOM results and those obtained by the EC Reference Method. Notwithstanding attempts to establish an adjustment factor between the two (multiplying TEOM values by 1.3), similar difficulties will arise in interpreting TEOM data in terms of the AQDD-based Objective, which is founded on the Reference Method.

Because the BAM and the EC Reference Method share the characteristic of sampling air at ambient temperature, it would be expected that results from the BAM would correlate more closely with the latter than those from devices which pre-heat inlet air, e.g. the TEOM. It may therefore be possible, with appropriate research, to derive a correction factor for BAM data which is more reliable over a range of conditions than that posited for the TEOM method.

The respective use of BAM or TEOM data relating to the same period at the same, or similar locations, has the potential to produce significantly different outcomes in terms of the statutory Review and Assessment.

This experience has been borne out in Leicester: Comparisons of data collected simultaneously from TEOM and BAM sites do in fact indicate that values obtained by the BAM instruments are often considerably elevated, compared to TEOM data from apparently comparable sites. However, the sites of BAM instruments are at kerbside positions on very busy roads so there may be genuine site-specific effects in operation.

In practice, the interim advice given in LAQM.TG4 (00) has been followed: In the main body of this Report, TEOM data is quoted both as validated and with a correction factor of 1.3. BAM data is quoted as validated.

B.3 Roadside Pollution Monitors (RPM's).

The Roadside Pollution Monitor (RPM) is an electro-chemical device for measuring carbon monoxide at kerbside sites in real time and transmitting the data to a central point. An air analyser module, containing the air sampling equipment and gas sensors, a processor module and a power supply are housed in a standard roadside traffic controller enclosure.

Recommended data quality objectives for carbon monoxide monitors are based on an EC common position paper on monitoring of CO and Benzene. (Guidance note LAQM.TG1 (00), *Review and Assessment: Monitoring Air Quality):*

Accuracy:	15%
Minimum data capture:	90%

In addition, however, to calculate the 8-hour running mean specified in the air quality Objective for carbon monoxide, at least 75% data capture is required for each 8-hour period, i.e. 6 hourly means out of the 8 possible must be valid.

For carbon monoxide determinations, the instruments are specified to an accuracy as follows, within an acceptable temperature range of –10^{o} C to 40^{o} C:

Table B.3/1: Accuracy of RPM's

Level, mg.m^{-3} (ppm)	Accuracy (+/- %)
0.58 (0.5)	20
1.16 (1)	12
>2.32 (> 2)	7

It can be seen that accuracy of the method lies outside the acceptable range for low levels of carbon monoxide.

The data capture for this technique also falls substantially below the recommended values, as can be seen from the following table:

Table B.3/2: Data Capture of RPM Sites:-

RPM site	1997	1998	1999
	Data Capture	Data Capture	Data Capture
Melton Rd/ Troon Way	46	57	72
Welford Rd/ Oakland Rd	45	45	65
Soar Valley way/ Lutterworth	37	61	55
Hinckley Rd/ Woodville	48	54	63
Uppingham/ Colman	24	65	67
Vaughan Way/ St Margarets	41	70	67
Narborough Rd/ Fullhurst Av	9	49	64
Newarke Street	-	49	73
A50/ New Parks Way	43	66	68

Data capture lies in the range 9 – 73%, with a mean for 9 sites over 3 years of around 50%.

Due to inherent and apparently insoluble difficulties with the temperature stability of this technique when used to monitor nitrogen dioxide and sulphur dioxide, the data for these species were rejected for the purposes of this Review and Assessment. This phenomenon may, indeed, cast some doubt on the integrity of RPM data for carbon monoxide.

Data from this source must therefore be regarded with some reserve. It is also the case that those sites which show a small number of exceedances of the Objective are situated at kerbside locations deliberately selected to be at or near the junction of two of the busiest roads in the area, where exposure over the averaging period of the Objective is not an issue.

For these reasons, data from the RPM's have not been used for the purposes of validating dispersion models.

B.4 Nitrogen Dioxide Diffusion Tube Surveys.

B.4.1 Summary of Method

Where NO_2 is monitored using diffusion tubes, the standard method recommended by NETCEN in the "*UK NO_2 Diffusion Tube Survey Instruction Manual*" is followed. (This method is based on the Harwell Laboratory Report, reference AERE-R12133, "*Measurement of NO_2 in the Outdoor Environment Using Passive Diffusion Tubes*", C.H.F. Atkins, February 1996).

NO_2 diffusion tubes are clear plastic tubes, with one open end and a closed end containing a NO_2 absorbing chemical matrix (triethanolamine). The open end is sealed with a plastic cap before it is transported to the site. At the site, the cap is removed and the tube is mounted vertically with the open end at the bottom.

The device operates on the principle that during exposure nitrogen dioxide in air will migrate to the absorbent at a rate dependant on several quantifiable variables defined by Fick's First Law of Diffusion:

- The path length between the top surface of the monitor and the absorbent matrix
- The cross sectional area of the sampler
- The exposure time
- The diffusion coefficient of nitrogen dioxide through air
- The ambient concentration of nitrogen dioxide

At the end of the monitoring period, the tubes are re-sealed and returned to the laboratory where they are analysed by a colorimetric method.

B.4.2 Description of Monitoring Sites

B.4.2.1 General:

In Leicester, diffusion tubes have been used to monitor nitrogen dioxide since 1992. Currently there are 41 sites which consist of : 4 UK Survey sites, 10 permanent sites (since 1992), 4 continued from previous city wide surveys and 23 for a survey started in April 1998. (See Fig. 12).

These tubes are used to monitor general urban air pollution therefore are not located close to industrial sources. The sites that have been selected are in areas where people are present. Local knowledge has been used to select the most appropriate sites, which fall into three categories:

(a) Near-road site (kerbside):

These are situated close to a busy road (1-5 m from a kerb edge). This is to show the maximum concentration of NO_2 to which people may be exposed (even if it is only for short periods).

(b) Intermediate:

These are sites at distance of 20-30m from a busy road. These are to show how much NO_2 people living close to busy roads are exposed to. In Leicester, large numbers of people live in areas close to busy roads. Here the NO_2 may not be as high as that measured close to the road, but may not be as low as typical urban background locations.

(c) Urban background:

These are sites at least 50m from a busy road. At these locations, the NO_2 concentrations will have equilibrated to a general urban background level.

B.4.2.2 Long term (ten site) Survey

A ten-site survey has been in progress since 1993, with diffusion-tubes being exchanged at each site monthly. Monthly data is therefore available for complete years from 1993 to 1997 inclusive, apart from minor gaps.

B.4.2.3 Specific Surveys

The following short-term surveys have been carried out in Leicester:

- The Woodgate Survey (Oct 1995 - May 1996).
- The Belgrave / Melton Road Survey (Oct 1995 - Jan 1996).
- The Enderby Survey (Apr 1996 - Apr 1998)

Particulars are shown in the following Tables (Section B.4.4), which summarises Leicester's current and previous NO_2 diffusion tube sites, including category of site, OS co-ordinates and date when monitoring began. (See also Fig. 12).

B.4.3 Quality Assurance and Quality Control

B.4.3.1 Diffusion tube preparation and handling

The interval between preparation and analysis is kept to a minimum (NO_2 tubes are known to degrade with storage). During storage the tubes are kept in a sealed plastic bag in a refrigerator. A blank tube is sent which is remains in the sealed bag in the refrigerator during the monitoring period and is returned with the rest of the tubes to the laboratory.

The analytical laboratory used (Lambeth Scientific Services Limited, Arlington Lodge, 26 Wanless Road, London, SE24 0HW) takes part in a performance testing scheme set out by NETCEN.

B.4.3.2 Diffusion tube positioning

The tubes are mounted on a mixture of lamp posts and drain pipes. No tubes are placed in recesses or corners as these can be subject to increased turbulence or stagnant air. Ideally, the tubes should be mounted on to spacer blocks (e.g. block of wood) and not attached directly to any surface. However, this makes them more prominent, therefore more prone to theft. Therefore, only the four tubes in the UK NO_2 Survey are mounted in this way. Ideally, tubes should be placed head height, but some have been placed higher where they are unlikely to be stolen.

Each site has a unique number and therefore the tube exposed at that site is given the same number so it can be identified during analysis. A careful record is made of the start and end date / time of the exposure period.

B.4.3.3 Time exposure and limitations of technique.

The time resolution of this technique is limited and can only provide information on the integrated average NO_2 concentration over the exposure period (typically 1-4 weeks). The tubes in Leicester are exposed for approximately 4 weeks. Therefore the tubes cannot be used to check compliance with average hourly and daily air quality standards.

However, they have been used for:

- estimation of the liklihood of non-compliance with short- or long-term standards.
- identification of hotspots within the City which may require more detailed studies.
- baseline surveys.
- area screening
- indicative monitoring.

B4.4 Tables of Location and Classification of NO_2 diffusion tube sites in Leicester.

Key to site location classification:

K = kerbside
I = intermediate
B = background

Table B4.4/1 Permanent Sites.

TUBE NO.	ORDNANCE SURVEY COORDINATES	LOCATION	CATEGORY	START DATE
1	SK583 028	Permanent Site: Raw Dykes Road (Electricity board).	I	Mar 92
2	SK564 042	Permanent Site: 1 Meadhurst Road.	I	Mar 92
3	SK565 060	Permanent Site: 3 Copeland Avenue.	B	Mar 92
4**	SK569 080	Permanent Site: 86 Blackthorn Drive.	B	Mar 96
5	SK600 072	Permanent Site: Melton Road (Police Station)	K	Mar 96
6	SK614 053	Permanent Site: 138 Uppingham Road	K	Mar 96
7	SK591 051	Permanent Site: St. Mathews Wy (Costa Brava Restaurant)	K	Mar 96
8	SK607 022	Permanent Site: Regency Hotel, 360 London Road	I	Mar 96
9	SK582 002	Permanent Site: 3 Stonesby Avenue	I	Mar 96
10	SK587 040	Permanent Site: Leicester City Council (AUN site).	I	Mar 96
11	SK593072	Belgrave Corridor Survey: 316 Loughborough Road	K	Apr 98
12	SK586069	Belgrave Corridor Survey: Beaumont Leys Lane/Abbey Lane	K	Apr 98
13	SK584066	Belgrave Corridor Survey: 182 Abbey Lane	I	Apr 98
14	SK587071	Belgrave Corridor Survey: 320 Abbey Lane	I	Apr 98
15	SK554 041	Woodgate Survey: J.R. Camping, Oswin Road	K	Apr 98
16	SK591054	Belgrave Corridor Survey: Belgrave Gate (before flyover)	K	Apr 98
17	SK593057	Belgrave Corridor Survey: Belgrave Rd (just after flyover)	K	Apr 98
18	SK565019	Belgrave Corridor Survey: Narborough Rd South/Braunstone Ln East	K	Apr 96
19	SK595061	Belgrave Corridor Survey: Belgrave Road (opposite McDonald Rd).	K	Apr 98
20	SK595064	Belgrave Corridor Survey: Melton Rd/Loughborough Road	K	Apr 98
21	SK597066	Belgrave Corridor Survey: Melton Rd / Broadhurst Street (nursery)	K	Apr 98
22	SK598071	Belgrave Corridor Survey: Checketts Road / Melton Road	K	Apr 98
23	SK601074	Belgrave Corridor Survey: Lanesborough Road / Melton Road	K	Apr 98
24	SK604082	Belgrave Corridor Survey: Troon Way / Melton Road	K	Apr 98
25	SK583062	Belgrave Corridor Survey:	K	Apr 98

		St. Margarets Way / Abbey Park Road		
26	SK572030	Enderby Survey: 267 Narborough Rd.	K	Apr 96
27	SK575 034	Enderby Survey: Upperton Road/Narborough Rd (church)	K	Apr 96
28	SK577 040	Enderby Survey: Narborough Road / Hinckley Rd	K	Apr 96
29	SK585061	Belgrave Corridor Survey: 75 Abbey Park Road	I	Apr 98
30	SK582071	Belgrave Corridor Survey: St. Margarets Way (outsideB&Q)	K	Apr 98
31	SK585049	Belgrave Corridor Survey: St. Margarets Way / Vaughan Way	K	Apr 98
32	SK595063	Belgrave Corridor Survey: Doncaster Road / Melton Road	K	Apr 98
33	SK595063	Belgrave Corridor Survey: 5 Doncaster Road	I	May 98
34	SK596063	Belgrave Corridor Survey: 17 Doncaster Road	I	Apr 98
35	SK596062	Belgrave Corridor Survey: 31 Doncaster Road	I	Apr 98
36	SK596062	Belgrave Corridor Survey: 47 Doncaster Road	I	May 98
37	SK597062	Belgrave Corridor Survey: 63 Doncaster Road	I	May 98
AEA1	SK587 033	DETR UK Survey: 83 Aylestone Road	K	Dec 96
AEA2	SK636 043	DETR UK Survey: 482 Uppingham Road	I	Dec 96
AEA3 **	SK571 071	DETR UK Survey: 86, Blackthorne Drive	B	Dec 96
AEA4	SK623 043	DETR UK Survey: Balderstone Close (Housing Office)	B	Dec 96

** Site 4 adopted as site AEA3, December 1996.

B4.4/2: Temporary Sites

TUBE NO.	**ORDNANCE SURVEY COORDINATES**	**LOCATION**	**CATEGORY**	**DATES**
11	SK577054	Woodgate Survey: Bassett Street		Oct 95-Jan 96
12	SK577051	Woodgate Survey: 123 Repton Street		Oct 95-Jan 96
13	SK576052	Woodgate Survey: 55 Central Rd		Oct 95-Jan 96
11	SK574043	Woodgate Survey: Fosse Rd/King Richards Rd		Feb 96-May 96
12	SK568042	Woodgate Survey: Hinckley Rd/Woodville		Feb 96-May 96
13	SK565042	Woodgate Survey: Hinckley Rd (school)		Feb 96-May 96
14	SK563042	Woodgate Survey: Hinckley Rd (rest home)		Feb 96-May 96
15	SK597066	Melton Rd Survey: Melton Rd/Acorn St		Oct 95-Jan 96
16	SK599066	Melton Rd Survey: Scarborough Rd (St Patrick's school)		Oct 95-Jan 96
17	SK602068	Melton Rd Survey: Harrison Rd (school)		Oct 95-Jan 96
18	SK599069	Melton Rd Survey: 4 Marfitt St		Oct 95-Jan 96
16	SK578003	Enderby Survey: Middleton St		Apr 96-Apr 98
17	SK564014	Enderby Survey: Braunstone Lane East		Apr 96-Apr 98
19	SK556026	Enderby Survey: Main Street		Apr 96-Apr 98
20	SK548031	Enderby Survey: 376 Braunstone Lane		Apr 96-Apr 98
21	SK545033	Enderby Survey: 438 Braunstone Lane		Apr 96-Apr 98
22	SK542036	Enderby Survey: Hinckley Rd/Braunstone Ln roundabout		Apr 96-Apr 98
23	SK546039	Enderby Survey: Wembley Rd		Apr 96-Apr 98
24	SK532041	Enderby Survey: Ratby Lane		Apr 96-Apr 98
25	SK570026	Enderby Survey: Fulhust Ave		Apr 96-Apr 98

B.5 Benzene Diffusion Tube Surveys.

B.5.1 Ten-site survey carried out by Stanger Science and Environment, 1995-6

a. Methodology

(i) Monitoring Sites

Monitoring was conducted at ten sites from April 1995 to March 1996. Tubes were exposed for monthly periods at each site. Descriptions of the ten monitoring sites are as follows:

Table B.5.1: Benzene monitoring sites

Site Code	Address	Nearest Busy Road	Vehicles per Hour		Distance from Roadside	Type
			Peak	Off Peak		
I	267 Narborough Road	A46 Narborough Road	1800	600	10m	Roadside
II	1 Meadhurst Way	A47 Hinckley Road	1400	400	35-45m	Background
III	86 Blackthorne Drive	B5327 Bennion Road	1000	450	500m	Background
IV	5 Salcoates Avenue	A46 Melton Road	1000	500	150m	Background
V	12 Donaldson Road	A46 Belgrave Road	2000	800	50-60m	Background
VI	Taylor Primary School	A5125 Dysart Way	1000	450	70-80m	Background
VII	138 Uppingham Road	A47 Uppingham Road	900	420	15m	Roadside
VIII	Regency Hotel London Rad	A6 London Road	1500	500	20-25m	Roadside
IX	3 Stonesby Avenue	B5366 Stonesby Avenue	1500	1000	10-15m	Roadside
X	Newarke Street	A50 Newarke Street	2185	2185	6-8m	Roadside

The locations of the sites are shown in Fig. 4.

As motor vehicle emissions are a major source of benzene, each of the sites was categorised according to distance from the nearest roadside. For the purposes of this exercise, sites were defined as “roadside” if they are within 20m of a busy road. A “background” site is one which is beyond 20m of any road, usually situated in a residential area. Monitoring was conducted at five roadside and five background sites.

(ii) Measurement Technique

Benzene measurements were made using Perkin-Elmer diffusive samplers. These comprise a stainless steel tube 9 cm long containing Chromosorb 106 polymer, an adsorbent material with an excellent affinity for benzene. The tubes are scaled at both ends with protective caps. On exposure, the lower cap is removed and replaced with a diffusion cap which allows air to diffuse at a constant rate into the tube.

All tubes were prepared by Stanger Science and Environment. The tubes were despatched by post to Leicester City Council and exposed on mounted perspex blocks for periods of four weeks. following which the diffuser head was replaced with the original protective cap. Upon receipt the tubes were stored refrigerated prior to analysis.

It should be noted that the time resolution of the technique is limited and can only provide information on the integrated benzene concentration over the exposure period of about one month.

(iii) Sample Analysis

The exposed tubes were analysed using desorption scanning gas chromatography/mass spectrometry (GC/MS). This method of analysis gives unequivocal identification of the benzene peak.

The mass of benzene collected in the tube is then expressed as an average airborne concentration (ppb) measured over the monitoring period. The diffusion coefficient for benzene was been empirically calculated at Stanger Science and Environment.

Quality control procedures integral to the analytical procedure involved verification of the benzene peak and calibration against internal spiking solutions. All cleaned tubes were analysed prior to exposure to ensure no benzene is retained by the Chromosorb.

b. Quality Assurance/Quality Control

(i) Controls

As part of the quality assurance/control procedures integral to benzene surveys conducted by Stanger Science and Environment, a selection of participating boroughs are sent one extra benzene tube per month for duplicate exposure at a regular monitoring site. In 1995 duplicate exposures were made on twenty-six occasions. This indicates generally good agreement between duplicate tubes. Overall, the coefficient of variation measured on duplicate tubes was less than 5% and on twenty occasions duplicate tubes gave identical results.

(ii) Benzene Recovery from a Standard Atmosphere

In order to validate the experimental method the recovery of benzene from diffusion tubes exposed in a standard atmosphere has been investigated. Tubes are exposed (or 'spiked') for different time periods in a standard atmosphere to give a range of loadings. These tests indicate good recovery of benzene on the exposed tubes, with a mean ratio of 0.9 between the benzene loaded and benzene recovered.

(iii) Calibration Against Internal -Spiking Solutions

Prior to each analytical run, blank diffusion tubes are spiked with concentrations of 10, 20, 50, 100 and 200 rig benzene. Recovery of benzene is excellent, achieving linearity over the range with a standard deviation of less than 5%.

B.5.2 "BTX" survey.

a Methodology

(i) Monitoring Sites.

From December 1996 up to the time of writing, six "BTX" diffusion tubes have been exposed at the sites detailed below, (see also Fig. 4). These devices are used for simultaneous determination of benzene, toluene, ethyl-benzene, p-m xylene and o-xylene.

Table B.5.2: Site locations

Site Code	Location
CMB I	New Parks Way/Scudamore Road roundabout
CMB II	Fulford Road
CMB III	Cathkin Close
II	1, Meadhurst Road
IV	5, Saltcoates Avenue
VIII	Regency Hotel, 358, London Road.

Note: Sites II, IV and VIII corresponded to sites used in the Stanger 1995-6 survey described in the preceding section.

This exercise was in connection with the investigation of emissions from the site of Carnaud Metal Box plc, Braunstone. This company was not an emitter of benzene: The determinations were aimed at detecting ambient levels of toluene and xylene species and the benzene data was obtained incidentally. No action has been taken against the Company as a result of this investigation.

(ii) Measurement Technique

Benzene measurements were carried out as described previously by Lambeth Scientific Services Ltd.

(iii) Sample Analysis

Tubes exposed for an average period of 4 weeks were analysed using gas chromatography (Perkin-Elmer 8500 fitted with a flame ionisation detector) in the following order, system blank, analytical blank, two standards, samples, field blank, two standards of known concentration.

The mass of benzene collected in the tube is then expressed as an average airborne concentration (ppb) measured over the monitoring period as described previously.

b Quality Assurance/Quality Control

At the analysis laboratory, at the start of each working day system blanks and then 3 working tube standards are run through to produce a performance check and the average response factor is calculated for use that day. As a quality control check during the running of a batch of tubes, working standard tubes are run at the beginning and at the end of a sequence.

Quality assurance is given by participation in the Working Atmosphere Sampling proficiency programme (WASP). Four times a year tubes with BTX components are circulated amongst the laboratories and analysed. These tests provide a regular independent check on the calibration

APPENDIX C: The Position with Ozone.

C.1 Characteristics

High in the stratosphere, the ozone layer shields life on the surface from harmful solar radiation. There is concern among scientists that some man-made pollution is depleting this layer, particularly over the poles.

However, at ground level, ozone is harmful: It causes lung function changes and airway inflammation. It is thought to increase sensitivity to inhaled allergens, thereby exacerbating asthma and other respiratory conditions.

C.2 Sources

Ozone is a *secondary* pollutant, i.e. it forms in a complex series of chemical reactions in the atmosphere, involving oxides of nitrogen, volatile organic compounds and the action of sunlight. These reactions unfold over significant times and distances. For this reason, maximum concentrations of ozone will not tend to occur on top of major sources of precursor pollutants (e.g. a city) but some distance downwind. Indeed, much of the ozone measured in Leicester has formed at distances as great as several hundred miles, in some cases over continental Europe.

In the short term, nitric oxide (NO) from traffic will “scavenge” ozone out of the atmosphere, to form nitrogen dioxide (NO_2), although this then contributes to the cycle of increased longer-term ozone formation downwind. When a summer ozone episode is observed in the City centre, levels are likely to be even higher in outlying rural areas.

C.3 Why a Statutory Objective is not set for Ozone

Ozone incidents regularly occur in Leicester in the summer months; the Air Quality Standard for ozone has been breached over the summers of the last six years (1994-9 – see Table, below).

However, ozone is a country-wide and, indeed an international problem for the reasons stated: Because of its secondary and transboundary nature, it is unlikely that any cost-effective action can be taken at local level to affect the excess ozone levels experienced in Leicester.

For this reason, ozone is not regarded by the Government as an appropriate pollutant for treatment under the Local Air Quality Management regime. The National Air Quality Strategy (2000) sets out a provisional Objective for ozone but it is not given *statutory* force in the associated regulations (Air Quality Regulations 2000). This means that the City Council has no legal power or duty to include ozone in the Review and Assessment process and exceedances of the EPAQS recommended limit cannot lead to the declaration of Air Quality Management Areas.

This does not prevent action from being taken under the City Council’s own sustainability strategies to make a significant impact on the emission of ozone precursors; these are also pollutants of local and global significance in their own right.

It also does not mean that the City Council or the Government is unaware of the potential discomfort caused to sensitive groups during ozone incidents: Ozone will continue to be monitored and advice issued when appropriate on the various information networks at both local and national level.

C.4 The Objective for Ozone.

The provisional, non-statutory Objective for ozone is 100 μg.m^{-3} (50 ppb), expressed as a daily maximum of running 8 hour means, not to be exceeded more than 10 times a year. The provisional date for compliance is 31st December 2005.

Table C.4: Exceedances of the Standard for Ozone

Site	**Year**	**Annual Mean mg/m^3 (ppb)**	**Max running 8hr average**	**Exceedances**	**Data Capture (%)**
AURN Council Offices, Welford Place	**1994**	32 (16)	160 (80)	**75 on 12 days**	97
	1995	34 (17)	170 (85)	**192 on 26 days**	97
	1996	32 (16)	174 (87)	**120 on 16 days**	95
	1997	32 (16)	182 (91)	**126 on 19 days**	97
	1998	34 (17)	116 (58)	**32 on 7 days**	95
	1999	42 (21)	182 (91)	**259 on 23 days**	91
LAMS, Harrison Rd.	**1997/98**	32 (16)	156 (78)	**59 on 12 days**	99
LAMS, Judge-meadow School	**1999**	46 (23)	172 (86)	**161 on 19 days**	64

APPENDIX D*:* Emissions Inventory*.*

D.1 General

Emission sources for modelling using AIRVIRO and ADMS-Urban are defined as point sources (industrial and commercial buildings), line sources (roads), or area sources (residential estates, initially restricted to Council estates).

For each source, the time varying emissions of NO_x, PM_{10} particulates, CO, SO_2, CO_2, VOC's and CH_4 were calculated

D.2 Point Sources.

D.2.1 Point Source Data Collection.

No Part A or B emissions are significant in terms of the Review and Assessment, but overall fossil fuel combustion within the City is likely to make a significant contribution to emissions of NO_2 and PM_{10} particulates. Initially, only the largest combustion sources have been included in the model, i.e. boilers of 125 kW or greater. This was the smallest size of commercial boilers (considered by British Gas as being boilers of 60 kW or greater) that could be included individually within the inventory, without the number of point sources becoming unmanageably large.

Emission data for industrial and commercial point sources within the City of Leicester was obtained directly from the appropriate person responsible for each individual source. Sources were identified by an "on the ground" survey of all industrial and commercial areas of the city by Officers from the Pollution Control Group of the City Council. This was followed up by hand, or occasionally postal, delivery of a standard form to be completed with the required information. Individual Officers were responsible for ensuring the return of each completed form. Where necessary Officers completed the form themselves, during a personal visit or telephone call with the person responsible. In this way all forms were returned, including all information available. A total of 250 industrial and commercial point sources were included in the emissions inventory.

For Local Authority owned sources, data was obtained from an energy survey undertaken by the Leicester City Council Energy Team. The survey included all council owned and managed buildings, including administrative buildings and offices, schools, elderly persons homes, museums, libraries, and District Heating Plants. With the exception of the District Heating Plants, for which detailed information was available, The information provided by the survey was generally restricted to fuel use and time varying factors. Chimney and building parameters were obtained by a survey of each source by an Officer from the Pollution Control Group. A total of 250 Local Authority sources were included in the emissions inventory.

The data required for each source, both Local Authority and industrial/commercial, were:

- address and contact details
- chimney height and diameter
- emission flow rate
- emission temperature
- dimension of largest building at base of stack
- daily, weekly and seasonal variations of boiler operation
- annual fuel use, preferably on a monthly basis

Where data was unavailable, the following assumptions were made:
emission flow rate - zero
emission temperature - 15°C (ambient temperature)
monthly fuel use - approximate monthly use derived from information from informant. This was always the case with non - metered fuel, e.g. solid fuel, and in some cases fuel oil.

All other information detailed above was essential for the inventory, and was available for all point sources.

Where necessary, chimney heights were calculated using an inclinometer. For sources with several chimneys, but only a single fuel use figure, the source was considered as a single stack, of the height of the shortest stack, this being the only source of emissions resulting from the fuel combusted on the site. Where individual fuel use figures were available for several stacks on a site, each was considered as an individual point source.

No individual industrial sites within the city were considered to be of sufficient size to be treated as an area source.

D.2.2 Point Source Emissions Factors.

Emission factors were obtained from NETCEN for each of the following emissions:

NO_x
PM_{10}
CO
SO_2
CO_2
VOC's
CH_4

The emission factors and emission rate (from the emissions data obtained for each source) were entered into a spreadsheet, that also included conversion factors to ensure that the fuel use was expressed in appropriate units for the application of emission factors. The final emission rate for each point source was expressed in tonnes per annum/grammes per second.

D.2.3 Point source Time Variations.

Potentially each point source may have had a different time varying pattern of emissions, depending on the function of the boiler or heating appliance concerned (space heating or process heating), the duration and start and finish times of a normal working day, seasonal working etc. Although it is possible to include a separate time variation of emissions for each individual source in the Airviro model, this would involve considerable additional data entering time. Consequently the time variation of emissions for each source was limited to "standard" of emission variations according to the daily, weekly, and seasonal pattern of emissions, specified as follows:

Daily variation options: Working day (0800 to 1700)
24 hour working.

Weekly variation options: Monday to Friday
Monday to Saturday
Seven days operation

Seasonal variation: As fuel data was generally supplied as a monthly figure, Seasons are defined in terms of whole months:
Spring is defined as March, April and May.
Summer is defined as June, July and August.
Autumn is defined as September, October and November.
Winter is defined as December, January and February.

AIRVIRO defines emission variations for a source by comparing any variation with the maximum variation (expressed as 100% emission rate). The emissions database used in the Leicester Airviro model compares the emissions for each season by comparison with the winter emission rate, which is defined as 100% emission rate. Variations are in steps of 25%. Thus the following are typical seasonal variations:

100% Winter, 50% Spring and Autumn, 0% Summer (typical for space heating)
100% Winter, 75% Spring and Autumn, 50% Summer (typical for space and process heat)
100% Winter, 100% autumn and Spring, 100% Summer (process heat only).

Combinations of daily, weekly and seasonal emission variations were thus classified according to "Formulae" of time varying emissions. The emission pattern for each individual source was described by one of these pre-defined classes. In practice the allocated Formula generally closely matched the actual emission pattern.

The seasonal variations used were:

CMF	*Continuous 24 hour emissions, Monday to Friday*
CMS	*Continuous 24 hour emissions, Monday to Saturday*
CW	*Continuous 24 hour emissions seven days per week*
DMF	*Emissions during the working day, Monday to Friday*
DMS	*Emissions during the working day, Monday to Saturday*
DW	*Emissions during the working day, seven days per week*

In addition to the above, some point sources, such as schools, or district heating schemes, had common emission patterns, and were each allocated an unique individual Formula.

D.2.4 List of Point Sources in the Emissions Inventory.

Local Authority Premises:

Abbey House EPH
Ald Rich Hallam Primary School
Alderman Newton School
Arbor House EPH
Ashfield School
Aylestone Leisure Centre
Babington Comm College
Beatty Ave DHS 'A' (blocks 3 & 4)
Beatty Ave DHS 'B' (blocks 1&2)
Beaumont Leys School
Bendbow Rise Infants School
Brookside Court EPH
Butterwick House EPH
Christ The King RCP (school)
City of Leicester School
Coleman Primary School
Cooper House EPH
Cossington Street Pool
Crown Hills School
Dale House EPH
De Montfort House EPH
Elizabeth House EPH
Ellesmere College
English Martyrs RC School
Evington Pool
Eyres Monsell Primary School
Forest Lodge Education Centre
Forest Lodge Primary School
Fosse Day Centre
Granby Halls
Greyfriars
Hamilton Comm College
Herrick Primary School
Humberstone Annexe (museum?)
Humberstone Infant School
John Ellis Comm College
Judgemeadow Sch/CC
Lancaster Boys School
Leicester Coll Adult Education
Leicester Leys L. Centre
Leics Arts (schools list)
Leics Museum & Art Gallery
Linden Primary School
Martin House DC
Mary Linwood School
Mayflower Junior School
Meadow Court EPH
Mellor Primary School/CC
Merrydale Junior School
Millgate Centre (School/coll)
Moat Centre
Moat Comm College

Mowmacre Hill Primary School
Mundella Comm College
Museum of Technology
Netherhall School
New Parks Comm. College
New Parks DHS
New Parks Leisure Center
Northfield House Junior School
Nuffield House EPH
NWC A-Block
NWC B-Block
Overdale Junior School
Ross Walk TC Landlord
Rowletts Hill DHS
Rowley Fields Sch/CC
Rushey Mead School
Sandfield Close Primary School
School Psych Service / museums
Scraptoft Valley Primary School
Shenton Primary School
Simon Lodge EPH
Sir Jonathon North CC (Sch/coll)
Soar Valley Comm Coll
Southfields Infant School
Sparkenhoe Primary School/CC
Spence Street Pool
Spinney Hill Primary School
St Andrews DHS
St Margarets Baths
St Marks DHS
St Matthews DHS
St Pauls RC School
St Peters DHS
Stokes Wood Primary School
Taylor Primary School
Thurnby Lodge Primary School
Thurncourt EPH
Town Hall
Valley House EPH
Western Park Pav (school)
Whitehall Primary School
Wigston Lane Community Home
Willowbrook Primary School
Woodstock Primary School
Wycliffe Comm College

Industrial premises

Leicester City area:

Fashion Fabrics (Boiler),
MLG Charnwood Laundry Groby Rd Hospital
B & M Finishing
Harvestime Fresha Bakeries
Martin Dyers & Finishers (gas boilers)
Artisan Press,
Trucolour (stentor)

Trucolour, Bath La (boiler)
AE Charlesworth (Boilers)
Universal Conveyors
Clarendon Dye Works
British Shoe (Space Heaters)
Leicester Dyers,
Saffron Dying & Finishing, .
Chilpruf Ltd 33 (Potterton boiler)
Ariel Fasteners Ltd (heavy fuel oil)
Parker Plant Ltd
Boston Dyers,
Richard Roberts Ltd
Donnisthorpe
Burberry Sock Division
Counterparts (Former Byfords),
BPX Electro-Mechanical Co Ltd
Eversmart Express
HM Prison (main boiler)
Taylor Hobson Ltd
Taylor Hobson Ltd PO Box 36
Holiday Inn,
Bridgeport Machines Ltd
Graphic Inline
Advance Tapes,
United Denim Services
Raab Karcher (Timber) (heavy fuel oil)
Premier Screw & Repetition Co Ltd
Midland Screenprinters
ISF Group Ltd (Boiler 1)
Jarvis Grand Hotel
British Shoe (Boiler)
Westdale Dyeing,
Westdale Dying and Finishing
Midland Denim Services
Top Colours (Boiler)
ISF Group Ltd (Boiler 3)
WYKES, Space heating factory 1
Vindla Knitware (Braithwaite boiler)
Courtaulds Textiles(Heating Boiler)
AE Charlesworth(Stentors)
Haymarket Theatre,
Royal Sun Alliance
Marks and Spencers
Camber International (Engineering factory)
Imperial Industry
Vindla Knitware (Fulton boiler)
Inland Revenue, 1 Causeway La
Linread Automotive 7 Abbey Lane
Leics Police HQ, St Johns Rd Enderby
G. Perry and Sons Ltd Hall Lane Aylestone
Alliance & Leicester PLC Halford House Charles Street
WYKES, Barkby Rd Space heating factory 2
Caradon Gent Ltd, 140 Waterside Rd
Marshall of Leicester 301 Thurmaston Lane
St Johns House 30 East St
Jessop Group Scudamore Road
Racal Radar Defence Systems Scudamore Rd (135kW boilers)
Jessop Group Murrayfield Road

Equity Shoes Ltd, 42 Weston Rd
HM Prison Welford Road (Plant room / Officers mess)
Knits Ltd 87 Parker Drive
Chilpruf Ltd 33 Evington Valley Rd (Allen Ynis boiler)
Martin Dyers & Finishers Slater Street (drier)
Martin Dyers & Finishers Slater Street (stentor)
Duplus Domes 370 Melton Road
Camber International 360 Melton Road (International factory)
Burton Mcall 163 Parker Dr
T. W. Burrell & Sons Ltd Abbey Park Rd (Fulton)
BXL Plastics Abbey Meadows (Concorde 650 boiler)
Hays Customer Solutions De Montfort St
Belgrave Business Enterprise Ltd 308A Melton Road
South Knighton Dyeworks South Knighton Rd (Lancs)
Leicester YMCA
KPMG 1 Waterloo Way
Amec Power Ltd, 143 Barkby Rd
Leicester City Bus Abbey Park Rd
Ceejay Knitware Ltd Woodbridge Rd
ISF Group Ltd Thurmaston Boulevard (Boiler 2)
BXL Plastics Abbey Lane (Beeston boiler)
BXL Plastics Abbey Lane (Beeston Robin Hood boiler)
T. W. Burrell & Sons Ltd Abbey Park Rd (Hamworthy)
Jelson Ltd 370 Loughborough Road
Electro-Motion UK (Export) Ltd, 161 Barkby Rd
BXL Plastics Abbey Lane
Perido 4 Bath Lane
R. W. Frost 3 / 5 Tuxford Rd
TESA RSD (Brown & Sharp) Bradgate Street
Top Colours Bradgate St (Stentor)
Royal Mail Area Delivery Office Loughborough Road
Alliance & Leicester PLC Permanent House Horsefair Street
South Knighton Dyeworks South Knighton Rd (Rushton)
B. Wigley & Sons,(gas)111-113 Barkby Road
Courtaulds Textiles Queen Street (Process Boiler)
Leicester Thread & Trimming Manufactures Ltd 107 Barkbt Rd
Ridgeway & Co, 101 Barkby Rd
WYKES, Barkby Rd Process heating factory 1
Alliance & Leicester PLC Southgates
Barclays Bank Town Hall Square
HM Prison Welford Road (New Hospital / Kitchen)
Ceejay Knitware Ltd Woodbridge Rd (Fulton boiler)
WYKES, Barkby Rd Space heating factory 4
Wells & Root Ltd, 135 Parker Dr
T. W. Burrell & Sons Ltd Abbey Park Rd (Powermatic)
Pinetree Health Centre, Slater St
Racal Radar Defence Systems Scudamore Rd (250kW boilers)
ISF Group Ltd Thurmaston Boulevard (Boiler 4)
Centre Point Display Ltd
Oakland Press Tool Co Ltd, 16 Claymill Rd
Martin Dyers & Finishers Slater Street (oil boiler)
St James House 55 Welford Rd
Page & Moy Abbey House Burlese Way
Sth Knighton Dyeworks Sth Knighton Rd (Themal Transfer Unit)
Hub Tubes New Star Road
Pannell Kerr Forster 159 Charles Street
Chevron Knitware, 81 Cannock St
Gates Inn, Humberstone Road

T W Kemptons 33 Abbey Lane
Fenwicks
Leicester Gen Hosp, Gwendolen Road
Mitchell Grieve 129 Parker Drive
Leicester Mercury St George's Street

Oadby and Wigston area:

Winfield House, 16-22 Station Street, S. Wigston
St John Fisher RC Primary School, Shenley Rd. WIG
Stowlin Ltd, Radnor Rd, S Wigston
W E Briggs & Sons Ltd, Cornwall Rd S Wigston
Thythorn Field Primary School, Bideford Close WIG
Honeytop Foods, 29 Chartwell Drive, Wigston
Shoefayre, Unit 1 Wilson Rd Wigston
AETC Ltd, Magna Rd, S Wigston
Turbine Controls Ltd, 41 Kenilworth Dr Oadby
Supportu Supplewear Ltd, Waterloo Crescent Wigston
Invicta Plasties Ltd, Harborough Rd, Oadby
Maren High School, Calse Close, Oadby
Livingston & Doughty Ltd, 17 Mandervell Rd Oadby
F+F Shoe Components Ltd, 53 Iliffe Avenue, Oadby
Langemoor School, Kenliworth Drive, Oadby
Wigston Dyers Ltd, Canal Street, S Wigston

D.3 Area Sources

D.3.1 Area Source Data Collection.

Nine housing estates of predominantly council owned properties were designated as area sources. These were selected as data on estimated fuel use was readily available from an energy survey undertaken by the Leicester City Council Energy Team. The survey was only of a limited number of houses on each housing estate, but each estate consists entirely of broadly similar house types.

For each house surveyed, monthly fuel use data was available, together with the occupancy pattern of the house. The City Council Housing Department were able to supply the total number of houses on each estate. It was assumed that the pattern of occupancy for all houses in each estate was similar. Thus the fuel use pattern for the surveyed houses was multiplied by the total number of houses in each estate to produce an overall area emission rate for the estate. It was also assumed that the only fuel used on the estates was natural gas. Although this is the predominantly used fuel, there is likely to be other fuels used within each area source, which has been ignored for modelling purposes, due the difficulty in identifying such individual sources.

Each area was defined on both ADMS and AIRVIRO models using local knowledge of the boundaries of each estate. Whereas the boundary of each area can be plotted on ADMS to closely fit the actual area boundary, on Airviro area sources must be plotted as a quadrant. The plotted area boundary will therefore differ from the actual area boundary. However as these area sources mostly influence air quality in terms of background, rather than point specific, pollution levels, it is unlikely that the boundary assumptions will significantly affect the results of model runs.

The modelled area sources include only approximately 25% to 30% of residential area in Leicester. Other area’s have not been included to date because of the difficulty of establishing the variation in fuel use data (including both rate of use and time variations) within area that consist of a wide variety of house types and occupancy.

It is accepted that the emission data for area sources is probably the least comprehensive, when compared to point and road source data. The Strategy Directorate of the Greater London Authority (Emissions Database Helpline) have supplied modelled gas use data but time constraints prevented its inclusion in dispersion modelling for the current Review and Assessment,. The inclusion of this data as area sources would enhance the accuracy of both models, provided care is taken to avoid “double accounting” large point source users of natural gas. This will be addressed in the next round of modelling.

D.3.2 List of Area Sources in the Emissions Inventory.

Local Authority housing estates:

Eyres Monsell
Braunstone South
Braunstone North
Braunstone Frith
New Parks
Kirby
Saffron
Mowmacre
Stocking Farm
Abbey Rise
Belgrave
Humberstone
Rushey Mead
Netherhall
Thurnby Lodge
Coleman
Goodwood
Rowletts Hill
Evington
Charnwood
St Marks
Beamont Leys
West End
Gilmorton
Rupert

D.4 Traffic and other Transport Sources. (Line Source Data)

D.4.1 General

Hourly emissions for each “link” of a length of road is used by the ADMS and AIRVIRO models for dispersion calculations. Hourly traffic flows are derived from daily average flows by applying the known flow pattern for the particular road type used to classify the link under consideration. Hourly flows are multiplied by emission factors for each pollutant that is to be modelled, to obtain an emission rate at different speeds (in steps of 10 km per hour).

Traffic flow data were obtained from the TRIPS traffic model. The vehicle emission factors used were obtained from the London Research Centre.

D.4.2 Traffic Flows

The following is a detailed description of the methodology used to derive the “differential growth” traffic flow data used for dispersion modelling, using a refinement of the existing TRIPS traffic model.

In Stage 1/2 of the Review and Assessment, traffic flows on major roads were taken from runs of the Greater Leicester Traffic Model (GLTM), which is based on the TRIPS (Transport Planning Software) Model (MVA). These were performed by the Planning and Transportation Department of Leicestershire County Council for its area as constituted prior to Leicester City Council achieving Unitary Status on 1st April 1997.

The TRIPS Model is designed to calculate traffic flow from land-use factors such as population, housing, industrial activity etc. The model also takes account of physical characteristics of roads such as carriageway widths and speed limits.

For the purposes of the Model, roads are separated into "links", i.e. lengths of road between significant junctions carrying traffic in one direction. Thus roads other than one-way streets will normally have two links between each major junction, one for each directional flow of traffic. As each link for traffic travelling in each direction along the same stretch of road would otherwise share the same grid references, the links for each direction have been separated by one metre. The Model uses data on around 3,500 links for the area covered by the pre-Unitary Status County of Leicestershire. Each link has an identifying number and spatial co-ordinates fixing either end of the section of road concerned.

For each road link, the Model outputs morning peak, evening peak and off-peak flow and speed data, which is then used to estimate annual average daily flows.

Before being used for air quality modelling, each link is classified according to the flow pattern of traffic along the link, so that time varying emissions can be calculated within the model. The traffic flow pattern allocated to each link was described according to peak flows (e.g. high morning peak, low evening peak), road type (e.g. estate road, through road) and traffic type (e.g. high volume of heavy goods vehicles). Traffic Control Engineers from Leicester City Council Area Traffic Control, based on local knowledge and experience derived the classification system.

Speeds within the GLTM are not based on actual traffic speeds but on the speed-limits applied to the road links concerned, which is clearly not satisfactory for dispersion modelling purposes. Before inputting to the dispersion model, this was therefore refined by inspecting individual links and amending the speed inputs where appropriate, according to available observations.

The classifications of the road links, with definitions, are as follows:

Bus	B*uses only*
Bus/Taxi	b*uses and Taxis only*
Car only (PM peak)	*Used only by cars, with an evening, but no morning peak. Applies only to roads leading exclusively to a car park)*
Car only (AM peak)	*Used only by cars, with a morning, but no evening peak. Applies only to roads leading exclusively to a car park)*
Commercial area	*Roads within a commercial or industrial area.*
Inbound Radial High HGV	*Road with morning only peak, and >= 10% Heavy Goods Vehicles*
Inbound Radial Low HGV	*Road with evening only peak, and* <10% *Heavy Goods Vehicles*
Inter Urban Minor	*Road, other than a trunk or A-Class road, within a non-commercial urban area.*
Local Roads (2 peaks)	*Road between two areas, with both morning and evening peaks.*
Local Road Inbound	*Road between two areas, with morning peak only.*
Local Road Outbound	*Road between two areas, with evening peak only.*
Motorway	
No Entry	
Non Urban Trunk Road	
Outbound Radial High HGV	*Road with morning only peak, and* >10% *Heavy Goods Vehicles*
Outbound Radial Low HGV	*Road with evening only peak, and* <10% *Heavy Goods Vehicles.*
Ring Road High HGV	*Road with* >10% *Heavy Goods Vehicles, but no distinct morning or evening peaks*
Ring Road Low HGV	*Road with* <10% *Heavy Goods Vehicles, but no distinct morning or evening peaks*

The percentage of heavy and light vehicles using a particular road is calculated from the road type. Hourly averages are then calculated for the heavy and light vehicle categories. Road width is standardised according to the number of lanes across the particular carriageway.

However, it was acknowledged that the TRIPS model output needed updating prior to its use in Stage 3 dispersion modelling to take into account a number of factors:-

The existing TRIPS Model outputs dated from 1995. Validation using a rolling programme of actual traffic counts had last been performed in 1996: The traffic base-line used for atmospheric dispersion modelling and was therefore out-of-date and in need of review.

It was considered that different parts of the area forming the subject of dispersion modelling would experience widely different rates of traffic growth, ranging from substantially positive to somewhat negative. This was based on the various projected impacts of development proposals and traffic schemes in different areas, superimposed upon the generalised projections of UK national traffic forecasts.

Certain, specific road schemes, either newly-completed or proposed were clearly going to result in significant redistributions of traffic between important routes. In particular, the following were regarded as potentially significant:-

- The Leicester Western By-pass (A46: M1/A46 link road): This recently-opened dual carriageway skirts Leicester on its western and northern sides, making junctions with the principal radial routes in that quarter. It is designed to relieve pressure on routes such as the Leicester Western Distributor Road ("Outer" Ring Road, A563), the Leicester "Middle" Ring Road (Fullhurst Avenue-Braunstone Avenue-Wyngate Drive-Woodville Road-Henley Road-Fosse Road North-Blackbird Road-Abbey Park Road-Dysart Way, the A5125 prior to declassification) and the Leicester Inner Ring Road (A594).

- The A46/A47 Link Road: This link, which opened in January 1999, makes a circumferential connection between these two routes in the east of the City and will relieve cross-town routes nearer to the City centre.

- The Belgrave Corridor Project: This project is designed, over the next few years, to give greater priority to buses and to reduce the amount of through traffic using this important radial corridor (A607) between the Belgrave flyover and the junction with Watermead Way/Troon Way. The scheme is intended to divert a proportion of through traffic to the Abbey Lane corridor (A6, formerly A5131) via Watermead Way and Redhill Circle.

- Vaughan Way/Burley's Way (Inner Ring Road, A594) capacity reduction: This scheme is in the course of implementation during 1999 with Single Regeneration Budget funding and aims at the regeneration of adjacent areas and the reduction of severance caused by this highway. The number of lanes and, hence, carriageway capacity has been reduced in order to discourage through traffic via the City centre and transfer it onto other routes.

It was therefore decided to undertake a review and update of the TRIPS Model data: To this end, a further study involving re-runs of the Model using up-to-date input data and validation data was commissioned from the Planning and Transportation Department of Leicestershire County Council.

The initial phase of the work was the updating of the existing GLTM output to 1998 standard. This involved updating the highway network within the Model to include highway network changes which had occurred in the intervening period, for example capacity changes, space reduction and reallocation, traffic calming, pedestrianisation, one-way schemes, traffic bans and parking restrictions. It should be noted that the effects of the Vaughan Way/Burley's Way capacity reduction scheme were *not* embodied in the updating exercise at this stage.

The origin-destination patterns of movement represented in the existing 1995 AM and PM highway matrices were updated through the process of Matrix Estimation, using available recent traffic counts. The second phase of the work was to extrapolate to the year 2005: The representation of the network was updated to embody all ongoing and planned network changes which are committed to be operational in 2005. Relevant phases of the Vaughan Way/Burley's Way and Belgrave Corridor schemes detailed above *were* embodied at this stage. However, certain anomalies occurred which, due to constraints of time, were not rectified, as detailed below. Interpretation of the modelling outputs presented in this Report should take these into account, i.e. where major road sources have appeared and others greatly reduced in significance:

In updating the TRIPS Model data, an attempt was made to refine the 2005 forecast of origin-destination patterns of movement by dividing the GLTM area into four sub-areas for which differential levels of traffic growth were projected. The traffic growth figures used for forecasting pollution levels in 2005 were derived from the City Council's work in carrying out its responsibilities as a local transport authority under the Road Traffic Reduction Act 1997:-

The Central Leicestershire transport authorities have been monitoring road transport trends for many years. The CALTRANS study (Central Leicestershire Strategic Transport Studies) set the baseline for future forecasts in 1995. Since then, traffic has grown by an average of about 1 to 2% each year over the whole network, although this masks considerable differences between rates of growth in different parts of the Central Leicestershire Local Transport Plan area:

Monitoring has shown that road traffic across the central area cordon has reduced in the last three years: In 1997, traffic levels on the Leicester Central Ring Road remained static (actually showing a very small fall). Current and possible future capacity reduction measures here are anticipated to effect a reduction in flows and preliminary data from the Vaughan Way scheme supports this view at time of writing. Conversely, growth on the motorway and trunk road network outside the urban area has increased each year by about 3 to 5%.

CALTRANS forecast growth in motor traffic of between 10% and 15% from 1995 to 2011 under a "Do Minimum " transport scenario. This is within a realistic land-use scenario based on implementation of the principles embodied in Planning Policy Guidance. Whilst the Transport Policy for Leicester and Central Leicestershire aims to slow this trend and eventually reverse it, CALTRANS concluded that, with current powers and levels of funding, it will only be possible to reduce the overall rate of growth to about half that of the forecast.

Therefore, the traffic growth rate forecasts for the Road Traffic Reduction Act and Air Quality work to 2005 are estimated to be distributed spatially over four sub-areas, as tabulated below. The area covered by the GLTM is divided for modelling purposes into a large number of "GLTM Zones" and each of these was assigned to one of the sub-areas. (See Fig. 23).

Table D.4.2/1: Traffic Differential Growth Zones

Sub-Area	**GLTM Zones**	**Growth Factor**
City Centre	1-22, 63-65, 67, 191.	-5%
Inner Suburbs	23-31, 58-62, 66, 68-73, 75-77, 88, 90-92, 94-109, 173-190, 192-198, 211-220.	0%
Outer Suburbs* , including the motorway complex to the west of the City.	221-223, 305-307.	10%
GLTM area lying outside the above three areas.	32-57, 74, 78-87, 89, 93, 110-172, 199-210, 224-304, 308-309.	9%

**Corresponding to the Central Leicestershire Local Transport Plan Area, as constituted at the time of the study. (This has subsequently been enlarged).*

Overall traffic growth was factored into the study using data from the National Trip-End Model (NTEM) forecast to project the 1998 patterns of movement (trip matrix) to 2005. This was used in preference to the National Road Traffic Forecast (NRTF) because the latter is based largely on national growth in vehicle mileage rather than growth in trips which start and finish within each local area. In contrast, the NTEM takes into account, through planning data supplied by local authorities, (population, household structure and employment projections) the effects of proposed developments. Conversely, the NTEM forecasts are "demand forecasts" and do not, therefore, take account network capacity constraints and the effects of local transport strategies.

Known forthcoming local developments, even those which would generate significant local traffic and thus potentially affect the air quality of a given location, were not directly included in the study within the short time-scale allowed due to the paucity of consistent, available data. This at least obviated the need to make adjustments for double counting in order to ensure that the total NTEM forecast growth for the area was not exceeded.

To keep these forecasts in line with national forecasts, the overall growth of traffic for the GLTM study area was controlled to equal the 8.8% "low growth" forecast for the NTEM for the Leicestershire area. The NTEM "low growth" scenario forecast was used because it is accepted practice to use it for peak period forecasts in urban areas, where there is little potential for growth due to planned capacity

Figure 23
Projected Differential Zones of Traffic Growth

constraints and existing congestion. The Leicestershire growth factor was used in order to characterise a wider “hinterland” of trip origins. A national growth factor derived from the NTEM was applied to all zones external to the County, while taking full account of the variable factors in the Table above. The results are as follows:

Table D4.2/2: Traffic Growth Factors

AM 1998 Matrix Total	102,657
AM 2005 Matrix Total	111,651
Growth	**8.8%**
PM 1998 Matrix Total	109,215
PM 2005 Matrix Total	118,826
Growth	**8.8%**

Because the NTEM forecasts represent an average week-day, it was necessary to make them compatible with the peak values modelled by the GLTM. In order to achieve this, the home based work-growth factor was selected as being most representative of the peak.

To summarise, a broad, overall level of demand was derived from the NTEM projections and this was then distributed over a GLTM matrix optimised for known changes in the network and estimated differential growth in sub-areas up to 2005.

For dispersion modelling purposes, Annual Average Daily Traffic (AADT) is the required input and it was therefore necessary to derive these from the average peak flows generated by the GLTM. This was done by factoring the peak flows by 10, i. e. it was assumed that the peak represents an average of 10% of daily flow. In practice, the peak to daily flow ratio is observed to vary between sites, areas (urban/rural) and time periods (AM/PM) over a range of about 6% to 11% but a mean ratio of around 10% was considered to be a reasonable approximation over the study area.

Speeds within the GLTM are not based on actual traffic speeds but based on the speed-limits applied to the road links concerned, which is clearly not satisfactory for dispersion modelling purposes. Before inputting to the dispersion model, this was therefore refined by inspecting individual links and amending the speed inputs where appropriate, according to available observations.

Clearly the traffic model used has significant limitations:

The GLTM is a simple, link-based model and cannot represent traffic behaviour at junctions.

The model is only as good as its underlying assumptions e.g. those made about differential growth factors applicable to different regions of the network to represent the impact of future policies and network changes. The model does not represent every road on the network and its outputs can only be regarded as indicative for broad, strategic purposes.

As part of the study, the GLTM was validated against observed traffic flows by plotting the latter against the values predicted by the model for AM and PM peak flows in 1998. A reasonably good degree of fit was noted, with R-square values of) 0.90 to 0.96 for the AM peaks and 0.97 for the PM peaks. The recommended acceptable standard in the Design Manual for Roads and Bridges (DMRB), Volume 12 (Chapter 4, Section 2, page 4/28) is a range of 0.9 to 1.0.

The table below provides an indication of the accuracy of TRIPS output as used as an input into air quality models. For a small sample of road links the TRIPS derived peak morning traffic flow rates (vehicles per hour) for the combined in-bound and out-bound carriageways, is compared with actual flow rates measured as part of the on-going traffic model validation process:

Table D.4.2/3: Validation of TRIPS Model

Road	Nodes	1998 Peak a.m.Traffic Flows		"Error" in model value
		TRIPS model derived value	Survey-based measurement	
St. Augustines Road	335-457	3,901	3,844	+1.5%
St. Margarets Way	767-	3,366	3,570	-6.1%
Humberstone Road	629-632	2,783	3,037	-9.1%
London Road	530-532	2,771	2,761	+0.4%
Upperton Road	414-453	2,468	2,017	+18.3%
Almond Road	422-488	1,859	1,742	+6.3%
Waterloo Way	370-378	1,488	1,707	-14.7%
Evington Road	595-596	1,445	1,705	-18.0%
Regent Road	369-371	2,045	1,608	+21.4%
Belgrave Gate	323-324	1,497	1,138	+24.0%
Fosse Road N.	830-853	1,259	617	+51.0%
Lancaster Road	363-576	596	534	+10.4%
TOTAL		**25,478**	**24,280**	**+4.7%**

The table below illustrates some of the traffic flows projected for 2005 using this methodology (combined in-bound and out-bound flows):

Table D.4.2/4: Projected traffic flows for 2005.

Road	Nodes	TRIPS-derived Peak a.m. Traffic Flow Projections		Change
		1998	2005	
Vaughan Way	339-340	6,381	6,303	-1.2%
Burleys Way	342-343	5,415	4,956	-8.5%
St. Augustines Road	335-457	3,901	3,880	-0.5%
St. Margarets Way	767-	3,366	3,457	+2.7%
Humberstone Road	629-632	2,783	2,863	+2.9%
London Road	530-532	2,771	2,825	+1.9%
Narborough Road	453-1163	2,742	2,683	-2.2%
Upperton Road	414-453	2,468	2,483	+0.6%
Regent Road	369-371	2,045	2,080	+1.7%
Almond Road	422-488	1,859	1,858	-0.1%
Belgrave Gate	323-324	1,497	1,409	-5.9%
Waterloo Way	370-378	1,488	1,543	+3.7%
Evington Road	595-596	1,445	1,489	+3.0%
Fosse Road N.	830-853	1,259	1,279	+1.6%
Lancaster Road	363-576	596	591	-0.8%
TOTAL		**40,016**	**39,699**	**-0.8%**

D.4.3 Traffic Emission Factors

D.4.3.1 ADMS Dispersion Model.

The default emissions database within this model were used to calculate traffic emissions. These are derived from the *Design Manual for Roads and Bridges* (Transport Research Laboratory, 1994; Volume 11, Section 3, Part 1).

D.4.3.2 AIRVIRO Dispersion Model.

More discretion was possible with this model, with regard to traffic input data within the existing constraints: The emission factors compiled and published by the London Research Centre on behalf of the DETR specifically in support of the Review and Assessment exercise were employed, (1996 version).

Six vehicle types are used in the emission database. These were selected as those vehicle types for which emission factors were available from the London Research Centre. The vehicle types, as classified in the model, together with definitions are as follows:

BUS	*Buses*
DIE-C	*Diesel cars*
HGV	*Heavy Goods Vehicles*
LGV-D	*Light Goods Vehicles with diesel engines*
LGV-P	*Light Goods Vehicles with Petrol Engines*
PET	*Petrol Cars*

Petrol cars were not classified according to those with or without a catalytic converter, since the emission factors used accounted for the proportion of each within the overall petrol car fleet.

D.4.4 Emissions from Rail Traffic

Leicester is situated on the Midland main line from London St. Pancras to Sheffield and the North. Two subsidiary routes, running towards Coalville and Nuneaton make junctions with the main north-south route within or near the City boundary, at Knighton and Wigston Junctions, respectively.

For the purposes of this Review and Assessment, emissions from rail traffic have been treated as negligible and have not been included in the emissions inventory used as input to the dispersion models.

In view of the recent increase in volumes of passenger and freight traffic using the route, this will be kept under review in future rounds of review and assessment.

APPENDIX E: Modelling: Methods, Validation and Interpretation.

E.1 The ADMS-Urban Dispersion Model (Version 1.53).

E.1.1 Description of the Model.

ADMS-Urban Version 1.53 is a version of the Atmospheric Dispersion Modelling System (ADMS) developed by Cambridge Environmental Research Consultants (CERC). It is a PC-based computer system that models dispersion in the atmosphere of pollutants emitted from industrial, domestic and road traffic sources in urban areas. The sources that are entered into the model are treated as point, line, area or grid sources. ADMS can incorporate these different types of source for modelling emissions over a large urban area.

A key feature of ADMS-Urban is that it can be used in conjunction with a Geographical Information System (GIS). The GIS software used is ESRI UK's desktop GIS, ARCVIEW. The two programs are fully integrated and model output pollution contour plots can be directly overlaid on many types of digital ordnance survey maps or images such as aerial photographs. Results can be calculated for specific receptor points (for example a monitoring station) and plot as time series graphs or for whole areas in the form of a contour plot on a GIS map. For receptor point model runs ADMS-Urban produces numerical output in comma separated variable (.csv) text file format. This can then be viewed in a spreadsheet such as Microsoft Excel and plotted as a time series graph.

A significant difference between ADMS-Urban and other models used for air dispersion modelling in urban areas is that ADMS-Urban applies up-to-date physics using parameterisations of the boundary layer structure based on the Monin-Obukhov length, and the boundary layer height. Other models often characterise the boundary layer in terms of the Pasquill stability parameter.

ADMS-Urban has a facility to link directly to an Emissions Inventory using a standard database package, Microsoft Access 97. Emission sources held in the Access database can be read directly into ADMS-Urban or Arcview in a visual format.

ADMS-Urban includes a meteorological pre-processor which calculates the boundary layer parameters from various input data: e.g. wind speed, day, time, cloud cover or, wind speed, surface heat flux and boundary layer height. Meteorological data is hourly sequential data and is loaded into the model as text files.

The meteorology pre-processing module is called once for each hour of data being run in the model and uses standard algorithms to calculate the boundary layer meteorological parameters required by the dispersion model. The processing module firstly checks that the input data is sensible. Whilst the pre-processor is running, the flow of data is scrolling on the screen and any warning messages or notification of errors are shown. If the meteorological mast is some distance from the area of dispersion, the meteorology input module can modify the wind profile at the source by taking account of the surface roughness at both the meteorological site and the source. The user can also enter a precipitation factor to account for differences in rainfall between the two sites if required.

The model can be run for a maximum of 10 pollutants at one time and can output 15 minute, hourly, 8-hourly, daily and annual concentrations in a range of output units. There are also options to calculate percentiles, rolling averages and time-varying concentration at one specific point. The model can be run using short term averaging or long term averaging. Short term averaging gives an output value for every meteorological hour run in the model at each geographical point selected. Long term averaging gives one output value averaged over the whole period of meteorological data at each location.

A pollutant is defined by a mass emission rate. If the pollutant is particulate, up to 10 different particle sizes may be defined, but if it is gaseous, only one species may be defined.

The model includes a chemistry module and can use the Derwent Middleton Correlation or model chemical reactions involving NO, NO_2 and Ozone to give predicted concentrations of Nitrogen Dioxide from Oxides of Nitrogen emission data. Background concentrations from monitoring sites can also be loaded into the model.

E.1.2 Model Inputs

E.1.2.1 Emissions Data

Emission data used to run ADMS-Urban and AIRVIRO is compiled from the Leicester Emission Inventories for 1998 “now scenario” and 2005 “future scenario”. An emissions database is held in Microsoft Access 97 and read directly into ADMS-Urban to run the model. The emissions database consists of point, line, area and grid sources. Data can be entered into the model as individual sources and have emission rates entered directly from the Emission Inventory. However, road sources from the Emission Inventory required further work before they could be entered into the model.

It was assumed that point and area emissions would remain unaltered between 1998 and 2005, because there was no methodology available for refining the inventory within the time and resource constraints of the exercise in order to take account of such changes. In addition, some relevant factors, such as general levels of economic activity are difficult to predict. It also appeared to be a reasonable assumption that any changes in these emissions over such a relatively short period would be insignificant compared to other variations and errors in the model inputs.

On the other hand a methodology was devised whereby considerable changes in traffic volumes on different roads (i.e. line sources) over the relevant period were input into the model. In the same way, the vehicle emission factors used exhibited considerable changes. This methodology is detailed in the preceding section on Emissions Inventory.

At the time when the City Council embarked upon the modelling component of the Review and Assessment exercise, the Objective date for all of the pollutants which were carried forward to Stage 3 (carbon monoxide, nitrogen dioxide and particulates) was set at the end of 2005 and the emissions inventory was designed accordingly. The change to the current air quality Objectives has brought deadline dates of the end of 2005 for nitrogen dioxide, 2004 for particulates and 2003 for carbon monoxide respectively. The manner in which this has been addressed is set out in Section 3 of this Report, on the outcome of the Review and Assessment for these pollutants.

ADMS-Urban can model up to 1000 road sources at one time. The TRIPS Model output generated over 3000 road links and therefore could not be entered directly into ADMS. In order to include all the emissions from road sources it was necessary to add two way flows for a road into a total flow and to combine some of the smaller roads into grid sources.

The first step was to covert two way traffic flows into a total flow for each road segment. In order to do this road links with traffic flows in one direction were given a unique reference according to the Anode and Bnode numbers. This unique identification could then be matched to that of another link, corresponding to the same “stretch” of road. This preparatory work was carried out using a query in Microsoft Access 97. This reduced the number of road sources significantly. Secondly it was necessary to grid some of the smaller roads to further reduce the number of sources run in the model. The method used to grid the smaller road sources is a simple script written in Arcview that splits each road up over a chosen grid matrix and then totals the emissions in that grid square. By using this method of combining two way flows and gridding smaller roads it was still possible to include all road emissions in the model. The end result is an emission database that includes point and area sources, major road links and grids that contain smaller road links added together.

In ADMS, the traffic emissions are calculated from an internal emissions database and depend on the vehicle category (light duty or heavy duty), average speed and traffic count. These parameters are entered into the model from the Leicester Emissions Database, then the emission factors and rates of key pollutants are automatically calculated. The emission factors used are from the Design Manual for Roads and Bridges (Highways Agency, 1999, Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1 - Air Quality, The Stationary Office). Emissions Factors g/km included in the model are for the following pollutants:

CO	Carbon monoxide
VOC	Volatile Organic Compounds (Hydrocarbons)
NOx	Total oxides of Nitrogen
PM_{10}	Particulates

From this database the model calculates the emission rate for each road link dependent on the vehicle speed, flow and composition. For road sources, emission rates are calculated in g/km/s.

The database built into the model also offers a facility to calculate emissions based on projected future vehicle emissions. Emission factors for all years from 1996 to 2025 are available within the database.

In order to account for changes in traffic flow throughout the day and week, a traffic profile is used in the model to represent the different vehicle flow patterns that occur at different times. This profile of time varying emission factors gives an increase or decrease in traffic flows, relative to the hourly traffic counts derived from the AADT flow (Annual Average Daily Traffic), for each hour of the day and days in the week, i.e. weekday a.m. and p.m. peaks and weekend flows. For example at 8.00am on a weekday the time varying emission factor is 1.62 times the hourly average count derived from the AADT. The traffic profile used for the ADMS-Urban model runs is a standard hourly profile for urban areas where am and pm peaks are shown and was provided by Cambridge Environmental Research Consultants.

E.1.2.2 Meteorological Data

For the purpose of the National Air Quality Strategy Review and Assessment, data for the meteorological year 1999 has been input into ADMS-Urban. Data for 1999 is used to assist validation of the model as there is a complete set of monitoring data for the year 1999 available. Meteorological data for 1999 is taken from a Meteorological Mast situated on a traffic island at Groby Road, Leicester. Weather data files are in standard ADMS Met. data format.

Data from Leicester Met. Mast are hourly sequential and include 7 variables:

YEAR	Year
TDAY	Julian day number
THOUR	Local time (hour)
TOC	Near surface temperature (^{0}C)
U	Wind speed (m/s)
PHI	Wind direction (angle in degrees)
FTHETA0	Near surface heat flux (w/m^2) *(Calculated)*

The meteorological year 1999 is “typical” in terms of weather.

E.1.3 Dispersion Calculations.

To assist in the Review and Assessment of Air Quality a series of dispersion model runs were designed to investigate air quality over the City of Leicester now and in the year 2005 and to establish if any breaches of the NAQS Objectives have or are likely to occur.

Air quality monitoring stations can only give an indication of historical pollution levels at particular geographical locations. Air quality dispersion models can give an indication of pollution levels now and in the future at any geographical location where emission data has been obtained. The model runs for the Review and Assessment of Air Quality in Leicester have therefore been designed to establish whether any of the NAQS Objectives are being breached now or will be breached in 2005 for all areas within the City of Leicester.

For the purpose of the modelling work, the dispersion models ADMS-Urban and AIRVIRO have been run with data for the meteorological year 1999. The purpose of running this particular year of meteorological data is to enable a process of validation of the model using monitoring data from the Leicester Air Quality Monitoring Network for the same year.

The series of dispersion model runs are carried out using both the ‘present’ (1998) emission inventory and also the ‘future’ (2005) emission inventory. The procedure for the dispersion model runs is in a series of four steps, which are as follows:

- Run annual means for the whole city as contour plots for the Met. Year 1999.
- Select receptor points around the city corresponding to monitoring sites.
- Run the model for these receptor points for the Met. Year 1999 to produce a value for every hour of 1999.
- Use the data to validate the model results by comparison with monitored data.

E.2 The AIRVIRO Dispersion Model. (Version 2.21).

E.2.1 Description of the Model.

AIRVIRO is a dispersion model, originally developed by INDIC, but now distributed, supported, and further developed by the Swedish Meteorological and Hydrological Institute (SMHI). The model is capable of grid, gaussian, or canyon dispersion calculations. The model operates on a UNIX workstation, and includes modules for data collection, and dispersion calculations, and an emissions database. Dispersion calculations are performed in the Dispersion Module, using meteorological data collected from the Leicester meteorological mast together with emissions data from the emissions database. Emission sources for modelling using AIRVIRO are defined as point (e.g. industrial and commercial buildings), line (roads), or area (residential estates, or large industrial) sources.

The Leicester AIRVIRO model can be run on either a City or County map, zooming into a smaller area where greater detail is required. Emissions from the entire selected map are used for dispersion calculations; even where the zoom function has been used to select a smaller area for subsequent post modelled display.

E.2.2 Model Inputs

E.2.2.1 Emissions Data.

The model includes several databases, each of which includes details of emissions from each source in the database. Most databases include source and emission details from a specific year using particular emission factors (including databases that predict emissions for 2005). The emissions factors used for all AIRVIRO runs were obtained from the Strategy Directorate of the Greater London Authority. For each source in each database, the time varying emissions of NO_x, PM_{10}, CO, SO_2, CO_2, VOC's and CH_4 were calculated.

Traffic (line source data):- Hourly emissions for each link of a length of road are used by AIRVIRO for dispersion calculations. Hourly traffic flows are derived from daily average flows by applying the known flow pattern for the particular road type used to classify the link under consideration. Hourly flows are multiplied by a pollutant specific emission factor for each vehicle type included in the model database, to obtain an emission rate at different speeds (in steps of 10 km per hour). Traffic flows were obtained from a TRIPS traffic model. wThe emission factors used were obtained from the Strategy Directorate of the Greater London Authority

Six vehicle types are used in the emission database. These were selected as those vehicle types for which emission factors were available from the London Research Centre. The vehicle types, as classified in the model, together with definitions are as follows:

BUS	*Buses*
DIE-C	*Diesel cars*
HGV	*Heavy Goods Vehicles*
LGV-D	*Light Goods Vehicles with diesel engines*
LGV-P	*Light Goods Vehicles with Petrol Engines*
PET-W-C	*Petrol Cars with catalytic converters*
PET-WO-C	*Petrol Cars without catalytic converters*

Petrol cars were not classified according to those with or without a catalytic converter, since the emission factors used accounted for the proportion of each within the overallpetrol car fleet.

Traffic Flow data: -The data for modelling for air quality review and assessment was obtained from the Greater Leicester Traffic Model (GLTM) traffic model, run undertaken in December 1998. The GLTM is a TRIPS type model, which predicts vehicle journeys, and consequently traffic flows on individual links, from land uses within the modelled area. The 1998 GLTM run was effectively an updating of a previous run made in 1996, to include all new major roads, and changes in traffic data.

Predicted traffic flows for 2005 were also from a TRIPS model run. To predict flows for 2005, the modelled area was sub-divided into Zones. For each zone, the change in the number of journeys was predicted by traffic engineers at both the City and County Councils, and this was used as the basis of a further full TRIPS run.

Road Links - The traffic model identifies approximately 3500 links, which have been applied to AIRVIRO. A link is a section of road, usually between two junctions, that carries traffic in one direction. Thus roads other than one-way streets will normally have two links between each major junction, one for each directional flow of traffic. Each link is defined by a national grid reference at each end. As each link for traffic travelling in each direction along the same stretch of road would otherwise share the same grid references, the links for each direction have been separated by one meter. The modelled traffic flow for each link from the GLTM is expressed as an annual average daily flow.

Before being used for air quality modelling, each link is classified according to the flow pattern of traffic along the link, so that time varying emissions can be calculated within the model. The traffic flow pattern allocated to each link was described according to peak flows (e.g. high morning peak, low evening peak), road type (e.g. estate road, through road) and traffic type (e.g. high volume of heavy goods vehicles). Traffic Control Engineers from Leicester City Council Area Traffic Control, based on local knowledge and experience derived the classification system. The speed allocated to each link was the statutory speed limit for the link, but amended as appropriate the allocated speed classification in the light of local knowledge and experience of traffic engineers.

The traffic database for 2005 was derived from a further run of the GLTM, using the 1998 run. 2005 traffic flows changes, compared to the 1998 modelled figures, were predicted for zones within the modelled area. Predictions were made by Traffic Engineers from Leicester City Council Traffic Group, expressed as an overall percentage positive or negative change for each zone These were applied to the GLTM, which was subsequently used to model predicted flows for each link in 2005.

The classifications of the road links, with definitions, are as described in Section D.4.

Point sources - general principles:- A point source is any source that has a well defined position, and an emission of small restricted volume. AIRVIRO Emissions Database module requires the following data for each point source:

- Name information - the name of the source
- General information - contact details, e.g. address, contact person
- Dynamic information - emissions data, including time and seasonal variations
- Static information - stack details, including location, stack dimensions and flue gas temperature. The dimensions of the largest significant building are also included. For the edb's used for Review and Assessment calculations this was defined as the largest building within 5 chimney heights of the stack concerned.
- Emission - substances emitted. AIRVIRO is able to calculate this from fuel use, but actual emissions are entered into all EDBs used for Review and Assessment dispersion calculations.

The location of each point source is entered into the model by clicking directly onto the model map.

Point sources - time variation: Time variations used for AIRVIRO dispersion calculations are as described in Section D.2.

Area sources: An area source is a diffuse emission, emitted from a defined area. Although may be applied to some industrial sites, for the purposes of Review and Assessment only housing estates were specified as area sources. AIRVIRO models the dispersion of emissions from area sources at a height of 2m.

Each area was defined on the model using local knowledge of the boundaries of each estate, plotted (because of model limitations) as a quadrant. The plotted area boundary will therefore differ from the actual area boundary. However as these area sources mostly influence air quality in terms of background, rather than point specific, pollution levels, it is unlikely that the boundary assumptions will significantly affect the results of model runs.

As for point sources, area emissions can be described in AIRVIRO in terms of time variations. The time variation for the area sources was taken from monthly gas used figures provided for the original energy survey, and was as follows:

January/February	100%
March	75%
April/May	50%
June/July/August	5%
September/October	50%
November/December	100%

E.2.2.2 Meteorological data.

Meteorological data used for AIRVIRO Review and Assessment runs for meteorological years 1997 and 1998, were retrieved by the model directly from the Leicester Meteorological Mast. This is located on a large open traffic island at the junction of Groby Road, New Parks Boulevard, and Glenfrith Road (O.S. Reference 55830638). The mast was installed specifically to provide data for the AIRVIRO model in September 1996. Meteorological data for runs for meteorological years 1995 and 1996 were from a mast located at Elmdon Airport, Birmingham. This data was purchased from the Met office, and transposed into a database suitable for AIRVIRO by SMHI.

The following data is retrieved from the meteorological mast by AIRVIRO every 15 minutes:

ID number
Year
Julian Day
Time
Absolute temperature at 8m
Absolute temperature at 2m
Difference between temperatures at 8m and 2m
Windspeed at 10m
Wind direction
Standard wind direction
Standard wind speed
Standard vertical wind
Maximum wind speed integrated over 30 minutes.

In addition the status of various alarms is retrieved.

E.2.3 Dispersion calculations.

The model area, pollutant, and desired year of meteorological data are each selected for every dispersion calculation. Each run can only model a single pollutant, but several runs can be performed at any time. Raw results are expressed as a series of hourly values, displayed as either isolines, or coloured grids that describes pollution levels in terms of predetermined classes.

When selecting the pollutant to be modelled, AIRVIRO includes the option of restricting the calculation to a particular source(s), for example only including roads in the calculation. All Review and Assessment calculations accounted for all sources.
Once a dispersion calculation is complete, statistical calculations may be performed on the hourly result using "TSCalc" software, developed by SMHI. This software allows the following statistical calculations to the dispersion result:

- Average of modelled period
- Maximum hourly value
- Time and date of maximum hourly value
- Minimum hourly value
- Time and date of minimum hourly value
- Maximum daily mean
- 90, 95, 98, 99, and 99.9 percentiles
- 8 hour, 24 hour, and annual rolling averages.
- Percentage time a predetermined value is exceeded.

The statistical results are displayed as grids or isolines in the same way as the dispersion calculation results.

Airviro allows dispersion calculations using either gaussian or grid models. The Gaussian model predicts pollutant concentrations by calculating the dilution of the emitted plume (including plumes from line sources, i.e. roads) under the selected meteorological conditions. The Grid Model calculates hourly pollution levels across each grid by assessing (a) emissions directly into the grid from sources within the grid area (b) emissions that migrate into the grid from adjacent grids and (c) pollution levels that remain in the grid area from the previous hour. Calculations can be performed on either 500m or 250m grids, the former allowing more rapid calculations, but the latter modelling in greater detail.

Following advise from SMHI, the Gaussian model was used for all annual average runs, since each model will produce similar results for a run of this type, and gaussian calculations are considerably quicker than those in the grid model.

E.3 Procedure for ADMS Dispersion Model Runs.

E.3.1 Annual Mean City-wide Runs.

The first step of the Model runs was carried out using ADMS-Urban. This involved running the model for the meteorological year 1999 with the output being in contour plot format for the whole City. The model was run to output three pollutants: Nitrogen Dioxide, Carbon Dioxide and Particulates (PM_{10}). The model firstly calculates a value for every hour in the met. data file for the whole year and using these values calculates the annual mean. The results are in the form of a coloured contour plot representing the annual mean concentration of the pollutant overlaid over a map of the City. Each pollutant is plotted for 1999 meteorological year, resulting in a total of three maps for the 'now' runs and three maps for the 'future' runs. The pollution contour plots are interpolated over ordnance survey GIS maps in Arcview. For Nitrogen Dioxide these maps are then used to determine whether the annual mean Objective has been or may be breached at any location in the City. The maps are also used to establish any significant 'hotspots' around the City.

E.3.2 Selection of Receptor Points.

The receptor points to run in the model correspond to all monitoring stations around the city. The purpose of this is to compare model results with actual monitored data for the purpose of validation of the model.

E.3.3 Table of receptor points selected for the model runs:

Table E.3.3: Receptor Points at Monitoring Stations

Receptor Name	Location	Co-ordinates
RM1	AURN, New Walk Centre, Leicester	SK 458763 304065
RM4	LAMS, Marydene Drive, Leicester	SK 463321 303073
RM6	NOx Analyser, Bassett Street, Leicester	SK 457788 305444
RM7	NOx and TEOM, Imperial Avenue, Leicester	SK 457245 303040
RM8	NOx and BAM, Melton Road, Leicester	SK 459528 306316
RM9	NOx and BAM, Abbey Lane, Leicester	SK 458574 306885
RM10	NOx Analyser, Glenhills Way, Leicester	SK 457083 300156

E.3.4 Receptor Point Runs

The ADMS-Urban Model is used to produce an output at the receptor points, for the meteorological year 1999, using both the “now” and “future” emission inventories. The results are in the form of a value of NO_2, CO and PM_{10} at each location, for every hour in the year that was used to run the model. The results are then exported to Microsoft Excel where they can be studied, graphed and statistically analysed. The analysis of results is different for each pollutant. For nitrogen dioxide the figures are studied to determine whether the hourly objective of 200 $\mu g.m^{-3}$ expressed as an hourly mean has been exceeded. The hourly peak values for which an Objective is also specified are more problematic and are discussed in more detail in the Section on the outcomes of the modelling process. For carbon monoxide the hourly values used to calculate the 8 hour rolling average to determine whether the objective of 11.6 $\mu g.m^{-3}$ has been exceeded. For particulates the hourly values in micrograms per cubic metre are used to calculate the 24 hour and annual mean values.

Constraints on resources and available model-time did not permit the AIRVIRO model to be used for predictions of future concentrations of the specified pollutants for Leicester. However, predictions of the current situation were available for both models for the distribution of annual mean values of nitrogen dioxide. Since this appeared to be the key factor in determining the extent of Air Quality Management Areas, comparisons were made between the performance of the two models for the purposes of validation.

E.4 Validation of Model Runs.

E.4.1 Carbon Monoxide

E.4.1.1 Modelling Results :1999

Monitoring data available for 1999 and which meets the criteria for data capture, precision and quality is restricted to 2 urban background sites at Marydene Drive and the AUN. It could be argued that these are the locations where the public are most likely to be exposed over an 8 hour period and are therefore most significant for air quality purposes. Current monitoring indicates that the air quality objective is not being exceeded at these locations.

E.4.1.2 Correction of Modelled Data

The modelled values are considerably lower than the measured values, and the model's performance is not considered to be entirely satisfactory as the model underestimates by more than 50% (LAQM/TG4/00). The trend, however, clearly agrees with the monitoring data, in that the carbon monoxide Objective is not being exceeded at present. These factors must be considered when interpreting the model outputs.

Table E.4.1.2: Modelling & Monitoring Output CO mg/m^3 (ppm)

Site	**AUN**			**Marydene Drive**		
Percentile	Measured	Modelled	Corrected Modelled	Measured	Modelled	Corrected Modelled
25th	0.4(0.3)	0.04 (0.04)	0.4 (0.4)	0.2 (0.2)	0.003 (0.003)	0.2 (0.2)
40th	0.4 (0.5)	0.07(0.08)	0.45 (0.5)	0.2 (0.2)	0.01 (0.01)	0.22 (0.3)
Average	0.6 (0.7)	0.1 (0.2)	0.6 (0.7)	0.3 (0.3)	0.02 (0.02)	0.3 (0.3)
90th	1 (1.16)	0.3 (0.3)	0.9 (1)	0.4 (0.5)	0.06 (0.07)	0.4 (0.4)
95th	1.2 (1.4)	0.4 (0.4)	1.1 (1.3)	0.6 (0.7)	0.09 (0.1)	0.5 (0.6)
99th	1.8 (2)	0.8(0.9)	1.9 (2.2)	0.9 (1)	0.2 (0.2)	0.9 (1)
8hr rolling average	**2.40 (2.8)**	**1 (1.16)**	**2.3 (2.7)**	**1.3 (1.5)**	**0.3 (0.3)**	**1.2 (1.4)**

The method used in validation was suggested by the Air Quality Modelling Helpline and involved comparison of modelled and monitored data, by looking at the percentile distribution. A quadratic relationship was derived by plotting modelled against measured values, and this was then used to correct the modelled values. This correction accounts for the systematic error that the model exhibits by underestimating the measured values. (See Fig. 24).

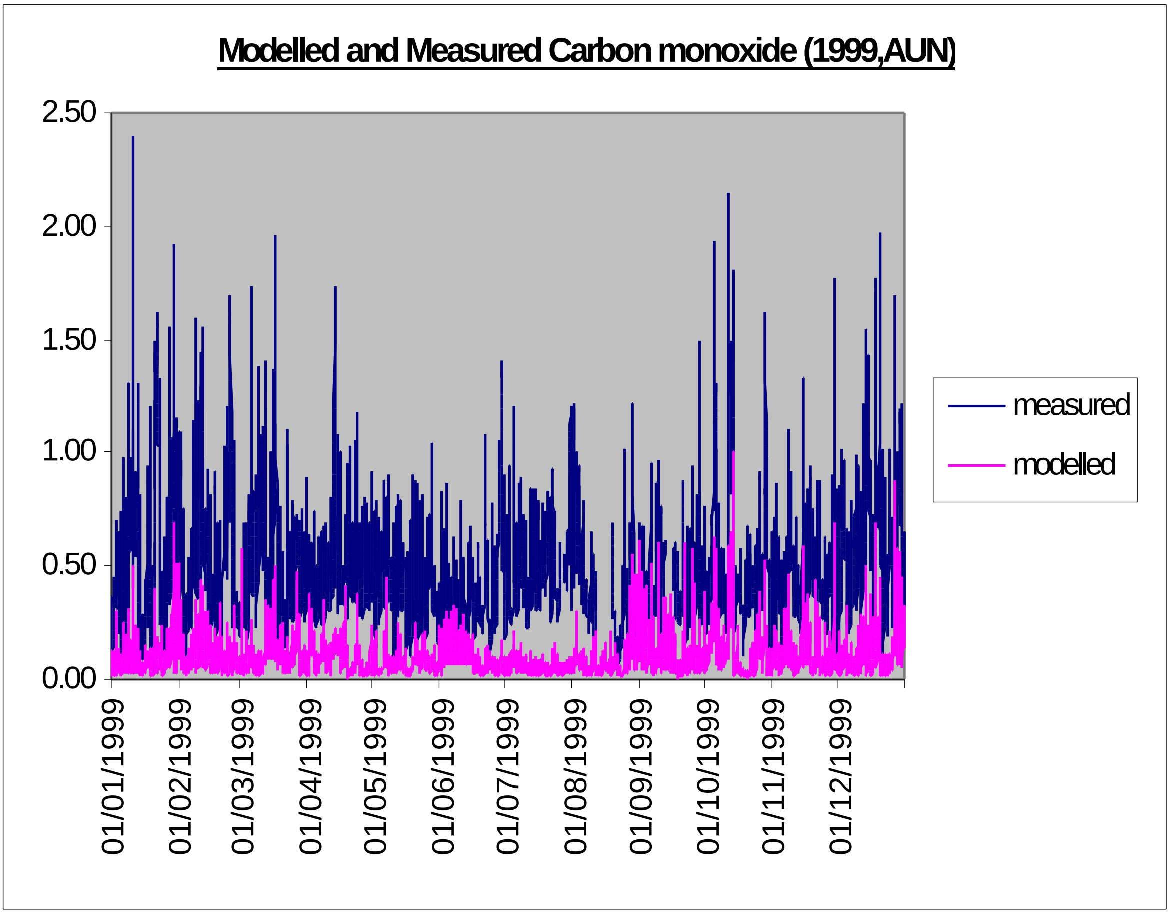


Figure 24: Graph of monitored and modelled carbon monoxide at the AUN in 1999

E.4.1.3 2005 Model Runs

It is assumed that the raw output from the modelling runs will require correction, as the model is also likely to underestimate for the future runs. The emissions inventory which has been created is for 2005, but it can be assumed that the levels predicted are not likely to vary greatly by the end of 2003.

Table E.4.1.3: Modelling & Monitoring Output CO mg/m^3 (ppm)

Site	**AUN**		**Marydene Drive**	
Percentile	Modelled	Corrected Modelled	Modelled	Corrected Modelled
25th	0.04 (0.04)	0.5 (0.4)	0.004 (0.003)	0.2 (0.2)
40th	0.08 (0.07)	0.5 (0.5)	0.007 (0.006)	0.2 (0.2)
Average	0.2 (0.1)	0.7 (0.6)	0.02 (0.02)	0.3 (0.3)
90th	0.3 (0.3)	1.0 (0.9)	0.07 (0.06)	0.5 (0.4)
95th	0.5 (0.4)	1.3 (1.1)	0.1 (0.1)	0.6 (0.5)
99th	0.9 (0.8)	2.2 (1.9)	0.2 (0.2)	1.0 (0.9)
8hr rolling average	**1.16 (1.0)**	**2.7 (2.3)**	**0.3 (0.3)**	**1.4 (1.2)**

E.4.1.4 Modelling Conclusions

The modelled output is very low and after correcting for systematic error, the levels are comfortably within the Air Quality objective for 2003. This is representative of the likely conditions at urban background locations, where the majority of long term exposure is likely to occur. Levels at roadside would be higher, however in the absence of reliable roadside monitoring data, it is not possible to fully validate the model output for roadside locations. It is therefore recognised that some precision monitoring of roadside carbon monoxide is required within the city, to allow enhanced modelling for 2003.

However it is noted that future predictions for road traffic indicate levels of carbon monoxide are likely to decrease further, and it is therefore considered unlikely that the roadside levels of carbon monoxide will exceed the objective in 2003.

E.4.2 Nitrogen dioxide

E.4.2.1 The relationship between NOx and NO_2 : Treatment of atmospheric chemistry by the models.

(a) ADMS

For ADMS-Urban there is a facility within the model to calculate the chemical reactions between nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3) and volatile organic compounds (VOC) in the atmosphere. To model the chemical reactions ADMS-Urban uses a scheme called The Generic Reaction Set. The Generic Reaction Scheme uses a set of chemical reactions to model the interactions of NO, NO_2, VOCs and O_3 in the atmosphere. In order to use this system background concentration data must be input into the model for the critical pollutants (i.e. NOx, NO_2 and O_3). The data used to compile the GRS file is taken from Ladybower Rural Monitoring Station for the year 1999 to correspond to the weather year being run in the model.

Road vehicles and industrial sources emit a complicated mixture of chemicals including many volatile organic compounds or VOC's and oxides of nitrogen which are involved in reactions with ozone. It is beyond the scope of a fast practical model to include all the reactions that these chemicals undergo. Therefore, ADMS-Urban uses the scheme known as the Generic Reaction Set (GRS; Venkatram et al., 1994) which models the important reactions involving nitrogen, VOC's and ozone. The GRS chemistry scheme is a semi-empirical photochemical model which reduces the complicated series of chemical reactions involving NO, NO_2, O_3 and many hydrocarbons to just seven:

(1) $ROC + h\upsilon \rightarrow RP + ROC$
(2) $RP + NO \rightarrow NO_2$
(3) $NO_2 + h\upsilon \rightarrow NO + O_3$
(4) $NO + O_3 \rightarrow NO_2$
(5) $RP + RP \rightarrow RP$
(6) $RP + NO_2 \rightarrow SGN$
(7) $RP + NO_2 \rightarrow SNGN$

where

ROC = Reactive Organic Compounds
RP = Radical Pool
SGN = Stable Gaseous Nitrogen products
SNGN = Stable Non-Gaseous Nitrogen products

Equations (3) and (4) represent exact chemical reactions which happen very quickly. The other equations are approximations.

(Taken from ADMS-Urban, An Urban Air Quality Management System, User Guide, November 1999, Section Nine: Technical Summary, Cambridge Environmental Research Consultants).

(b) AIRVIRO

For AIRVIRO to produce a result in nitrogen dioxide, a conversion factor must be included in the model as emissions in the database are in total oxides of nitrogen. The method used to convert NOx emissions into a pollutant value in NO_2 is the Derwent-Middleton Correlation. When using this equation, output concentrations of NO_2 are calculated from input NOx emissions. The concentration of NO_2 is calculated using the following function, where concentrations are hourly average concentrations in ppb.

$[NO_2]=2.166-[NOx\ (1.236-3.348A + 1.933A^2-0.326A^3)]$

where $A = \log_{10}(NOx)$

The equation is valid in the range 9ppb to 1141.5ppb.

This equation is used to subdivide calculated concentrations of NOx into NO_2 and NO. *(Derwent R.G. and Middleton D.R. 'An empirical function for the ratio NO_2:NOx.' Clean Air, vol 26, No3/4, pp57-60, 1996).*

E.4.2.2 Background correction.

It has been suggested that a value for “suburban” background should be added on to predictions for urban receptor points. However, this view is not accepted by Leicester City Council: It is considered that any urban background will contain emissions which are accounted for in the emissions inventory, i.e. emissions will be "double counted" and levels over-estimated by this procedure. Future model outputs corrected in this way confirms serious over-estimation, showing the whole area of Leicester is experiencing exceedance of the Objective for Nitrogen dioxide in 2005. Since monitoring shows that this is clearly not the case *now* and that exceedances only occur within the zone of influence of major roads and since the relevant components of emissions inventory are predicted to decline considerably between now and 2005, this is manifestly unlikely.

Therefore, a background correction for model predictions derived from a convenient rural Nitrogen dioxide monitoring site has been adopted for this Review and Assessment. This is based on the 1999 annual mean for the nearest suitable rural nitrogen dioxide monitoring site, i.e. **Ladybower**.

Background correction to model output for 2005 = 11.1mg.m^{-3} (5.8 ppb)

E.4.2.3 Predicted maximum hourly means.

It is difficult to predict short-term values of pollutants accurately with dispersion models (LAQM.TG3 (00), *Review and Assessment: Selection and Use of Dispersion Models,* paras. 7.21-7.22). Correlation between modelled and monitored levels of nitrogen dioxide for corresponding hours was not successful. This can be accounted for by wide and rapid short-term fluctuations of pollutant levels near to major roads. The method adopted for analysis was therefore designed to assess if the model could satisfactorily predict maximum NO_2 levels, rather than match the particular hours in which they occurred.

(a) Estimation of systematic error

The model receptor runs provided average hourly data at each of the monitoring points in the city. The modelled and monitored data was sorted and the top 50 values for each set were then closely examined and percentile values were compared. A ratio was then derived at each of the monitoring stations based on *monitored/modelled* which could be applied to the raw modelled data to correct the model. This correction factor is to account for the systematic error within the model output.

Table E.4.2.3: Calculation of systematic error corrections (hourly means)

ADMS Maximum hour nitrogen dioxide	**Monitored* maximum hour NO_2**	**Modelled* maximum hour NO_2**	**Correction Factor**	**Corrected model output**
Melton Road	263 (138)	173 (91)	1.36	230 (120)
Imperial Ave	231 (120)	175 (92)	1.31	232 (121)
Glenhills	151 (79)	176 (92)	0.85	234 (123)
Abbey Lane	321 (172)	164 (86)	1.79	218 (114)
Roadside group mean			1.33	
Basset Street	110 (58)	163 (85)	0.65	105 (55)
AUN	108 (57)	170 (89)	0.66	109 (57)
LAMS Marydene	90 (47)	139 (73)	0.62	89 (47)
Background group mean			0.64	

* All NO_2 values in micrograms per cubic metre (ppb)

The modelled peak values do not vary greatly between roadside and background sites, although the monitored levels are clearly higher at the roadside sites. The model is generally underpredicting at roadside sites, and overpredicting at background sites. The only exception to this is Glenhills Way, where the objective is not currently exceeded.

The correction factors at the roadside sites were then plotted in a scatter plot, and a regression analysis was carried out. A reasonably good relationship (R^2 =0.75) exists between the monitored and the corrected modelled output, indicating that a significant component of the systematic error in the model predictions has been accounted for.

(b) Estimation of random error

The method for estimating remaining uncertainty within the data was that suggested by the NSCA Guidance-Note "*Air Quality Management Areas: Turning Reviews Into Action,* Part 2". A standard deviation was calculated of 7µg/m^3 (3ppb).

In practice however, it is not possible to produce a sensible map output for this objective since peak hours do not correspond at different monitoring stations, being dependant on wind direction and other factors.

It is only at the roadside locations that exceedances of the hourly objective would be likely to occur. The correction factor of 1.33 could therefore be applied to the 2005 model output in a map form, and contours plotted at the standard deviation intervals. The map output would then be interpreted to identify exceedances within 10m of the roadside. For zones more than this distance from major roads, a significant reduction would be effected in the predictions by applying an estimated factor of about 0.64 to the model output.

This difficulty in producing specific map output for the hourly objective is not considered to be a problem, as the potential area of exceedance indicated by both monitoring and modelling is within about 10m from the roadside. This would mean therefore that the area where the hourly objective may be exceeded would be within that already identified for the annual mean objective.

As a cross-check, the 99.8th percentile of hourly values for nitrogen dioxide was also estimated from annual mean values, using an empirical relationship suggested in the Guidance (see next section).

E.4.2.4 Predicted annual means.

Current annual mean levels of nitrogen dioxide for various receptor points corresponding to automatic monitoring sites were modelled using the ADMS and AIRVIRO dispersion models. Since 1999 was the only full year for which extensive monitoring data was available, the meteorological data for 1999 was also used in the modelling. This data was used for validation of the models and the outcome was mapped using ADMS. The output was assessed, following consideration of various factors, in accordance with the statutory Guidance:

(a) Estimation of systematic error.

The monitoring data for the receptor points was subjected to appropriate QA/QC procedures and validation procedures, as detailed in Appendix B. Full details of the location and characteristics of these monitoring sites are also given in Appendix B.

In order to estimate the systematic error to which the modelling was subject, the ratio -

[monitored annual mean / modelled annual mean]

-was calculated for each model, with respect to each receptor site. It was noted that there was variation in this ratio between sites, ranging from considerably less than unity to considerably in excess of unity. It was observed that the ratio tended to be largest (i.e. the model under-predicted) at sites close to busy roads and that it tended to be smallest (i. e. the model over-predicted) at sites at greater distances from such roads. The following Tables illustrate the position, with receptor points ranked in ascending order of distance from the kerb. It will be noted that there is a close degree of agreement between the two models.

4.2.4: Estimated systematic error corrections (annual mean)

Table 4.2.4/1 (ADMS)

ADMS Annual mean nitrogen dioxide	Kerb distance from major road (m.)	Monitored* annual mean NO_2	Modelled annual mean NO_2	Ratio monitored: modelled (= correction factor)	Standard deviation of correction factor	Corrected model output (x mean correction factor)
MeltonRd	2.5	63 0 (33)	45.8 (24)	1.38	**0.24**	69.0 (36.1)
Imperial Ave	3.3	74.5 (39)	42.0 (22)	1.77		63.2 (33.1)
Glenhills	3.8	68.8 (36)	42.0 (22)	1.64		63.2 (33.1)
Abbey Lane	8	49.7 (26)	40.1 (21)	1.24		60.4 (31.6)
Mean:				**1.51**		
Bassett St	11.8	40.1 (21)	43.9 (23)	0.91	**0.15**	38.4 (20.1)
AUN	35	42.0 (22)	42 0 (22)	1.00		36.7 (19.2)
LAMS Marydene	380	22.9 (12)	32.5 (17)	0.71		28.3 (14.8)
Mean:				**0.87**		

*All NO2 values in microgrammes per cubic metre (ppb)

Table 4.2.4/2 (AIRVIRO)

AIRVIRO Annual mean nitrogen dioxide	Kerb distance from major road (m.)	Monitored*	Modelled*	Ratio monitored: modelled (= correction factor)	Standard deviation of correction factor	Corrected model output (x mean correction factor)
MeltonRd	**2.5**	63.0 (33)	42.0 (22)	1.50	**0.27**	66.3 (34.7)
Imperial Ave	**3.3**	74.5 (39)	40.1 (21)	1.86		63.2 (33.1)
Glenhills	**3.8**	68.8 (36)	40.1 (21)	1.71		63.2 (33.1)
Abbey Lane	**8**	49.7 (26)	40.1 (21)	1.24		63.2 (33.1)
Mean:				**1.58**		
Bassett St	**11.8**	40.1 (21)	43.9 (23)	0.91	**0.06**	38.0 (19.9)
AUN	**35**	42.0 (22)	47.8 (25)	0.88		41.3 (21.6)
LAMS Marydene	**380**	22.9 (12)	28.7 (15)	0.80		24.8 (13.0)
Mean:				**0.86**		

*All NO2 values in microgrammes per cubic metre (ppb)

The ratios were plotted in a scatter-graphs and it was noted that a good logarithmic curve of "best fit" was obtained. The graphs indicate that the correction factor declines rapidly in value with increasing distance from kerb at small distances from major roads but much more slowly with increasing distance, as the curve tends to become more parallel with the *x*- axis. (The estimation of a notional distance for a suburban background site such as Marydene from the nearest parts of the major road-network does not present a problem since, for relatively large values of distance, considerable differences in distance have relatively little influence on the correction factor.)

The separation point between the model under-predicting (near major roads) and over-predicting (in background situations) can be estimated from the graph: The curve of best fit intersects a ratio between modelled and monitored value of unity (*y-axis*) at a distance from the kerb of around 50 metres (*x-axis*). (See Figs. 25, 26).

However, considering the plotted values for the sites, it is noticeable that the systematic adjustment required to the model output at distances between, say, 10 and 400 metres lies within a small range and is less than unity; For distances of less than 10 metres, the sites fall into a group, again lying within a comparatively small range but exhibiting a systematic correction somewhat in excess of unity. Variations in the performance of the model would be expected to be larger for the sites in very close proximity to major roads because the greater short-term fluctuations in Nitrogen dioxide concentrations experienced at these locations are more difficult to model accurately.

This suggests that a convenient classification of the receptor points into those for which the correction factor was greater than unity and those for which it was less than unity could be established by adopting a critical distance of about 10 metres. The sites were therefore divided into two groups and their correction factors averaged for each group, as shown in the above tables.

It is acknowledged that this analysis has been carried out with a relatively small sample of receptor-points, with data for only one calendar year. However, it was considered on balance better to classify the sites for the purposes of model validation on the basis of the actual behaviour of the model than to rely on a purely verbal descriptions derived from the Guidance, such as "roadside" or "background". The essential difference in the former approach lies in estimating from the local data the distance at which the influence of major roads becomes of less significance. In practice, this analysis agrees with the demarcation given in the Guidance (LAQM.TG4 (00), para.6.32)

For the purposes of mapping the predictions of the ADMS model, a systematic correction of 0.9 has therefore been plotted for comparison with the raw output with respect to the year 2005, since the boundaries of areas of exceedance of the air quality Objective occur in regions where a correction factor of this order is appropriate.

It must be borne in mind that, where people *are* exposed to traffic-generated Nitrogen dioxide at distances of less than 10 metres from the kerb, they will be exposed to significantly higher levels since it is estimated that values predicted by the models will be too small by approximately 50%.

(b) Estimation of random error.

Random error for the ADMS model was calculated using the method set out in the NSCA Guidance-Note "*Air Quality Management Areas: Turning Reviews Into Action,* Part 2". A standard deviation was calculated for the data and this was superimposed upon the mapping by plotting the isopleths of pollutant concentration in increments of this estimated value of uncertainty. In this way, zones where there is a range of probability of exceeding the Air Quality Objective *from "almost certain to"* to *"almost certain NOT to"* can readily be read off the map.

The standard deviation was calculated to be 2.18 $\mu g.m^{-3}$ (1.14 ppb). For practical purposes, this was assumed to be equal to 2 $\mu g.m^{-3}$ (1 ppb).

Fig. 25: Chart of observed: modelled ratio against kerb distance (ADMS model).

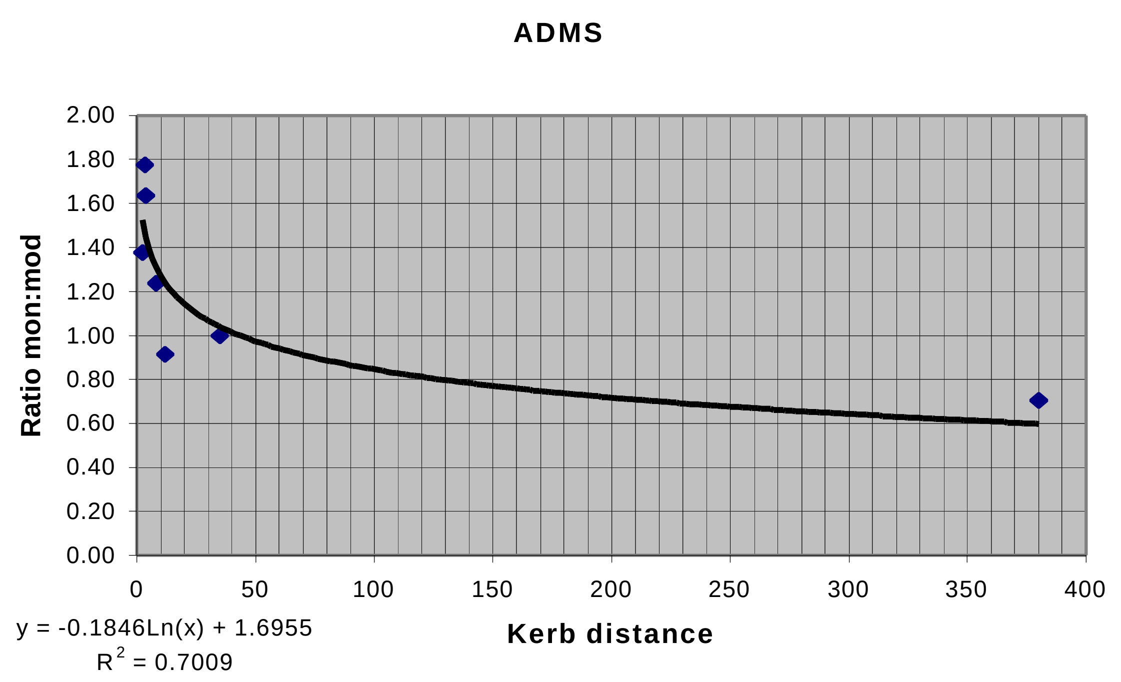
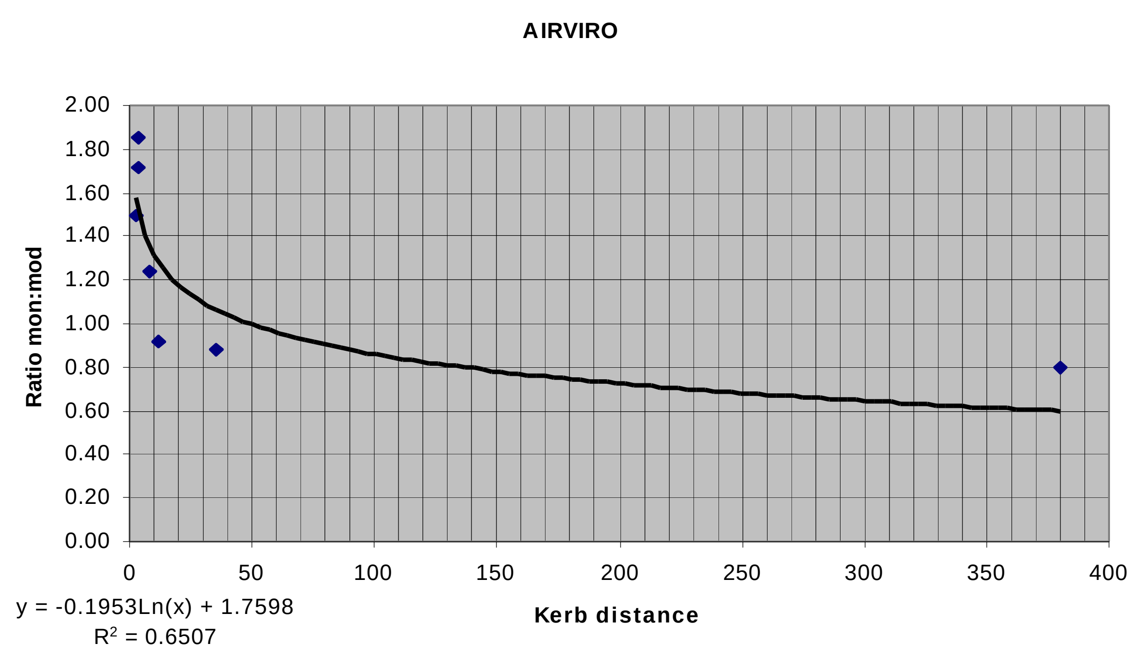


Fig. 26: Chart of observed: modelled ratio against kerb distance (AIRVIRO model).



E.4.3 PM_{10} Particulates

E.4.3.1 Background correction.

For **ADMS-Urban and AIRVIRO** the model gives a PM_{10} prediction for primary emitted particles by using the emission database. The secondary and coarse components of PM_{10} must be added to the model results.

Secondary particles are formed in the atmosphere by the oxidation of sulphur dioxide and oxides of nitrogen to form sulphate and nitrate particles. Secondary particles are formed relatively slowly in the atmosphere which means their contribution to PM_{10} is more uniform across the country than primary particles.

There is a clear relationship between the non-combustion component of PM_{10} and concentrations of sulphate. The slope of about 3 shows the scaling factor required to convert sulphate measurements to secondary PM_{10}. This relationship therefore provides a method for estimating the contribution of secondary particles to PM_{10}.

The sulphate data used to obtain a secondary PM_{10} value is taken from the Rural Sulphate Monitoring Network. Data is taken from five monitoring sites and hourly wind direction is used to determine which site sulphate data is taken from for each hour. The sulphate monitoring sites used are as follows:

High Muffles (340 – 45 degrees)
Stoke Ferry (45 – 120 degrees)
Barcombe Mills (120 – 180 degrees)
Yarner Wood (180 – 260 degrees)
Lough Navar (260 – 340 degrees)

All data are as mass of sulphur and are measured in micrograms of sulphur per cubic metre. The measurements are firstly multiplied by a factor of 2.5 to convert the data to sulphate. This value is then multiplied by a factor of 3 to give an estimation of secondary particles.

A constant value of 5 $\mu g.m^{-3}$ is used to represent the coarse component of $PM_{10.}$

Therefore the equation used to obtain a model output for PM_{10} is:

PM_{10} value = ADMS modelled + (measured sulphate* 7.5) + 5 (coarse)

All values are in micrograms per cubic metre.

E.4.3.2 Estimation of systematic and random modelling error for annual means and 24-hour means..

A difficulty in model validation is that the monitoring sites in Leicester are divided between the TEOM and BAM measurement techniques. It is difficult to make comparisons between data derived from the two methods for the reasons discussed in detail in Appendix B.2.2.4. If the two types of site are treated separately for the purposed of validation, the number of available sites is correspondingly reduced. (Three sites for TEOM, only one of which is roadside, and two for BAM).

Using the ADMS model, annual mean and 24-hour values were modelled at receptor points which corresponded to automatic particulate monitoring sites. Meteorological data for 1999 was used because this was the year for which the maximum number of monitoring sites was available. These are set out as follows:

Table 4.3.2/1: Modelling Outputs Compared to 1999 Monitoring Data

ADMS Modelling PM10		**Annual means***		**Max. 24-hour means***		**Number of 24-hour means > 50***	
TEOM Sites (x 1.3)	**Kerb distance**	**Monitored**	**Modelled**	**Monitored**	**Modelled**	**Monitored**	**Modelled**
Imperial Ave.	3.3	**55**	11.5	129	30.3	**180**	0
AUN	35	21	12.1	55	29.8	5	0
Marydene Dri.	380	21	10	55	26.7	2	0
BAM Sites							
Melton Rd.	2.5	37	13.2	117	32.6	**61**	0
Abbey La.	8	37	11.6	118	31.9	**61**	0

*All data in microgrammes per cubic metre

A correction factor was calculated for each modelled annual mean and the mean correction factor calculated for TEOM and BAM sites, respectively and applied to the modelled values. An attempt was also made to estimate the 95th percentile of 24-hour means (approximating to 35 exceedances per year), which corresponded to each corrected annual mean:-

Table 4.3.2/2: Estimated model correction factors

SITE	**Correction factor for modelled annual mean**	**Corrected modelled annual mean (adjusted)**	**Estimated 95th percentile of 24-hour means**
TEOM	**(Monitored/ modelled)**	**(X mean correction factor)**	**(Corrected modelled annual mean X 1.68)**
Imperial Ave.	4.8	33.0	55.5
AUN	1.7	34.8	58.4
Marydene Dri.	2.1	28.7	48.3
BAM	**2.9**	¬ **(Mean)**	
	1.66	¬ **(Std.deviation)**	
Melton Rd.	2.8	39.6	66.4
Abbey La.	3.2	34.8	58.4
	3.0	¬ **(Mean)**	
	0.27	¬ **(Std.deviation)**	

It can be seen that, while the values for the BAM sites lie in the middle of the distribution, the monitored/modelled ratios for the TEOM sites lie in the range 1.7-4.8. I.e. the model is grossly underestimating annual means and in no case does its prediction lie within 50% of the measured value. It can also be seen that the number of exceedances of the 24-hour Objective criterion is also grossly underestimated by the model: None are predicted for sites where monitoring data shows a large number of exceedances.

It is therefore considered that a satisfactory estimate of systematic error for the model cannot be derived and applied.

It would clearly be still more unsatisfactory to attempt to use corrected annual means based on such a wide and variable systematic error to estimate maximum 24-hour means using the empirical relationship set out in the Pollutant-Specific Guidance.

APPENDIX F: Consultation Strategy.

F.1 Statutory Consultation:

Schedule 11 of the Act requires all Local Authorities to consult a number of bodies/organisations as statutory consultees. As statutory consultees they have received a full copy of the Stage 3 Review and Assessment Report. These Statutory Consultees are as follows :-

- The Secretary of State for the Environment, Transport and the Regions.

- The Environment Agency.

- All neighbouring Local Authorities, which comprise:

    - Blaby District Council
    - Harborough District Council
    - Charnwood Borough Council
    - Oadby and Wigston Borough Council.

In fact, all Local Councils in Leicestershire and Rutland, as members of the Leicestershire Air Quality Forum, will be consulted (see below).

- Other Public Bodies, which we have decided comprise:

    - The Highways Agency
    - Government Office of the East Midlands
    - Leicestershire County Council
    - Rutland County Council District Council
    - The Highways Agency
    - Leicestershire Health Authority
    - Fosse Health Trust
    - Hinckley and Bosworth Borough Council
    - North West Leicestershire District Council

A Register of Consultees has also been compiled, containing individuals and organisations who have a statutory (or quasi-statutory right) to consultation, or have expressed an interest at previous stages of the process, so that each receives an appropriate version of the consultation material. This database includes local organisations (e.g. community and environment groups), business groups (e.g. the Chamber of Commerce) and individuals.

F.2 Public Consultation:

In addition to the Statutory Consultees, Leicester City Council has endeavoured to promote the Stage 3 Review and Assessment as widely as possible. The following lists the local consultation and feedback process involved in this stage of the process.

- It is expected that the Stage 3 Review and Assessment will be publicised in the local media. A summary of the findings of the stage 3 Assessment and a map of the Air Quality Management Areas is to appear in “Leicester Link”, which is a free publication, and is delivered to every house in the City.

- An open day has been arranged in the City Rooms, close to the shopping areas in the City Centre. This will involve a public display, with officers from Pollution Control present to answer any questions from the public on air quality issues and the Local Air Quality Management Areas.

- A public display will also take place at the City Council Offices, New Walk Centre, with a full copy of the stage 3 assessment available for viewing.

- A full copy of the Stage 3 Review and Assessment will be available at all Leicester City Council Libraries for the public to view. Accompanying the report will be a map of the Air Quality Management Areas and leaflets requesting individuals responses to the Assessment.

- In other Leicester City Council buildings posters and leaflets will be distributed, and responses will be collected from these buildings. Responses to the Review and Assessment can be made by means of the telephone, by letter, or by E-Mail. All of which have been included in any publicity.

- Pollution Control Officers will also be available for talks to local groups and interested parties.

F.3 Action on Consultation Responses Received:

All responses to the consultation exercise will be considered. They will be summarised in the Final Report, published post-consultation

APPENDIX G: References.

G.1 Legislation:

Environment Act 1995, [Chapter 25], Part IV.

Environmental Protection: The Air Quality Regulations 2000 [S.I.2000 No. 928].

Environmental Protection Act 1990, [Chapter 43], Part I.

Environmental Protection (Prescribed Processes and Substances) Regulations[as variously amended].

G.2 Statutory Guidance:

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, January 2000.

Local Air Quality Management Guidance Note LAQM. G1(00): *Framework for Review and Assessment of Air Quality.*

Local Air Quality Management Guidance Note LAQM. G2(00): *Developing Local Air Quality Action Plans and Strategies: The Main Considerations.*

Local Air Quality Management Guidance Note LAQM. G3(00): *Air Quality and Transport.*

Local Air Quality Management Guidance Note LAQM. G4(00): *Air Quality and Land Use Planning.*

LAQM. TG1(00): *Review and Assessment: Monitoring Air Quality.*

LAQM. TG2(00): *Review and Assessment: Estimating Emissions.*

LAQM. TG3(00): *Review and Assessment: Selection and Use of Dispersion Models.*

LAQM TG4(00): *Review and Assessment: Pollutant Specific Guidance.*

G.3 Leicester City Council Publications:

Leicester Air Quality Strategy, Environment and Development Department, August 1998.

Leicester Air Quality Review and Assessment: Interim Stage I / II Report, December 1998.

G.4 Technical:

Air Quality Management Areas: Turning Reviews into Action. (National Society for Clean Air and Environmental Protection.) (2000).

Report.of the Airborne Particles Expert Group: *Source Apportionment of Airborne Particulate Matter in the United Kingdom* (January 1999).

Particulate Monitor Comparison, Marylebone Road. D. Green, South East Institute of Public Health, June 1999.

Reports of the Expert Panel on Air Quality Standards (EPAQS):

Carbon monoxide, 1994
Nitrogen dioxide, 1996
Particles, 1995
Benzene, 1994
1,3-Butadiene, 1994
Sulphur dioxide, 1995
Ozone, 1994.

An Empirical Model for Estimating Roadside Nitrogen Dioxide Concentrations in the UK. (AEAT 4291), Stedman, Bush and King, December 1998.

Automatic Urban Monitoring Network, Site Operator's Manual, AEA Technology, February 1996. (AEA/RAMP/20029001/01).

Air Quality Monitoring: A Handbook for Local Authorities, AEA Technology, August 1996.

UK NO_2 Diffusion Tube Survey Instruction Manual, Version 1.2, AEA Technology, June 1998.

DETR Reports, *Air Pollution in the UK: 1994, 1995,* and *1996,* AEA Technology.

Quantification of the Effects of Air Pollution on Health in the United Kingdom, Committee on the Medical Effects of Air Pollutants (COMEAP), Department of Health, HMSO, 1998.

Automatic Urban Monitoring Network, Site Operator's Manual (AEAT-4495), NETCEN, October 1998.

APPENDIX H: Glossary of Terms.

Term	*Definition*
$\mu g.m^{-3}$	Micrograms per cubic metre.
Accuracy	The closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value.
ADMS	A computer-based atmospheric **dispersion model.** Developed by Cambridge Environmental Research Consultants (CERC).
AQDD	Air Quality Daughter Directive: The EC Directive which originally laid down some of the current UK Air Quality Objectives.
AQMA	Air Quality Management Area: A legally defined area identified as one in which the statutory air quality Objectives will not be met. An Action Plan must be drawn up to improve the air quality.
Air Quality Objective	An **Air Quality Standard** modified to include a date by which a particular maximum level of a pollutant must be achieved. Some Objectives also allow a maximum number of exceedances of the related Standard because it is accepted that this in unavoidable.
Air Quality Standard	The maximum acceptable level of a pollutant in the air which will not cause health risks, even to vulnerable groups in the population. Compare with **Air Quality Objective.**
AIRVIRO	A computer-based atmospheric **dispersion model.** Developed by the Swedish Meteorological and Hydrological Institute (SMHI).
APEG	The Airborne Particles Expert Group: The UK group of scientists appointed to advise on the complex issues surrounding the composition and origins of the particulates in the atmosphere.
Automatic pollution analyser	A complex device for accurately monitoring the level of a particular pollutant and sending the information to a central point.
BAM	Beta Attenuation Monitor: An automatic device for monitoring particulate concentrations by measuring the mass collected through the degree to which Beta radiation is attenuated in passing through it.
Data capture	The percentage of the time that a pollution monitoring device is working and collecting reliable data.
DETR	Department of the Environment, Transport and the Regions: The Government Department responsible for the UK's air quality.
Diffusion tube	A simple, inexpensive monitoring device, with limitations: It has poor **accuracy** and **precision** and only yields one monthly average figure for air quality, so misses short-term pollution peaks. Large numbers can be used to cover a wide area. Useful as a survey tool.

Dispersion model	A computer programme which inputs **emissions inventory** data and meterorological data and predicts the distribution of pollutants in the atmosphere.
Emission inventory	A catalogue of the sources of a pollutant in an area, with information about their positions and the quantities emitted. Used in **dispersion models.**
EPAQS	The Expert Panel on **Air Quality Standards**: The UK group of scientists appointed by the Government to set standards for maximum acceptable levels of pollutants in the UK atmosphere.
Mg.m^{-3}	Milligrams per cubic metre.
NO	Nitric oxide.
NO_2	Nitrogen dioxide: A toxic pollutant.
NOx	A mixture of **nitric oxide** and **nitrogen dioxide.**
Particulates	Particles so small that they are suspended in the atmosphere, usually invisible, and small enough to be breathed in. See **PM_{10}** . Can be **primary** or **secondary.**
Percentile	The percentage of items in a set of data lying above or below a particular value (e.g a particular concentration of a pollutant); the value above or below which a stated percentage of the items in a set of data lie.
PM_{10}	**Particulates** suspended in the atmosphere smaller than 10 millionths of a metre in aerodynamic diameter: Harmful to health.
ppb	Parts per billion.
ppm	Parts per million.
Precision	The closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions.
Primary pollutant	A pollutant which is directly emitted from a particular source, e.g. a car's exhaust pipe. Compare with **secondary pollutant.**
QA/QC	Quality Assurance / Quality Control: A set of procedures to ensure that pollutant monitoring devices produce sound data, representative of the type of site being monitored, with good **accuracy**, **precision** and **data capture**.
RPM	Roadside Pollution Monitor: An electro-chemical device used to monitor levels of carbon monoxide at roadside situations; of relatively low sensitivity, accuracy and precision compared with **automatic pollution analysers.**
Secondary pollutant	A pollutant which is not directly emitted but which forms in the atmosphere from other substances by chemical reaction. Compare with **primary pollutant.**

SO_2	Sulphur dioxide: A toxic pollutant.
Statutory Guidance	Documents issued by the **DETR** on administrative and technical issues to help local authorities to carry out their air quality Review and Assessments. Councils are legally obliged to have regard to this Guidance.
TEOM	Tapering Element Oscillating Microbalance: A instrument for measuring concentrations of particulates by changes in the resonant frequency of an element on which a particle collection filter is mounted.