North West Leicestershire District Council

AIR QUALITY REVIEW AND ASSESSMENT

FINAL REPORT

Environmental Protection Section
Planning and Environment
Council Offices, Coalville,
Leicestershire, LE67 3FJ

January 2001

ADDENDUM

North West Leicestershire District Council

Air Quality Review and Assessment – Final Report (not Draft) Jan 2001

Review of Changes from the Draft Document (Dec 2001)

Response from DETR

The Draft document was sent for consultation to the Department of the Environment Transport and the Regions. The report was accepted as fulfilling the requirements of the Environment Act 1995 and the conclusions reached were accepted for all pollutants.

However, the following comments were made regarding details of the report.

1. It is not explicitly clear how background has been added when modelling nitrogen dioxide.
2. It is not made clear how the traffic data have been generated and validated nor is it made clear how junctions have been addressed in the modelling.
3. It is not clear if the diffusion tube data reported have been scaled to account for laboratory analytical performance.

Changes to the Report

An amendment was made to page 58 regarding a mistake in omitting a reference to a chart (appendix 8)

In response to comment 1 (above) a section regarding background correction has been added to page 106.

In response to comment 2, Details regarding traffic data have been modified in section 2.4.4

The diffusion tube data has not been used to validate the model only as part of the comparison and discussion of the modelling results. However a description of a comparison study is provided on page 17.

Page Nos.

Page Nos.

1. Introduction

1.1 Background

Growing public awareness of environmental issues and increasing incidence of childhood asthma and traffic congestion has led to general concern regarding air quality. Previous simple solutions applied to preventing the heavy smog type image prevalent in urban areas up until the 1950s and '60s are no longer applicable and any solution to current air quality problems requires a coherent national strategy applied flexibly at a local level. We are all stakeholders in our air quality and improvements will require the participation of all members of the community as well as the specialist input from scientific and professional groups and the support of government locally, nationally and internationally.

In the early 90's the Expert Panel on Air Quality Standards (EPAQS) was set up by the Secretary of State for the Environment following the publication of the white paper 'Our Common Inheritance'. The remit of the Panel was to advise on the establishment and application of Air Quality Standards based on the effects of pollutants on human health and the wider environment.

In 1995 the Environmental Act was passed of which Section 80 required the Secretary of State to publish a National Air Quality Strategy. Following consultation, this Strategy was published in April 1997[1]. This strategy has brought about a change in the way local air quality is managed.

key pollutants, which might harm our health are identified.
Levels are set for each of these pollutants in the air, which avoid health risks based on the EPAQS findings.
Deadlines are set for achieving these levels
The local authority must check whether these deadlines will be met.
If they are predicted to be unlikely to be met then Action Plans must be drawn up.

1.2 Statutory Requirements and changes to the Guidance

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*[1]. 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 different requirements of the EC Air Quality Daughter Directive.

The Act also requires local authorities 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 the district 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.

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.

1.3 National Air Quality Standards

Table 1 Key Pollutants, Showing Air Quality Objectives

Pollutant	Sources	UK 1995 emissions (1,000's of tonnes)	% of UK emissions from traffic	Air Quality Objective	Date for Compliance with Objective (31st December of year).
Benzene	Petrol storage, distribution and use	35	67	16.25 µg.m.^{3} (5 ppb) annual mean	2003
1,3-Butadiene	Petrol storage, distribution and use	9.6	77	2.25 µg.m.^{3} (1 ppb) annual mean	2003
Carbon monoxide	Poor combustion of carbon fuels	5478	75	11.6 mg.m.^{3} (10 ppm) running 8 hour mean	2003
Lead	Industry. Being phased out in petrol	1.5	78	0.5 µg.m^{-3}, annual mean	2004
				0.25 µg.m^{-3}, annual mean	2008
Nitrogen dioxide	Motor vehicles. Combustion plant	2293	46	200 µg.m^{-3} (105 ppb), 1 hour (18 exceedances permitted per year)	2005
				40 µg.m^{-3} (21 ppb) annual mean	2005 (provisional)
Particulates (PM_{10})	Primary: Motor vehicles and combustion plant. Also natural sources Secondary: Remote combustion plant.	232	26	50 µg.m^{-3}, 24 hour (35 exceedances permitted per year)	2004
				40 µg.m^{-3}, annual	2004
Sulphur dioxide	Combustion plant (power stations) Domestic coal and oil burning	2365	22	266 µg.m^{-3} (100), 15 minute mean (35 exceedances permitted per year)	2005
				350 µg.m^{-3} (132 ppb), 1 hour mean (24 exceedances permitted per year)	2004
				125 µg.m^{-3} (47 ppb), 24 hour mean (3 exceedances permitted per year)	2004
Ozone	Secondary from action of sunlight on NOx and VOC's			**NO STATUTORY OBJECTIVE SET** Provisionally: 1000 µg.m^{-3} (50 ppb), daily maximum of running 8 hour means. (10 exceedances permitted per year) ***[See Section.3.1.4]***	*(2005)*

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

1.3.1 Explanation of the National Air Quality Standards

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.

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 maximum can therefore exceed the limit value on 35 days in each year before the Objective is breached.

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.

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.

1.4 Consultation and Liaison

The Environment Act and supporting Guidance require local governments 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 North West Leicestershire District Council to consult as fully as possible with all stakeholders in the district. The Council extends an invitation to all interested parties to make their contribution to better air quality in North West Leicestershire.

Any air quality concerns or comments expressed in response to this consultation draft of the North West Leicestershire 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 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.

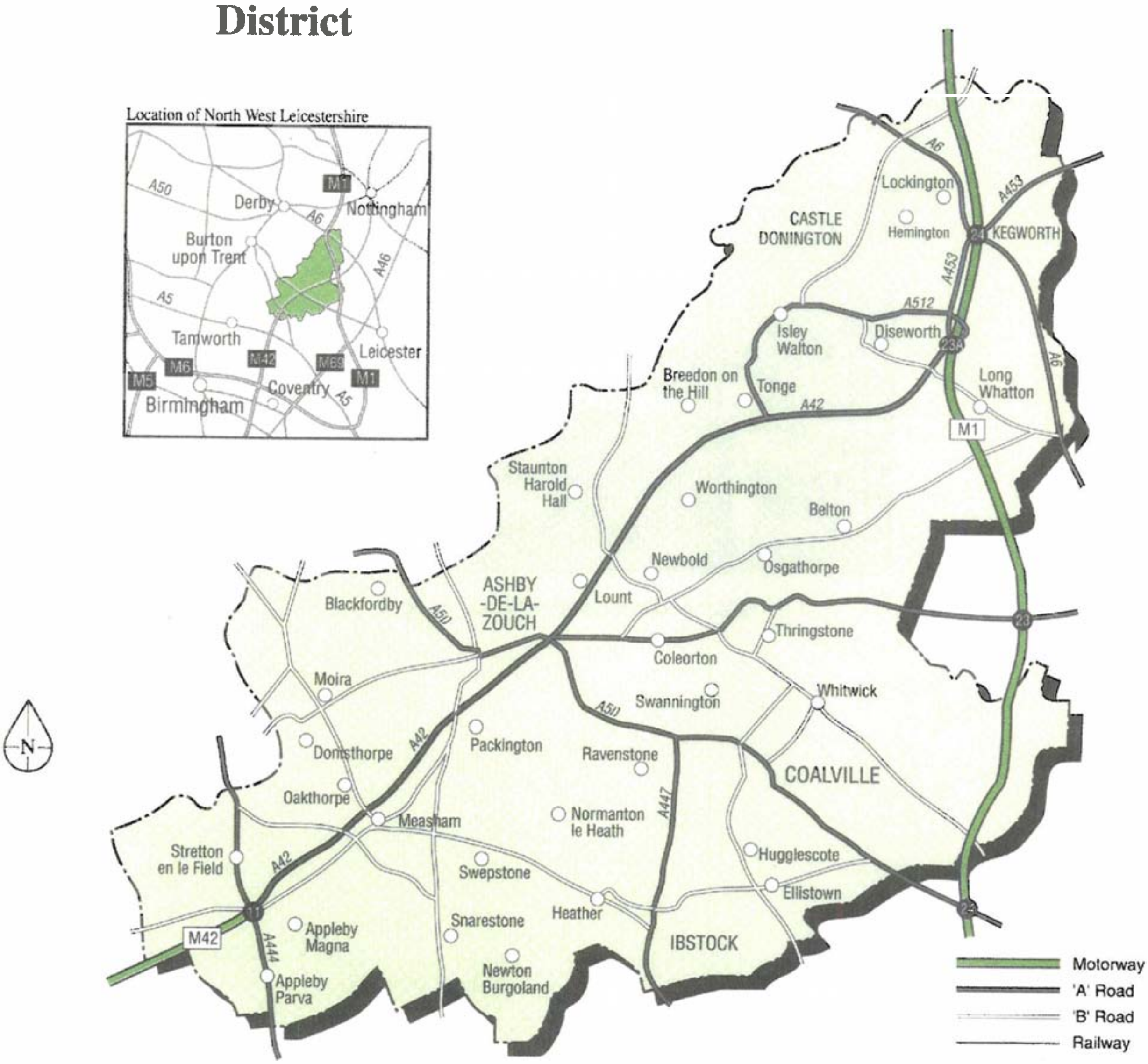
Air pollution is no respecter of boundaries. North West Leicestershire is surrounded by 7 other local authority areas and many pollution sources such as power stations and major roads extend beyond these boundaries. The council has worked together with these authorities and combined with the other Leicestershire authorities to form 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, work with dispersion modelling has been carried out in partnership with Leicestershire City Council where we have been able to share their expertise in this area but also together with other Leicestershire authorities we have used the same model validation based on local monitoring data.

1.5 Air Quality in North West Leicestershire

1.5.1 Description of the District

North West Leicestershire District



North West Leicestershire is both the name and geographical location. The district lies between Leicester, Burton-on-Trent, Derby and Nottingham. The district covers 105 square miles and is mostly rural with a large extent of industry both historically from coal mining, and more recently with East Midlands Airport and large opencast mines and quarries. The population of 88,800 (1999) mainly live in the principle towns of Coalville and Ashby-de-la-Zouch and within the large villages of Castle Donington, Kegworth and Ibstock. Three established main roads run through the District the M42/A42 between Birmingham and Nottingham, the M1 and the A50/A511 from Leicester to Burton-on-Trent. As does the recently completed Stoke / Derby by-pass. The district lies in the East Midlands Region.

1.5.2 History

The coal mining heritage of the district means that there is still heavy reliance on coal with 3% of the population receiving concessionary coal and many other properties (including 30% of council housing) using solid fuel.

Traffic congestion has been a problem in the centres of Coalville, Ashby-de-la-Zouch, and Kegworth, and around junction 24 of the M1. Despite having a bypass built in 1989 Coalville centre continues to get heavily congested. Funding for the proposed Ashy Bypass was confirmed in 1999 with completion of the scheme predicted for April 2002.

Since publication of the Stage 1 report there have been further developments, such as the DHL air expressway facility and Pegasus Business Park that have affected traffic flows in the vicinity of East Midlands Airport. There has also been further expansion at the Bardon 22 area in the south of the district.

The coal fired Castle Donington Power Station closed in September 1994 and Willington Power Station also ceased production in December 1999. Two other coal-fired power stations remain close to the district. Since 1998 the Council offices in Coalville and a unit providing heat for 230 homes in Measham have been converted from coal to gas.

Monitoring for SO_2 and smoke has continued since the 1980's and NO_2 was measured at 7 sites since 1994 until this was increased to 12 sites in April 1998 and to 18 sites in August 1999. In June 1999 a PM_{10} Particles monitor was located along the A6 in Kegworth and we continue to receive PM_{10} and dust data from 4 mineral extraction sites within the district.

Reviews of monitoring were compiled annually from 1994 and in December 1998 our Stage 1 Review and Assessment was published under the requirements of the Environmental Protection Act. This report covers progress of the review and assessment from December 1998 (stages 2&3)

Since the Stage Report was published the following related documents have also been published.

North West Leicestershire District Council Corporate Policy Statement ***(CPS)*** Oct 1999
Leicestershire Local Transport Plan 2001-2006 ***(LLTP)***(Sep 2000)
Regional Planning Guidance, Public Examination Jun 2000 Report of the Panel ***(RPG)***

1.5.3 Conclusions and Recommendations of Stage 1 Review and Assessment (Dec 1998)

Benzene
Predictions for benzene levels are higher for 1998 than for 2005. Although it is predicted that the air quality objective may be exceeded on the M1 and M42/A42 during heavy congestion, the concentrations fall well below the objective for the nearest residential locations. Emissions from industrial sources including the East Midlands Airport are negligible. It will not be necessary to continue the review and assessment to stage 2.

1,3 – Butadiene
Emissions from the nearest sources in the district of East Staffordshire are unlikely to affect this district therefore further assessment to stage 2 will not be necessary.

Lead
Due to increasing use of unleaded petrol it is unlikely that emissions from road vehicles will cause exceedance of the air quality objective by 2005. There is likely to be significant emissions from the secondary lead smelter in Woodville in the district of South Derbyshire that may impact upon the residents of Albert Village some 250 meters away. Further assessment may be necessary following stage 2 of the air quality review by South Derbyshire District Council.

Liaison with South Derbyshire district council regarding the lead smelter at Woodville was recommended.

Carbon Monoxide
Road traffic emissions are not likely to cause exceedance of the objective by 2005 in areas where people may be exposed for the period of 8 hours. Emissions from individual industrial sources are also unlikely to cause exceedance of the objective and do not significantly overlap with major roads and residential areas. Further assessment to stage 2 will not be necessary.

Nitrogen Dioxide
Emissions from road traffic may cause exceedance of the air quality objective during congestion. This includes roads that are lined with shops and houses where people may be exposed to concentrations for the period of 1 hour. Monitoring results also suggest that the objectives are being exceeded at 6 of the 12 monitoring locations in the district. Emissions from the East Midlands Airport and Ratcliffe-on-Soar power station will also raise nitrogen dioxide concentrations. Further assessment to stage 2 will be necessary.

It was recommended that further review should focus on the northern parishes where there are overlaps between road traffic emissions of the M1, A6 and A42 and emissions from Ratcliffe-on-Soar power station and the East Midlands Airport. Also for consideration of the impact of proposed road developments on other roads in the district which presently have concentrations above the objective.

Sulphur Dioxide
Information on coal usage in the district suggests that considerable emissions may arise from domestic coal burning. Results and research from the automatic monitoring station in Leicester Centre show that emissions from the power stations to the north-west of the city of Leicester cause exceedances of the national air quality objective in the city of Leicester. The district of North West Leicestershire lies between these power stations and the city of Leicester. Further review and assessment to stage 2 will be required.

A review of modelling performed by Eastern Merchant for sulphur dioxide emissions from the Drakelow power station and a further assessment of coal usage (possibly with the aid of increased monitoring by use of diffusion tubes) was recommended.

Particulates PM_{10}
Emissions from industrial sources such as the quarries and open cast coal mines together with relatively high background levels and emissions from road traffic are likely to cause exceedances of the objective in some locations. Further assessment to stage 2 will be required.

Further assessment focusing on areas of overlap between industrial sources and road traffic emissions by use of particle size specific monitoring equipment was recommended.

1.5.4 Current Policy

General

It is the council's aim to preserve what is good, improve unsightly areas, prevent environmental damage and combat pollution to secure a safe, pleasant and healthy environment.

The council will seek to ensure that all its decisions and activities secure the optimum level of environmental sustainability by minimising any adverse effects on the environment and in particular that it does not perpetuate the need to travel by private car.[3]

The council is fully supporting the establishment of the National Forest. This project includes some ¾ of the district and aims to have 50%-60% cover with woodland. This is of local, national and international importance in an attempt to reverse global deforestation and thus control rising levels of CO_2.

Transport

The Council will ensuring that new development meets the objects of environmental sustainability by:

a. Securing sustainability assessments of Development Plan proposals and major departures from approved plans.

b. Reducing the need to travel by private car by:

- locating new development where it can be readily served by public transport
- concentrating new housing development in locations well related to employment opportunities and services
- promoting public transport and necessary infrastructure, through planning agreements related to new development proposals

c. securing pedestrian and cycle routes within and between communities, employment sites and other facilities

d restricting car parking on development sites where this is likely to encourage the use of public transport.

e moving towards the use of 'green' fuels and propulsion methods for Council vehicles

f. Securing, with the County Council, an integrated Transport Policy for the District, which will:

- secure and promote the use of public transport;
- secure the early opening of the Ivanhoe/National Forest passenger railway line;
- secure the early completion of the Bardon By-pass and the Ashby (A511) By-pass;
- pursue proposals for a by-pass for Kegworth
- promote cycling, cycleways and cycle facilities;
- secure traffic management measures (traffic calming, pedestrianisation etc):
- improve urban environments and public safety;
- review overall car parking provision and needs within the District.

1.5.5 Future Plans and Developments

General

The council's Local Plan[9] for the district includes provisions for commercial / industrial growth. The premises that could be built may include those that this council will need to authorise under Part 1 of the Environmental Protection Act 1990 (EPA 90). However it can be assumed that with these controls in place any new industrial developments would not have significant effects of the current levels of pollution.

There are no current plans or proposals to open any new open cast mines or quarries in the district. Any extensions of existing mines and quarries will have to show dust (particulate) prevention methods in relation to the air quality objectives in the planning applications.

In December 1999 the Leicestershire County Council as the Mineral Planning Authority granted planning consent to the Bardon Quarry, Coalville (now renamed Aggregate Industries UK Ltd.) for a major upgrade to the secondary and tertiary minerals plant. This will include the encapsulation of crushers, screens, conveyors and stone stock piles previously sited in the open air. This upgrade will have significant effect on emissions to the atmosphere.

The Environment Agency has issued revised authorisations that should ensure that emissions from coal and oil fired power stations will not cause an exceedance of the air quality objectives from 2005. This however only applies where emissions from the power station are the single cause of a potential exceedance.

Transport (Road Traffic)

The Draft Regional Planning Guidance[8] (9.16) states that the proposed Kegworth bypass should be evaluated as part of the wider issue and included in the multi-modal study of north-south movements in the East Midlands. If a bypass was completed there would be a significant reduction in traffic flows through Kegworth particularly the HGV element. However, if a bypass was proposed as part of this study it would be unlikely that it would be completed by 2005 and thus has not been included in this report.

A similar multi-modal study is being prepared for the A453 from junction 24 of the M1 to Clifton (Nottinghamshire) by the Government Office for the East Midlands. If this study concluded that improvements (possibly duelling) of this road were recommended it would be unlikely that any such improvements would be completed by 2005. Therefore, this proposal has not been included in this report.

This guidance also discusses the development potential around junction 24 of the M1 (chapter 10). There are proposals submitted for large-scale storage and distribution developments within this area as well as for new housing. One of the proposals (Castle Donington Power Station Site) also includes a scheme for new link to the A50 Sawley Interchange. The local plan has outlined the Castle Donington Power Station Site and Willow farm site for storage and Distribution and other employment activities. Some of these proposed developments could be operational and therefore impact upon air quality by 2005. Therefore this review has included two scenarios in its predictions for 2005 (see section 2.4.4).

- Scenario 1 (do nothing) represents the situation where no major new developments affecting traffic flows in the Castle Donington and Kegworth area have been completed by 2005.

Scenario 2 (do something) represents the situation where at least one of the proposed storage and distribution facilities have been completed.

Work on the Ashby Bypass is expected to start early 2001 and be completed April 2002. The impact of this bypass on the traffic flows in the area have been modelled for when the bypass is completed. It is proposed to introduce an integrated package of traffic management and town centre improvements for Ashby on completion of the bypass. The objectives include reducing speeds on through routes and prohibiting HGV through movements. The predicted traffic flows show a significant decrease in the traffic flowing through the centre of Ashby along the A511 especially the HGV content. This will further reduce the pollution levels and has been included in our modelling.

The Councils Local plan includes proposals for large housing development between Bardon Road and Hugglescote. This development is subject to the construction of a new 1.5 km section of road to bypass the A511 between the Birch Tree Roundabout and the Coalville Relief Road. This would have air quality benefits to the occupants of Bardon Road. This proposal may not be completed by 2005 and has not been included in our modelling.

Transport (Rail)

Although the Council supports the opening of the Ivanhoe Railway Line there are concerns relating to the uncertainties in funding for local rail improvements and the subsequent need for substantial and ongoing subsidies.

A planning application has also been received for a new 'Parkway' station on the Midland Mainline at Ratcliffe on Soar. This would offer the opportunity to provide a high frequency shuttle service to the airport.

The impacts of these proposals on traffic flows have not been included in our modelling.

Transport (East Midlands Airport)

The passenger terminal currently serves over 2 million passengers per annum (mppa). The airport now has the third longest runway in the country and is one of the largest cargo airports in the UK.

Passenger numbers are predicted to rise from 2mppa to 5mppa by 2006. The predicted impact of this growth on air quality, both from the planes and associated increase in traffic has been provided by the Airport and are included in our modelling predictions.

2. Methods of Review and Assessment

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*[2]): This document also outlines the methodologies to be used. 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.

North West Leicestershire has already completed the first stages of its statutory Air Quality Review and Assessment as prescribed by statutory Guidance. The procedure and findings were published in *North West Leicestershire District Council, Air Quality Review and Assessment Stage 1, December 1998.* Please see section 1.5.2 for the conclusions and recommendations of this report.

2.1.2 Stage 2, Review and Assessment:

The second stage is optional and consists of the application of more elaborate screening models. Since North west Leicestershire had applied the DMRB (Design Manual for Roads and Bridges[4]) screening model (recommended for stage 2) as part of the Stage 1 review and it was decided to proceed directly to Stage 3 for the pollutants recommended by the stage 1 review as needing further assessment. Certain Stage 2 methodologies have been adopted as a crosscheck on findings. (LAQM.TG4[5] (00), para. 6.60).

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)[1], *Framework for the Review and Assessment of Air Quality,* which superseded LAQM.G1(97)[1] after the completion of the Stage 1 / 2 exercise. These comprise detailed investigations. using monitoring and dispersion modelling:

Monitoring gives us an accurate picture of pollutant levels at our monitoring sites. However, we cannot monitor everywhere in the district neither do we have high quality 'real time' monitoring stations that other (mostly city) authorities can afford. Also monitoring can not tell us what is going to happen in the future, yet the Environment Act requires us to predict pollutant levels for 2005.

Alternatively, computer modelling enables us to map what is happening over the whole district 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, these techniques are put together. Dispersion models are used to predict air quality at points in space and time for which actual monitoring data is available (i.e. at monitoring stations) and by comparing modelled with observed data an estimate of the range of error in the model's predictions can be calculated. This is known as *validation* of the model. This model validation was carried out by Leicester City Council using their monitoring data. The results were then compared with the data available to North West Leicestershire

The dispersion model was then used to map out contours of air quality in future years and use the 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 district.

2.2 Monitoring.

2.2.1 Types of Monitoring Sites

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 classification of monitoring sites. They may be characterised as:-

- Kerbside: At the side of a major road (within 1m) 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 (within 1 – 5m of the road). Affected by pollution from the road but not as much as the Kerbside situation.
- Urban Background: More than 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 from elsewhere in the UK or Europe.
- Industrial; An area where industrial sources make an important contribution to the total pollution burden.

Details of the locations and classification of individual monitoring sites in the district are given in Appendix 1.

2.2.2 Automatic Monitoring Stations

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. 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. The nearest station within this network is located at the New Walk Centre, in Leicester and is managed by Leicester City Council. However, there is also a station in Weston on Trent run for the Joint Environmental Programme of National Power, Powergen and TXU.

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 close to North West Leicestershire, the data obtained by them is generally available to the public via the Internet etc.

The council hired the use of a mobile automatic monitoring station for one month (August 2000) from Power Technology. This was located at Kenilworth House, Whatton Road, Kegworth being 500m from the M1 and directly under the eastward flight path from East Midlands Airport but otherwise an essentially rural location with no other sources. Although any trends and statistical analysis really needs at least 6 months worth of data it was thought that this monitoring would provide details of the type of daily, hourly and peak patterns of pollution at this location.

2.2.3 Active Samplers

Sulphur Dioxide Bubblers
There are three of these monitors located throughout the district at Moira (Woulds Court, Since Mar 2000), Castle Donington (Parish Council Offices, Since mar 2000) and Coalville (District Council Offices, 1995 - 2000) (see appendix 1). The monitor draws a metered volume of air through a liquid medium over 24 hrs and the quantity of Sulphur Dioxide (SO_2) is measured using the acidimetric (total acidity) method. This type of monitoring is only recommended for stage 1 and 2 review and assessment however we have also compared the data with the model output.

Particulate Monitors (Light Scatter)
These monitors determine particulate concentration by measuring the degree of scattering occurring when the particle stream is passed through a beam of laser light. Particles are classified by size (PM_{10}=10μm, $PM_{2.5}$=2.5μm, PM_1=1μm) and the mass concentration is determined by calibration of the instrument using the mass deposited on an in line filter. There are 2 of these monitors located in the district. One run by the council and is located is at Kegworth for the A6 road traffic source. The other is run by RJB mining and is located at Donisthorpe School for the opencast coal extraction source. There will shortly (early 2001) also be another one of these monitors located at Bardon Quarry.

2.2.4 Passive Sampling (Diffusion Tubes)

These devices consist of small plastic tubes that are fixed for a month at locations such as on buildings or a lamppost. They are open at one end and contain a mesh coated in a chemical that absorbs Nitrogen Dioxide. When the month's 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. The tube results are helpful 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. However the guidance (TG4)[5] states that there is a potentially useful role for diffusion tubes in assisting with the spatial variability of concentrations. For the third stage review and assessment it is essential that authorities justify and document the equivalence of any diffusion tube results against a chemiluminescent analyser.

2.2.5 Data Collection, Processing and Quality Assurance

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.

Each month raw data received from the SO_2 bubblers is sent to AEA Technology who run the UK Smoke and Sulphur Dioxide Network. Procedures specified for this network are followed in accordance with the UK Smoke and Sulphur Dioxide Network Instruction Manual[6]

Each month the NO_2 tubes are sent to the Stanger Science and Environment laboratories. The analysis is performed in accordance with guidelines set out by the UK Nitrogen Dioxide Diffusion Tube Network. This lab is accredited by the Workplace Analysis Scheme for Proficiency[7]. Also, as recommended by the NSCA guidance[13] the Leicestershire local authorities placed their diffusion tubes next to the AUN Automatic monitoring site in Leicester for a period of 4 months to compare the results. Tubes were provided by both our old supplier (pre April 2000) and our new supplier (post April 2000). Our tubes displayed a maximum variation of between –7.4% and +32% (new supplier) and between –5% and +37% (old supplier). This compares to the ±17% typical of this method (Smith et al 1999). These results suggest that on average the error due to random variation is typical, therefore it has been assumed to be ±17%. However in general the tubes are over predicting with a probable systematic error of around +12%. These errors has been considered as uncertainties in the results section (Chapter 3).

Each month data is downloaded from the PM_{10} light scatter devices. The instruments are calibrated yearly and used in accordance with the guidance given by the manufacturer, Turnkey Instruments.

The details of the quality assurance and use of the automatic monitoring stations operated by Leicester City Council and used in their validation of the model that we have used are given in appendix 2

2.3 Meteorology.

In the long term, gross emissions of pollutants will slowly change. This may be brought about by advancement in industrial or automotive technologies, legislation to bring about improvement however the weather is a major factor in determining hourly, daily and even annual variations in pollutant levels. 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 that 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. Data used for the Air Quality Review and Assessment has been taken from the weather station operated by Leicester City Council in Leicester. North West Leicestershire District Council operates two wind speed and direction stations (at Coalville and Kegworth) both showing very similar readings to those in Leicester.

Meteorological data is therefore 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. For the modelling work used (both for

1998 and 2005 predictions) the 1998 weather data set was used. 1998 was a reasonably "typical" year in that it did not exhibit exceptional concentrations of certain pollutants such as occur every five to ten years, also a complete data set for the Leicester weather station was available.

2.4 Emissions Inventories.

2.4.1 General

An emissions inventory is simply the identification and cataloguing of sources of the pollutants in which are significant. Most of these are within the district but there are also significant, identifiable sources further afield such as major roads, industrial plants and power stations.

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.

This Council, in partnership with Leicester City Council used a more detailed approach. Information was collected on individual sources or types of source. The data gathered included the quantity of pollutant emitted as well as the exact location of sources such as chimneys, major roads or areas of housing. 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, 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 point sources 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 and 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. The runway for East Midlands Airport was also described using a line source.
- *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. The coal use data was also put into the model using area sources.

As conditions change over time sources may appear, disappear or change their behaviour. Therefore the council aims to constantly review the emissions inventory to keep it up-to-date. However, for the purpose of modelling and interpretation it was decided to use data from 1998 and predictions for 2005.

2.4.2 Point Source Data

As detailed in the stage 1 review and assessment there are industrial processes authorised under Part A or Part B of Part I of the Environmental Protection Act 1990 which were found to be significant for the purposes of the Review and Assessment. The details of these processes were added to the emissions inventory and include all the power stations within 20 miles of the district and significant emission points from quarries, roadstone coating plants and brickwork manufacturers. The Environment Agency provided the data for the power stations. For predictions for 2005 data was also received from TXU (Drakelow Power Station) regarding the most likely emissions at this time considering their renewed authorisation. The quarries, brickworks and roadstone coating plants are authorised by the Council under part B of part 1 of the Environmental Protection Act 1990 and emissions were taken to be the maximum permitted according to the authorisation. However, as daily average emissions were required for the model, likely plant operation times were accounted for.

2.4.3 Area Source Data

Domestic Coal Burning

Due to the coal mining heritage of the district there is a higher than average domestic coal use. The following method describes how we calculated emissions from coal burning across the district on a ¼ km^2 grid.

The majority of coal users within the district receive free or discounted coal from the National Concessionary Fuel Office. The concessionary fuel office has been able to provide the Council with specific details including coal type used of each coal user under their scheme. Together with details of council tenants who use coal we had details of 2869 coal using households. In 1998 a National Energy Survey was carried out in the District that had provided information on fuel use. There were 960 returns from a possible 35,000 households representing a return of 2.7%. Of these 12.8% were coal users and of the coal users 43% were not known to us as either concessionary coal users or council tenant coal users. It was assumed that the survey was representative of the population, this was backed up further by rough calculations from the major coal suppliers that estimated that between 10 and 20% of the district were coal users. It was than calculated that there were 4480 (35,000 x 12.8%) coal using households in the district. As we knew the details of 2869 users we assumed that there were 1611 unknown users (36% unknown). This ratio of unknown users is similar to the 43% unknown users that responded to the survey.

Each coal using household was plotted on a map and allocated to a square of a ¼ km^2 grid. For each square the value of coal using households was then multiplied by 1.56 (100/64) to account for the unknown 43%. From the concessionary coal use data we knew that the average consumption was 2 tonnes per year and that approximately 50% used smokeless fuel, 22% used Anthracite based fuels and 28% used housecoal. These figures were then used together with emission rates from 'Emission factors for the combustion of solid fuel'

(AEA Technology) to estimate domestic coal burning emissions for each ¼ km^2 grid square in the district. These emissions were then converted to the g/m^2/second required by the model. These rates were then put into the emission inventory as area sources.

Other Sources

All the major quarries, clay pits and opencast coal mines were also added as area sources to account for fugitive emissions (see map page 27). The council receives data from multidirectional dust samplers from most of these sources. This data shows the proportions of dust emitted from the source compared with the background. Annual averages were calculated for each source type, (quarry, opencast coal mine, and clay pit). The data received from the light scatter PM_{10} monitor located at Donisthorpe School shows the average proportions between total particles and PM_{10} particles from this type of source. This conversion factor was applied to estimate the fugitive emissions from these area sources.

Other area sources were considered but not included in the current emission inventory. These included domestic (non-coal) fuel burning, blocks of minor roads and car parks. 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

Road Traffic

Data for road traffic was collected from five main sources.
The Highways Agency
Leicestershire County Council
Leicestershire Constabulary
Independent consultant's reports associated with planning applications.
Modelled traffic flows in connection with the new Ashby Bypass and other proposed major developments.

The age and extent of the data varied with source, the model required AADT (annual average daily traffic) flows, average speeds and % heavy vehicles for each road link / section. Also a set of time varying emission factors were required to reflect the change in traffic flows throughout the day. Where possible data used was from counts taken in 1998. Some minor roads had earlier counts (1995, 1996 or 1997) so these were factored using local traffic area forecast factors supplied by Leicestershire County Council. Similarly the 1998 flows were factored using these forecasts (shown below) to provide 2005 predicted flows.

1998 - 2005	Light vehicles			Heavy Vehicles		
	Low	Medium	High	Low	Medium	High
Rural minor Roads	1.02	1.07	1.12	0.98	1.03	1.08
Rural A roads	1.09	1.14	1.19	1.05	1.10	1.14
Rural Motorways	1.19	1.25	1.30	1.16	1.22	1.27
Urban Minor Roads	1.11	1.16	1.20	1.04	1.10	1.15
Urban A Roads	1.05	1.09	1.13	0.98	1.02	1.06
Total	1.12	1.17	1.22	1.11	1.16	1.21

Table 2 North West Leicestershire Traffic growth Factors for 1998 to 2005 (provided by Leicestershire County Council)

We were able to gather data for all the roads within the district with AADT values of over 3000. Flows of some of the more minor roads were estimated based on known flows of similar roads within the district and local knowledge. The map 'line emissions on Page 26 shows which roads are included in the emission inventory. For the 'worst case hour runs' (see section 2.5) a peak hour traffic flow figure was required for each road link. Some of the data that was split by hour provided this information however, the two directions of travel had to be combined to obtain a value for the peak hour flow for the link as a whole. Where there was significant directional differences throughout the day the peak combined peak hour was not always the same as the peak hours of flows for each direction. Where this was not available the peak hour was assumed to be a tenth of the AADT.

Most of the traffic data did not include speed information. Generally the average speed was assumed to be the speed limit as this was close to the values that we did have. Where there was more than one limit within a specified road link the faster value was taken. The model can not account for congestion so although regularly congested roads were noted, specific information relating to congestion does not exist in the emission inventory.

The majority of the traffic data contained vehicle breakdown details. Where a more detailed vehicle breakdown was supplied it was assumed that the classes OGV1, OGV2, Bus/Coach, HGV(2-5 axles) would contribute to the 'Heavy' component and all other categories would contribute to the 'light' component. Where vehicle breakdown was not known (of roads AADT>3000) 2 x 1hr counts were taken by the council (daytime, not peak, midweek) and used as an approximation. Minor roads (<3000 AADT) were estimated using known values of similar roads in the locality and local knowledge.

Hourly variations were provided on some of the traffic counts. Although the majority show the typical 08:00 – 09:00 and 17:00 – 18:00 peak hours some particularly around the airport had atypical variations. Some roads, especially in the northern parishes also showed heavily unbalanced flows depending on direction of travel. The time varying emission factors (that are used by the model for the district as a whole) were based on combined directions of travel and were based on an average of the motorways and major roads where these factors may be more crucial.

For Ashby (2005 road data) AADT flows were converted from the 'do-something predictions' in the stage 2 Ashby Bypass report[10] and were factored from 1995 to 2005 to give modelled traffic flows for all the major streets in Ashby once the bypass had been opened. Although this offers the best predictions for the pollution emissions of traffic in Ashby in 2005 modelling on modelled data will increase the likelihood of errors.

For the Castle Donington Scenario 1 (do nothing) the 1998 traffic flow data was factored using the high range of growth factors in table 2.4.4. For the Castle Donington Scenario 2 (do something) it was assumed that at least one of the major storage and distribution developments proposed for the area will have been completed. Two of the proposed sites are located with direct access to the major road networks. Whilst this would affect flows on the major roads (A453, M1 and A50) and associated junctions however these roads all currently have high flows. The proposal for the Castle Donington Power Station Site would also affect traffic flows on the M1, A453 and A50 but the proposals of associated new relief roads would also mean that the proposal will have significant impacts on the existing local Castle Donington Roads (some increased, some reduced). Therefore, it was decided to use the modelled traffic flows based on this proposal together with the high range of growth factors to represent other developments on the area for this scenario. The traffic flows given in the Environmental Statement[11] were converted to 2 way flows and factored to 1998 and 2005 before being added to the emissions inventory.

Aircraft and Airport
The data for aircraft movements was supplied by East Midlands Airport, based on 1998 data and their current forecasts for 2006. The runway was treated as a line source that changed to a volume source (a line with height) towards the ends. This data also included predictions for the contributions of traffic using airport service roads and car parks.

Other Line Sources
Although there will be some emissions from the railways, minor roads and non East Midlands Airport flight paths these emissions have been considered to be insignificant however it does mean that the emissions inventory can be regarded as conservative in terms of mass emissions of the specified pollutants from all line sources.

2.4.5 Traffic Emission Factors

Studies by Leicester City Council showed that the most significant variable put into the model in terms of predicted pollution levels was the traffic emission factors. Also changes in HGV content was more influential than changes in speeds, hourly variations or total flows.

Because of improvements in vehicle technology and the progressive elimination of older vehicles over time, emissions per vehicle are projected to considerably decrease. Predicted increases in the number of vehicles will offset total mass emissions from motor vehicles but give an overall 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.

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

2.4.6 Interpretation of Modelling Results Using the 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. However the inventory will continue to be reviewed and updated for use in subsequent refinements of Review and Assessment of Air Quality within the district.

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 precautionary stance to be taken in terms of modelling error. (see section 3).

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. Computer-based atmospheric dispersion models are 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.

The Council has joined a partnership with Leicester City Council and joined resources to use the model ADMS-URBAN Version 1.53. With this dispersion model an estimate of the pattern of emissions likely from a given scenario can be modelled. The resulting pollution picture can be compared with the predicted outcomes of different development proposals, policy options or scenarios. However, dispersion modelling is subject to considerable uncertainties. The designers of models have to make simplifying assumptions about extremely complex real-life situations. The inventory information depends on making assumptions (see section 2.4) and predicting emissions in the future as situations change introduces an extra layer of uncertainty. 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 Description of the ADMS-Urban Dispersion Model

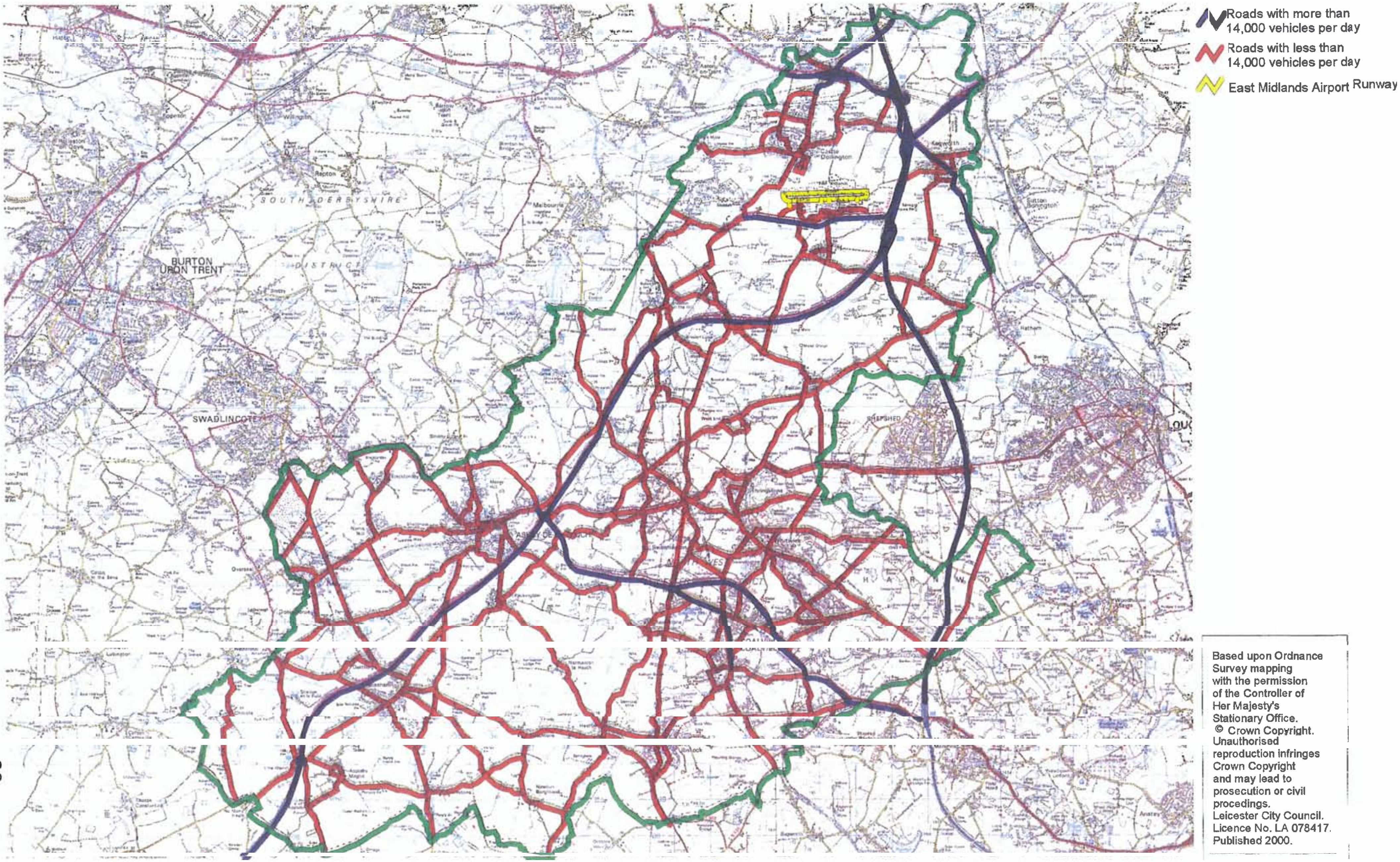
ADMS-Urban Version 1.53 is a version of the Atmospheric Dispersion Modelling System (ADMS) developed by Cambridge Environmental Research Consultants (CERC). It is a PC-based computer system that models dispersion in the atmosphere of pollutants emitted from industrial, domestic and road traffic sources 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.

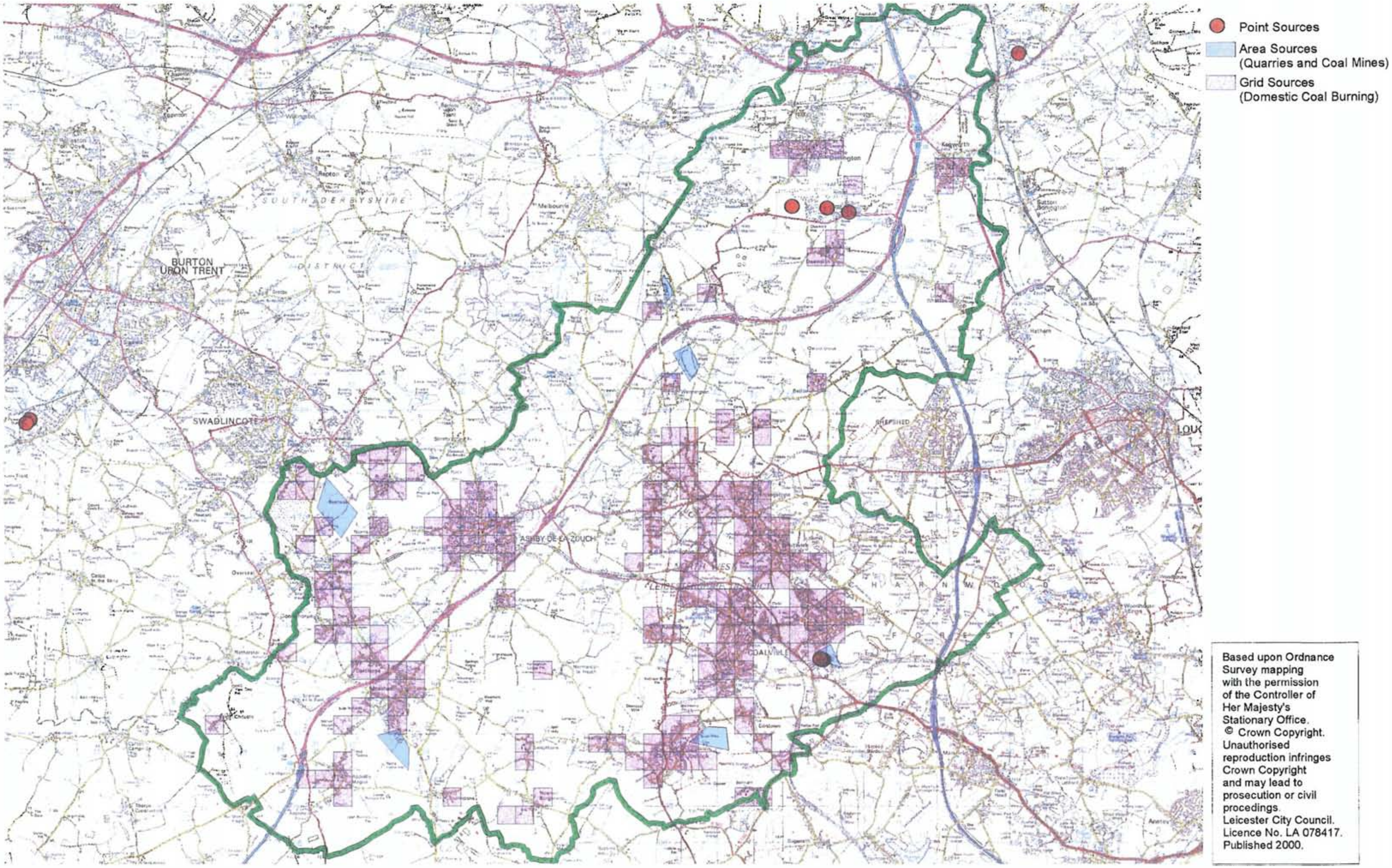
A significant difference between ADMS-Urban and other models used for air dispersion modelling in urban areas is that ADMS-Urban applies up-to-date physics using parameterisations of the boundary layer structure based on the Monin-Obukhov length, and the boundary layer height. Other models often characterise 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.

Line Emission Sources used in the ADMS-Urban Model



Non Line Emission Sources used in the ADMS-Urban Model



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.

2.5.3 How the Model was used.

The ADMS model was used to calculate levels of pollutants at both receptor points and over large areas of the district. The model was run at receptor points to give a detailed data series for that point. These were at monitoring sites to compare with measure pollutants or specific receptor sites where more precise detail was needed. The model was also run for larger areas so that a spatial distribution could be seen to help determine boundaries of air quality management areas and also for presentational purposes.

The model was run in all instances to predict levels of the three pollutants identified (in the stage 1 report) of needing further assessment (NO_2, SO_2 and PM_{10}) both for 1998 and 2005. To assess whether there was likely to be an exceedance of the National Air Quality objectives the model had to be run in terms of the different averaging times for the pollutants (see table 1 page 4). The model was run for the whole district for a series of hours which were known to produce high pollution levels. These were chosen for weather data that produced high pollution values but also hours that would coincide with the heaviest traffic from the time varying emission factors. The peak hour traffic data was used. The model was also similarly run for a 'worst case 15 minutes' for SO_2 and 'worst case day' for PM_{10}. The amount of calculations involved in predicting the annual average pollution concentrations over large areas meant that when the model was run for annual averages for 1998 it took nearly 4 weeks. This time constraint meant that for the 2005 annual average predictions the district was divided into three main areas of interest.

1. Northern Parishes including, Castle Donington, Kegworth, East Midlands Airport and the M1

2. Coalville and surrounding villages

3. Ashby and surrounding villages including Boundary, Measham and Norris Hill.

2.5.4 Model Imputs

The North West Leicestershire Emission Inventory Database was added to the model. This consisted of geographical and emission data for all the sources used (see section 2.4). The emission factors for the roads were calculated by the model using the factors 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).

The weather data used was from the Leicester weather station 1998. The monin-obukhov boundary height layer was chosen as 10m (recommended for small towns with population <50,000) and the surface roughness was chosen as 0.5m (open suburbia).

2.5.5 Model Error and Validation

Dispersion models are subject to systematic error and random error.

- Systematic error, or bias 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 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.

Systematic Error
NO_2
By comparing the behaviour of the model in receptor point runs with monitoring data for the same period, systematic correction factors were derived for NO_2. The validation methods (see appendix 3) used Leicester data from a variety of roadside and urban background monitors compared with modelled Leicester results. The correction factors (for annual averages) were applied by correcting by 1.4 (thus increasing levels of predicted pollutants) for locations within 10m from a major road and by 0.9 (thus decreasing) for background locations. For Hourly averages the correction factors were similarly 1.33 for roadside locations and 0.64 for background locations.

It was assumed that the model would have a similar pattern of systematic error for results for North West Leicestershire as for Leicester despite differences in geography and background pollutant levels as the validation process. This assumption was made because it was concluded that the systematic error was most dependant on distance from roads. However, it was also assumed that the 10m from roadside correction factors could only strictly apply to roads of a similar nature to those next to the 4 Leicester monitoring sites used in the roadside validation. As these roads were all in urban locations and had flows of between 15,000 and 35,000 (AADT) it was considered appropriate to only strictly apply these factors to roads with AADT greater than 14,000 (see map page 26) and to be cautious where the factors were applied to rural roads especially with high flows such as the M1 and the M/A42.

The assumption is also made that these relationships will hold approximately true for model predictions of pollutant concentrations in future years, so the derived factors were applied to the outputs for 2005. However, the dependence of the process on assumptions about the future behaviour of emission sources will inevitably introduce considerable uncertainties. As the validation had been based on distance from roads it could not be assumed that the same correction factors should be applied to distance from other sources, in particular distance from the runway at East Midlands Airport (see section 3.3.5).

PM_{10}

For PM_{10} (annual average predictions) Leicester City Council found that it was not possible to derive a sufficiently robust validation factor to correct future outputs with any degree of confidence. The model significantly underpredicts the concentrations of PM_{10} but the possible factors to correct for this ranged from 1.7 – 4.8. A comparison of monitored PM_{10} levels from the Light Scatter monitor in a roadside location in Kegworth (corrected for loss of volatiles due to heated inlet and filter by 1.3) showed that average monitoring results were 40.69$\mu g/m^3$ compared with modelled results for the same site of 11.36$\mu g/m^3$. This would suggest a correction factor of 3.58 could be used for this area and similar roadside sites. However this correction factor would be site specific and not apply to other roads such as motorways or other emission sources such as quarries and opencast coalmines. Also the most significant fraction of the modelled PM_{10} is from the secondary particulates which will be the same throughout the district so to apply such a large site specific correction factor for a small proportion of the variable may propagate further errors. It was therefore also concluded that it was not possible to derive a significantly robust validation factor to correct the model output but to recognise the general tendency to underpredict in the evaluation if the results (see section 3.3)

SO_2

Two monitoring stations in Leicester measure for SO_2 The AUN site in the city centre and the LAMS site at Judge Meadow School in an outer suburb semi-rural location. As the model uses hourly met data it cannot predict 15 minute means for SO_2. Leicester is some 20 km from the Trent Valley power station sources and has small emissions from domestic coal burning due to smoke control areas. Due to this (and that Leicester City Council did not need to assess SO_2 to stage 3) the Leicester City emissions database only had roads, power stations and a few industrial processes as sources of SO_2 emissions. However compared with monitoring data (1999) the model was still significantly overpredicting (see table below). As the number of blank hours on both modelled and monitored data points used for the LAMS site was greater than 25% this data was disregarded. However the derived factor was similar to that from the AUN site which was used to correct the model output data for both hourly concentrations and annual averages.

Monitoring Site	**Monitored Average Hourly SO_2 (ppb)**	**Modelled Average Hourly SO_2 (ppb)**	**Resultant factor (To apply to modelled results)**	**% data used**
LAMS (Judge Meadow School)	9.00	2.77	0.31	58
AUN (City Centre)	9.22	3.20	0.35	91
AUN (monitored values of 0.0 not used)	9.20	3.23	0.35	86

Table 3 Comparison of Monitored and Modelled results for SO_2.

Random Error

NO_2

Estimates of random error were also attempted for NO_2 using the guidance and Leicester City Data (see appendix 3). However there is a great variation in geography of the district from 'motorway-side' to rural locations compared with the city of Leicester. There is also significant differences in published variations in background levels of pollutants (see stage 1 report[12]) throughout the district as well as compared with Leicester. Although these differences may be best treated as different systematic errors depending on geography, the lack of quality monitoring data throughout the district means that the model output for whole district needed to be treated as a whole. Considering this expected larger scale variation around the Leicester data, two standard deviations of error (estimated at ±2ppb for NO_2) were applied to the predicted pollutant contours produced by the ADMS model.

PM_{10}

The random error for PM_{10} was calculated by the method outlined in the NSCA guidance[13] using a u value of 0.3 to give ±12 $\mu g/m^3$. This large variation combined with the cautious approach to the systematic error casts significant uncertainty on the PM_{10} modelling results.

SO_2

The random error for SO_2 (1hr mean) was calculated by the method outlined in the NSCA guidance[13] using a u value of 0.5 to give ±23.4ppb. This very large variation especially considering that this u value may have been capped to prevent negative concentrations also casts significant uncertainty on the modelling results.

Application of Validation

For this report the contour maps and figures (unless otherwise stated) for SO_2 and PM_{10} have had the corrections for systematic error applied. However as the systematic error for NO_2 depends on distance from roads it has not been possible to apply this correction on the contour maps. The NO_2 contour plots that are included in this report show results factored for background locations (0.9 and 0.64, annual and hourly respectively) and with the maximum of the band of values considering the random error. Although not included in the validation of the model output, the same principles have been applied in the assessment of all the data (chapter 3). The results of the modelling and monitoring (considering the random and systematic errors of both) are discussed (chapter 3) to qualitatively validate the determination of where it is "likely" that there will be an exceedance of the air quality objective in 2005. Thus, to qualitatively validate the recommendations for where it is "likely" that Air Quality Management Areas are necessary. This information was then used to draw the boundaries of recommended Air Quality Management Areas, adjusted outwards to "logical", physical boundaries.

Regarding the hourly means 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 was placed in the model predictions of an annual means than in the number and value of peaks occurring over a year for that pollutant.

3. Results of the Review and Assessment

3.1 Pollutants Not Requiring Stage 3 Assessment.

3.1.1 Review and Assessment of Benzene

Introduction

Benzene (C_6H_6) is a volatile aromatic hydrocarbon composed of a ring of carbon atoms with single hydrogen atoms attached to each.

In the UK the main source of benzene is the combustion and distribution of petrol of which it is a constituent. Petrol vehicles are the main source (67% of total emissions) where benzene is released either as an unburned constituent of the fuel or as the product of the combustion of other hydrocarbons. Other significant sources include other motor vehicles (8%), stationary combustion sources (7%), some industrial activities (7%) and evaporation due to spillage or other loss (5%). Due to the nature of its source and its propensity to rapidly disperse in air, benzene is seen only of concern to human health in the immediate vicinity of its production.

Benzene is a carcinogen that can cause leukaemia over long term exposure. There is therefore no level of exposure at which there is zero risk. EPAQS considered the medical evidence and decided that a level of 5ppb as a running annual mean represented an exceedingly small risk to health. This is reproduced as the air quality objective in the National Air Quality Strategy. There are currently no new Air Quality Daughter Directives for Benzene from the EU Environment Council.

National Trends

Monitoring in London suggests that there has been a substantial decline in benzene over the past 20 years. The adoption by the UK of European Directives controlling traffic emissions are likely to result in a continued decrease in benzene in the atmosphere to about 35% of its current levels by the year 2005. In view of this, national policies are likely to deliver the prescribed air quality objective for benzene by 2005 unless there are significant local sources of the pollutant.

Conclusions of the Stage 1 Report

The National Air Quality objective is 5ppb as an annual average. The predicted emissions from East Midlands Airport of 3.2ppb for total hydrocarbons in 2006 are unlikely to exceed the objective even with large errors on this figure as benzene is likely to constitute only a small proportion of this total.

Although some petrol stations are close to housing areas they are unlikely to cause exceedances to the objectives as only 5% of the total benzene comes from spillages and lost vapour and new vapour recovery systems will continue to decrease the amount of lost vapour.

Predictions for benzene levels are higher for 1998 than for 2005. This is because the increase in emissions due to higher traffic flows is smaller than the decrease in emissions due to catalytic converters and engine improvements. Although the 5ppb limit is predicted to be broken during congestion, this would require congestion for 24 hrs per day and for every day of the year, which is unlikely, but the figures give some idea of the peaks expected such as those seen at the Birmingham East monitoring station. Some kerbside predictions are close to 5ppb however there are no people living at these kerbsides, the nearest gardens being at 30 meters from the M1 and 20 meters from the M42/A42. For the residential distances the maximum prediction is for the M1 at 1.38 ppb, which falls well below the 5ppb limit and properties here are also well screened by earthworks and trees.

In conclusion it is unlikely that the annual average of 5ppb is being broken or will be broken by 2005 in any areas of the district where people are expected to be exposed over a year even with a large error margin. There are no areas where combined effects from the airport, filling stations and major roads overlap and intercept with residential, school or hospital uses. There is no need to proceed to stage 2 or further assessment unless there is a change in threshold.

Further Assessment Following the Stage 1 Report.

Since the stage 1 report was published East Midlands Airport have published an Environmental Statement[14] in conjunction with a planning proposal. The modelling work used in this report included data provided by the council for traffic and industrial processes that may be emitting hydrocarbons. This model predicts that annual average hydrocarbon levels in 2006 for receptor locations near to the airport are 3.8ppb (Hill top Farm) and 3.2ppb (Stonehill). This confirms the previous predictions that benzene levels (which will only be a small part of the total hydrocarbons) will be well below the objective levels (5ppb Benzene) in this area.

Since the Stage 1 report there has been an increase in the number of complaints received by the council regarding nuisance and health effects of odours and deposits allegedly from aviation fuel in the vicinity of East Midlands Airport. However, a detailed study believed to be "the most comprehensive and thorough investigation of the possible health effects of a major airport on public health anywhere in the world"[15] was recently published regarding a similar situation at Birmingham International Airport. This study included long term real time monitoring and concluded that 'the comprehensive study showed no significant effect on general or respiratory health attributable to activities of the airport in people who live nearby'[16].

There have been no other new developments in the district likely to affect benzene levels and no new evidence to suggest that the National Air Quality Objective will not be met in 2005. Therefore, further assessment continues to not be required.

3.1.2 Review and Assessment of 1,3 – Butadiene

Introduction

1,3 Butadiene is a volatile hydrocarbon composed of four carbon and six hydrogen atoms.

In the UK the main source is from road vehicles with petrol engines emitting 67% of the total annual mass and diesel a further 11%. The compound is not present itself in fuel, but is formed as a product of the combustion of the olefines in the fuel. Approximately 17% of 1,3 butadiene is derived from a few industrial sources primarily specialising in the production of synthetic rubber for tyres. Similar to benzene, 1,3 butadiene disperses fairly rapidly in air and is only of concern in the immediate vicinity of its source.

1,3 butadiene is a carcinogen that can cause cancers of the bone marrow, lymphomas, and leukaemia. There is therefore no level of exposure of which there is zero risk. EPAQS set a level of 1ppb as a running annual mean as representing an exceedingly small risk to health. This is reproduced as the air quality objective in the National Air Quality Strategy.

National Trends

Due to the increase in the use of olefines in petrol, the amount of 1,3 butadiene in the atmosphere is thought to be increasing. However, three-way catalytic converters have been shown to decrease emissions by 90%, and as such 1,3 butadiene emissions across the UK should reduce by 55% by the year 2000, and 73% by 2010. In view of this, national policies are likely to deliver the predicted air quality objective by 2005 unless there are significant local sources of the pollutant.

Conclusions of the Stage 1 Report

As vehicle emissions are considered to be negligible and emissions from the processes in East Staffordshire[16] are likely to only affect adjacent areas then further review and assessment will not be necessary for this pollutant.

Further Assessment Following the Stage 1 Report.

There have been no other new developments in the district likely to affect 1,3 Butadiene levels and no new evidence to suggest that the National Air Quality Objective will not be met in 2005. Therefore, further assessment continues to not be required.

3.1.3 Review and Assessment of Lead

Introduction

Lead is an elemental metal. Most lead found in the atmosphere is in the form of very fine particulates of less than 1 micron (one thousandth of a millimetre) although some sources of lead generate larger particulates which tend to fall relatively quickly out of the atmosphere. The lead in particulates may be in its elemental form or as an alloy or compound.

The majority of emissions of lead in the UK come from petrol driven road vehicles (72%) where the lead is emitted as fine particulates in the exhaust fumes. Lead in the form of tetraethyl lead is added to petrol to enhance its octane rating. The other important source of airborne lead is primarily from smelting activities (9%). Human exposure to lead is primarily through ingested food. However, whilst the percentage absorption of lead in the gastrointestinal tract is only 10% in adults, the level of absorption through the respiratory tract may be as high as 60%.

Lead is bio-accumulative, namely, it concentrates within body tissue once absorbed, primarily in the bones, teeth, skin and muscle. It exhibits toxic effects by interfering with haemoglobin synthesis, causing neurological damage and affecting the kidneys, gastrointestinal tract, joints and reproductive system.

At the time of the production of the National Air Quality Strategy, no EPAQS Report had been published relating to lead. A revised 1987 WHO Guideline for lead set a figure of 0.5 μm^{-3} as an annual mean, and it is this figure that was adopted for the purposes of the Strategy. In 1998 EPAQS published their report on lead which recommended an air quality standard of $0.25 \mu g m^{-3}$ as an annual average.

The Air Quality Daughter Directive agreed by the EU Environment Council 16 June 1998 has an annual limit value of $0.5 \mu g/m^3$.

National Trends

Levels of atmospheric lead have dropped dramatically in the UK since the early 1980s due to a reduction in the permissible concentration in lead in petrol combined with the necessity to remove lead altogether from petrol used in cars equipped with catalytic converters. As catalytic cars replace the leaded petrol fleet, then lead will continue to reduce. By 2005 emissions of lead are likely to have decreased by 90% based on 1995 levels. In view of this, national policies are likely to deliver the Air Quality objective by 2005 unless there are significant local sources of lead.

Conclusions of the Stage 1 Report

Although the largest source of lead has been from road traffic emissions, increasing use of unleaded fuel means that it is unlikely that the air quality objectives are being exceeded or will be exceeded in 2005 by this source. This is confirmed by the background data which shows levels well below the objective even around the motorway sites which sites are also distanced from residential school or hospital uses.

Due to the size of the Pegson foundry (Mammoth Road, Coalville) operations there is likely to be only negligible emissions of lead from this process. Similarly the size and distance away from the district of the bell foundry in Loughborough means that a breach of the objectives is unlikely from this process.

The secondary lead smelter in Woodville is likely to have significant emissions of lead to require a further assessment to stage 2. This will require liaison with South Derbyshire District Council as they proceed to stage 2 particularly regarding concentrations likely to impact upon the residents of Albert Village.

Further Assessment Following the Stage 1 Report

In early 1999 the Pegson foundry ceased its melting and smelting processes in that it no longer required authorisation under the Environmental Protection Act.

South Derbyshire[17] have used the Environment Agency's Guidance on single stack assessments. Based on known emission rates the of 0.0037 g/sec (see appendix 4) the predicted environmental concentration was determined to be 0.0125 $\mu g/m^3$. Therefore it is unlikely that the air quality objective for lead (0.5 $\mu g/m^3$, annual mean) will be breached in the vicinity of Midland Lead.

Considering these new details further assessment will to not be required.

3.1.4 Review and Assessment of Carbon Monoxide

Introduction

Carbon Monoxide (CO) is a colourless and odourless gas consisting of one carbon atom and one oxygen atom.

Carbon monoxide is largely produced due to the incomplete combustion of fuels containing carbon. The main source of emissions in the UK is road transport which produces 75% of total UK emissions. 71% of the total national emission comes from petrol vehicles.

CO is best known as a pollutant in restricted areas with poor ventilation - in particular domestic houses with badly maintained gas fired appliances where it can reach dangerously high concentrations. These sources only contribute 6% of the total CO generated in the UK. Similarly CO is only a significant pollutant in the wider environment near to heavily trafficked or congested roads. Concentrations fall away rapidly with distance from roads and CO is only therefore a pollutant of concern in the immediate vicinity of its production.

At high levels of CO, prolonged exposure can lead to death as it inhibits the distribution of oxygen around the body by blocking the carrier molecule in red blood cells. At lower levels the effect, whilst not fatal, can lead to impaired mental performance and coronary stress. Short term exposure causes reversible effects whilst long term exposure may lead to chronic health effects.

EPAQS recommended a level of CO at which there is insignificant risk to health to be 10ppm as an 8 hour average. This is reproduced as the air quality objective in the National Air Quality Strategy.

National Trends

Emissions of CO in the UK increased by 13% between 1970 and 1990. However, they have been decreasing every year since. There is clear evidence of this in rural areas, but less so in urban areas. The improvements in emissions is largely attributed to stricter emission standards for road vehicles. Tighter fuel standards from the EU Auto-Oil directives (for all new cars sold from 2001 to 2006) will deliver an emission reduction of 30% for carbon monoxide compared to 1997 levels.

Conclusions of the Stage 1 Report

The traffic data predicts that the air quality objectives for carbon monoxide will not be exceeded in 2005 unless there is severe continual congestion. Even should this occur the concentrations are predicted to still be below the limit at residential locations. Predictions for 1998 are higher and suggest that during continued congestion there may be peaks above 10ppm however, these levels resulting from congestion are unlikely to be sustained for the full 8 hours.

Results from the Leicester monitoring station confirm that even in a busy town centre close to a major ring road average carbon monoxide levels fall well below the objective.

Although road traffic emissions may be presently close to the objective during congestion and adverse weather conditions emissions are decreasing to an extent that in 2005 it is unlikely that the objective will be exceeded.

Emissions from the power station are not likely to cause exceedance of the national objectives in areas where people may be exposed to emissions over an 8 hour averaging period as effects are seen only in the immediate vicinity of production. Other industrial sources within the district are negligible and do not overlap with major traffic flows and residential areas.

Further assessment to stage 2 will not be necessary.

Further Assessment Following the Stage 1 Report

There have been no other new developments in the district likely to affect carbon monoxide levels and no new evidence to suggest that the National Air Quality Objective will not be met in 2005. Therefore, further assessment continues to not be required.

3.1.5 Ozone

Introduction

High in the stratosphere, the ozone layer shields the surface of the earth 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.

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 town centres, levels are likely to be even higher in outlying rural areas.

Why a Statutory Objective is not set for Ozone

Ozone is a country-wide and international problem because of its secondary and transboundary nature, it is unlikely that any cost-effective action can be taken locally to affect the local ozone levels. 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 District 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.

However, the council continues to monitor for ozone levels throughout the summer months at 4 locations using passive diffusion tubes. The results (shown below) show no clear trend over the last 5 years

year	Coalville	Ashby	Kegworth	Griffydam
Average 96	14	15	15	20
Average 97	18	20	21	28
Average 98	12	11	14	26
Average 99	15	11	14	19
Average 00	15	11	13	18

Table

3.2 Review and Assessment of Nitrogen Dioxide

3.2.1 Introduction

Nitrogen dioxide is a gas formed from one nitrogen molecule and two oxygen molecules. In sufficient concentrations in air it appears as a red/brown colour and it is in part this coloration which creates the discoloured 'smog' which can often be seen in the skyline of cities.

Nitrogen dioxide is formed to a small extent directly in combustion processes. However, most nitrogen based combustion products are emitted as nitric oxide (NO). Nitric oxide is relatively unstable and is relatively rapidly oxidised to nitrogen dioxide in air. The most significant source of these gases is road transport which accounts for 46% of the total UK emission. The electricity supply industry produces another 22%, other industrial sources 12% and domestic sources 3%. Nitrogen dioxide is of concern both locally and globally. Accumulations of the gas in the vicinity of sources can give rise to direct health effects whilst the gas also acts indirectly as greenhouse gases.

The principal health effects of nitrogen dioxide relate to impaired lung performance from changes in structure and function and suspected hyper reactivity to allergens (causes of allergic response). Effects are reversible; however, ongoing exposure may lead to poorer lung function later in life. Exposure to high concentrations for short periods is considered more toxic than low concentration exposure for long periods.

EPAQS recommended that short term concentrations below 150 parts per billion should be avoided. They did not recommend a desirable level over a longer averaging period but commented on the possibility of the cumulative effects of longer term exposure. In response to this the National Air Quality Strategy has two objectives for nitrogen dioxide:- 150ppb for one hour and 21ppb as an annual mean.

The EU air quality daughter directive defines the same limits but also specifies a limit of 18 exceedances of the hourly limit in any one year.

3.2.2 National Trends

A total of 94 automatic monitoring stations operate at various locations around the country. In addition, the National Environmental Technology Centre co-ordinates the collation of data from passive diffusion tube samplers collected from approximately 300 different local authorities across the country. Trends indicated from the automatic stations vary depending on local influences. Of the diffusion tube surveys there appeared to be a 34% increase in the period 1986-1991 (corresponding with a 30% increase in road traffic). NETCEN are cautious about drawing national trends from more recent data. However, 1995 results indicated that 326 of the 1220 sites monitored were in exceedance of the then WHO annual average guideline of 20.9ppb.

Road Traffic NOx emissions are predicted to drop by 46% by 2005 due to a variety of EU Directives.

3.2.3 Monitoring Results

Since the stage 1 report the number of diffusion monitoring tubes (see section 2.2.4) has been increased to 18 at various sites throughout the district. (see appendix 1 for details). Using unvalidated raw data there are currently (Aug 99 – Jul 00) 6 of these sites where the objective for annual mean NO_2 (21ppb) is not met. This decreases to 4 if the correction for probable systematic error is used, see table 4 below.

Location of Diffusion Tube	Annual (99/00) Average (raw) ppb	Annual (99/00) Average (factored) ppb
Belvior Rd. Coalville	28.7	25.3
Ibstock	21.1	18.6
Market St. Ashby	26.5	23.3
High St. Castle Donington	23.6	20.8
Kegworth (A6)	28.6	25.2
Bardon Road, Coalville	26.7	23.5

Table 4 Raw and factored Diffusion tube monitoring results for 1999/2000

Real time data from Weston on Trent Monitoring Station (see section 2.2.2) which is just outside North West Leicestershire but representative of most rural locations within the district, gives an annual (1998/1999) average of 11.2 ppb and a maximum hourly mean in that year of 52 ppb.

Results for the real time monitoring station set up in August 2000 at Kenilworth House, Kegworth showed that the average NO_2 was 10.1 ppb with the maximum peak hour of 46.5 ppb both well within the objectives. However in the minute data regular peaks are seen some as high as 400ppb.

3.2.4 Modelling Results

The model was run using the methods described in section 2.

Annual Average
The results for the annual mean runs for NO_2 (with the 0.9 'Background' factor derived from the validation applied) can be seen on pages 44-49. These contour plots have also been corrected to assume for the worst case random error (+2ppb) thus where an exceedance (>21 ppb) is shown this represents where it is 'likely' that an exceedance will occur. It can be seen that the model predicts an exceedance of the 21 ppb objective in 2005 in 3 main areas.

1. **In the vicinity of the M1, at a distance of approximately 200m to the east and 100m to** the west (considering that the model output is not smooth but somewhat 'blotchy')

2. In the vicinity of the runway of East Midlands Airport

3. A couple of locations along the A42 mainly at junctions.

However, when the correction factor of 1.5 is applied (for locations within 10m of a major road) the whole district is shown as an exceedance with the exception of a band to the west of the A42 and the south of the district comparable to the areas coloured light blue (13 – 15 ppb) on the 1998 maps (pages 44-46). This suggests that except for these areas all other locations within 10m of a major road will exceed the air quality objective in 2005. This can be see on Table 5 (following) which shows roadside locations (mostly where diffusion tubes are located) which are all predicted to be over 21ppb except for Jackson Street, Coalville; High Street, Ibstock; Wilson and Norris Hill. However, these results are discussed in relation to the monitoring data and uncertainties in section 2.2.5.

Location	Diffusion Tube results 1998	Diffusion Tube results 1999	Raw Model results 1998	Factored Model results (roadside; x1.5) 1998	Factored Model results (bkgrd; x0.9) 1998	Raw Model results 2005	Factored Model results (roadside x1.5) 2005	Factored Model results (background x0.9) 2005
Kegworth A6 (NO2)	31.3	31.8	19.95	29.93	17.96	18.19	27.29	16.37
Kegworth A6 (Pm10)			21.96	32.94	19.76	19.75	29.63	17.78
Ashby A42 Loweswater		19.6	17.88	26.82	16.09	16.23	24.34	14.61
Ashby Market St.	31.[illegible]	27.9	18.09	27.13	16.28	15.77	23.65	14.19
Diseworth School			15.58	23.37	14.02	14.91	22.37	13.42
Hilltop C/Don			16.04	24.06	14.43	15.55	23.33	14.00
M1 Long Whatton.		21.8	27.19	40.79	24.47	24.01	36.01	21.61
Stonehill C/Don	16.0	17.8	15.53	23.29	13.97	15.39	23.08	13.85
Whatton Rd Kegworth		19.8	19.61	29.41	17.65	18.06	27.09	16.25
Wilson			13.56	20.34	12.21	13.16	19.74	11.84
Ashby Marlboro'R	20.7	23.2	14.65	21.98	13.19	13.63	20.45	12.27
Boundary			14.88	22.32	13.39	13.79	20.68	12.41
Norris Hill Moira			13.91	20.87	12.52	13.32	19.98	11.99
Measham High Street	23.9	23.5	16.05	24.07	14.44	14.69	22.03	13.22
Ibstock Melbrn. Rd.	20.7	23.0	14.34	21.51	12.91	13.54	20.31	12.18
Belvoir Rd. Coalvile	34.6	32.0	16.84	25.27	15.16	15.46	23.18	13.91
Jackson St. Coalville	23.9	22.1	14.97	22.45	13.47	13.96	20.94	12.56
Council Off. Coalvile			16.31	24.46	14.68	14.79	22.18	13.31
Oxford St. Coalville	22.8	21.2	15.48	23.23	13.94	14.26	21.39	12.83
Abbotts Oak Drive	20.6	20.6	15.34	23.01	13.80	14.19	21.28	12.77
Bardon Rd Coalville		32.6	17.60	26.41	15.84	15.91	23.87	14.32

Table 5 Results for Monitored and Modelled results for receptor runs. All runs using Castle Donington Scenario 1 data. All values in ppb

Hourly Averages

Table 6 (following) shows the maximum hourly mean for the receptor points. There are no predicted exceedances of the hourly objective (104.6ppb [18 exceedances permitted]) throughout either the 1998 or the 2005 predictions. The contour plots pages 52-57 show predictions based on one of these maximum hours thus representing the spatial distribution of a typically bad hc These plots are only based on the corresponding hour of weather data (in this case with wind from the west) Therefore they do not represent maximum values in all locations as this will be very much dependant on wind direction and direction from source.

Location	Maximum Hourly NO_2 1998	Number of times Hourly NO_2 >105 ppb 1998	Maximum Hourly NO_2 (C/Donington scenario 1) 2005	Number of times Hourly NO_2 >105 ppb (C/Donington scenario 1) 2005	Maximum Hourly NO_2 (C/Donington scenario 2) 2005	Number of times Hourly NO_2 >105 ppb (C/Donington scenario 2) 2005
Kegworth A6 (NO_2)	88.98	0	88.45	0		
Kegworth A6 (Pm_{10})	88.79	0	88.52	0		
Ashby A42 Loweswater	97.84	0	96.10	0		
Ashby Market St.	97.24	0	94.83	0		
Diseworth School	94.86	0	94.03	0	95.86	0
Hilltop C/Don	94.84	0	93.45	0	~~96.89~~	~~0~~
M1 Long Whatton.	95.89	0	93.84	0		
Stonehill C/Don	93.37	0	92.13	0	95.50	0
Whatton Rd Kegworth	89.90	0	89.14	0		
Wilson	95.01	0	94.56	0		
Ashby Marlboro'R	95.72	0	94.78	0		
Boundary	96.80	0	95.99	0		
Norris Hill Moira	95.88	0	95.12	0		
Measham High Street	94.2	0	93.27	0		
Ibstock Melbrn. Rd.	93.90	0	92.98	0		
Belvoir Rd. Coalvile	94.17	0	92.60	0		
Jackson St. Coalville	93.88	0	92.73	0		
Council Off. Coalvile	94.72	0	93.80	0		
Oxford St. Coalville	94.83	0	93.77	0		
Abbotts Oak Drive	94.68	0	93.79	0		
M1 Copt Oak			127.54	3		
Bardon Rd Coalville	94.41	0	93.68	0		

Table 6, Modelled receptor runs for hourly NO_2 levels. (all ppb)

3.2.5 Discussion of Results

The modelling results suggest that the air quality objective for annual mean NO_2 may not be achieved at locations within 10m of major roads (>14,000 AADT) and in the vicinity of the M/A42, M1 and runway of East Midlands Airport. Therefore these sources are discussed separately. The modelling results suggest that the air quality objective for hourly NO_2 is likely to be achieved.

Roads with flows over 14,000 are:
A6 Kegworth (Junction 24 of M1 to Hathern)
Belvoir Road, and Ashby Road, Coalville.
A511 (from Tesco Ashby Roundabout to M1 including Sinope and Bardon Road)
A453 (from B6540 junction near East Midlands Airport to Ratcliffe on Soar)
A50
M42 / A42
M1

A6 Kegworth
This is a trunk road through a large village fronted by shops and houses (many with facades within 10m of the kerbside). The 1998 and 1999 diffusion tube results for tubes (placed 2.5 m from the kerbside) show levels of 31.3ppb and 31.8ppb respectively, this compares to the 29.93ppb annual average predicted by the model for the same location with the 1.5 (10 m from kerbside) correction factor applied. This appears to be a good agreement, therefore the model prediction of 27.29ppb (for locations within 10 of the kerbside) suggests that it is likely that the air quality objective (21ppb) will not be met by 2005 at these locations.

Belvoir Road, Coalville
The top end of Belvoir Road close to the junction with High Street and Ashby Road is part of the central shopping area of Coalville. Vehicle flows in 1998 were 12719 (AADT) which would become 14182 (AADT) in 2005 using local traffic growth factors (see section 2.4). This part of the road especially between the sets of traffic lights has often been heavily congested although some improvements to this have been noted in the last year (2000). The road is narrow and fronted with shops (most within 10m), some have residential flats above them. The NO_2 tube results placed at 3m from the kerbside have consistently been the highest in the district with levels of 34.6ppb (1998 annual average) and 32.0ppb (1999 annual average). The model results however, only predict 25.27ppb for 1998 and 23.18ppb for 2005. This apparent underestimation of the model in this area may be because the model does not account for congestion or canyon effects (pollution getting trapped between high sided buildings). However despite the uncertainties it is likely that the objective for annual mean NO_2 will not be met by 2005. Although the model does not predict an exceedance of the hourly objective for NO_2 in this location and there is no monitoring evidence available, it is possible with the congestion and large numbers of people using the pavements in this shopping area that there may also be health effects caused by peak concentrations of NO_2.

Ashby Road, Coalville
Although similar flows of traffic are shown for Ashby Road as Belvoir Road, (17223 ,AADT 1998) this is based on traffic flows before a substantial traffic calming scheme was implemented. Traffic flows have reduced and the majority of residential properties are also set back at distances further than 10m from the kerbside. There is also little or no congestion. Thus the model prediction of around 18ppb for greater than 10m and 23ppb for within 10m of the kerbside is considered to be an overestimation and that is likely that the objective for annual mean NO_2 will be met in these areas by 2005. However, new monitoring sites will need to be established to confirm this position.

A511 Tesco-Ashby Roundabout to M1

This road forms the main route between Leicester and Burton on Trent and cuts between the M1 and the A/M42. Traffic flows along its length are typically around 20,000 (AADT) with 10% HGV element. There are 4 sections where the road is fronted by residential properties; Sinope including Hoo Ash, Bardon Road Coalville, Bardon Road, Bardon Hill and the intersection with Broom Leys Road. Of these Bardon Road, Coalville is typical and the modelling results show predicted annual average levels of NO_2 (within 10 m) to be 26.4ppb (1998) and 23.8ppb (2005). This compares with diffusion tube results (at 1.5m from the kerb) currently at 32.6 ppb (1999). This suggests that the objective is unlikely to be met within 10m of the A511 by 2005.

A453 from East Midlands Airport to Ratcliffe on Soar

This is a major trunk road which for part of this length is a dual carriageway running parallel and adjacent to the M1. AADT flows currently range from 13,000 to 25,000 generally increasing westwards. The model results predict an exceedance of the annual objective for NO_2 in 2005 within 10m of this road but not beyond 10m except where adjacent to the M1. There are no residential properties that fall into the category where the exceedances are predicted.

A50

The A50 is a trunk road linking the M1 to Stoke-on-Trent and the M6. AADT flows are around 40,000 and the section within North West Leicestershire (Derby Southern Bypass) is through a completely rural area. This casts uncertainty on the validation of the model that gives the factors for 10m within a road is the location is considerably different to those of the monitoring station used in the validation (see section 2.5). However, the model predicts that within 10m of the road the annual average objective for NO_2 will not be met in 2005. There is 1 isolated property that fits this criteria.

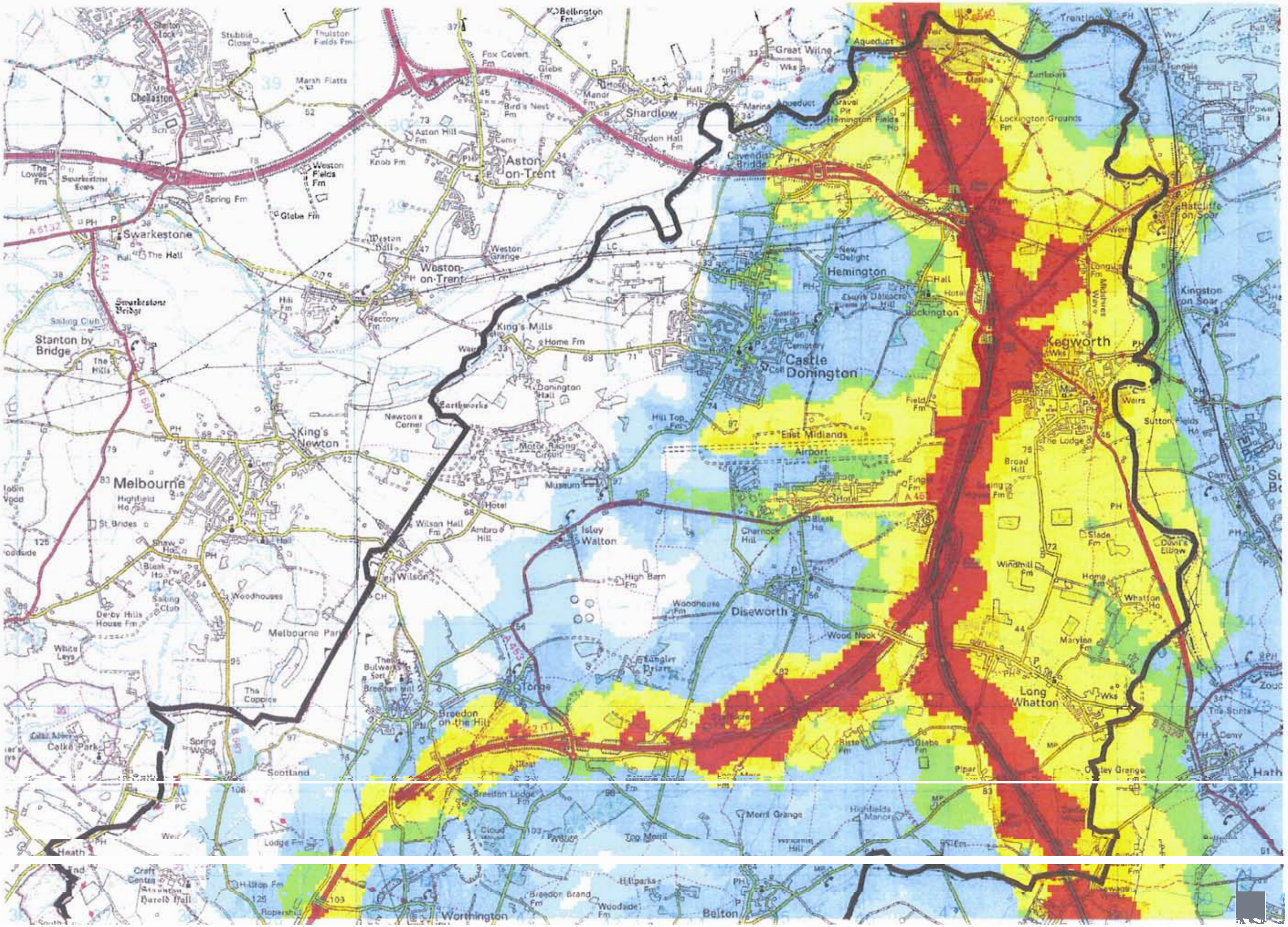
M42/A42

This road runs NE/SW through the whole length of the district. The daily flows are currently between 45,000 and 50,000 (AADT). The nature of the road is similar to the A50 and thus again there is uncertainty extrapolating the model correction factors. The graph below shows the modelled and monitored results for distance from the A42 at Ashby. For the monitoring results it should be noted that the value for 10m from kerbside represents 1998 data, 50m represents 1999 data and 200m is from an urban background site in Ashby(1998). Also the modelling results are for raw data (no factors applied).

Predicted levels of Nitrogen Dioxide in 1998 (Annual Mean)

North of the District

Validation correction factor (0.9) applied



NO2 ppb

13 - 15	
15 - 15.5	
15.5 - 16.5	
16.5 - 17	
17 - 19	
19 - 20.9	
20.9 - 27	

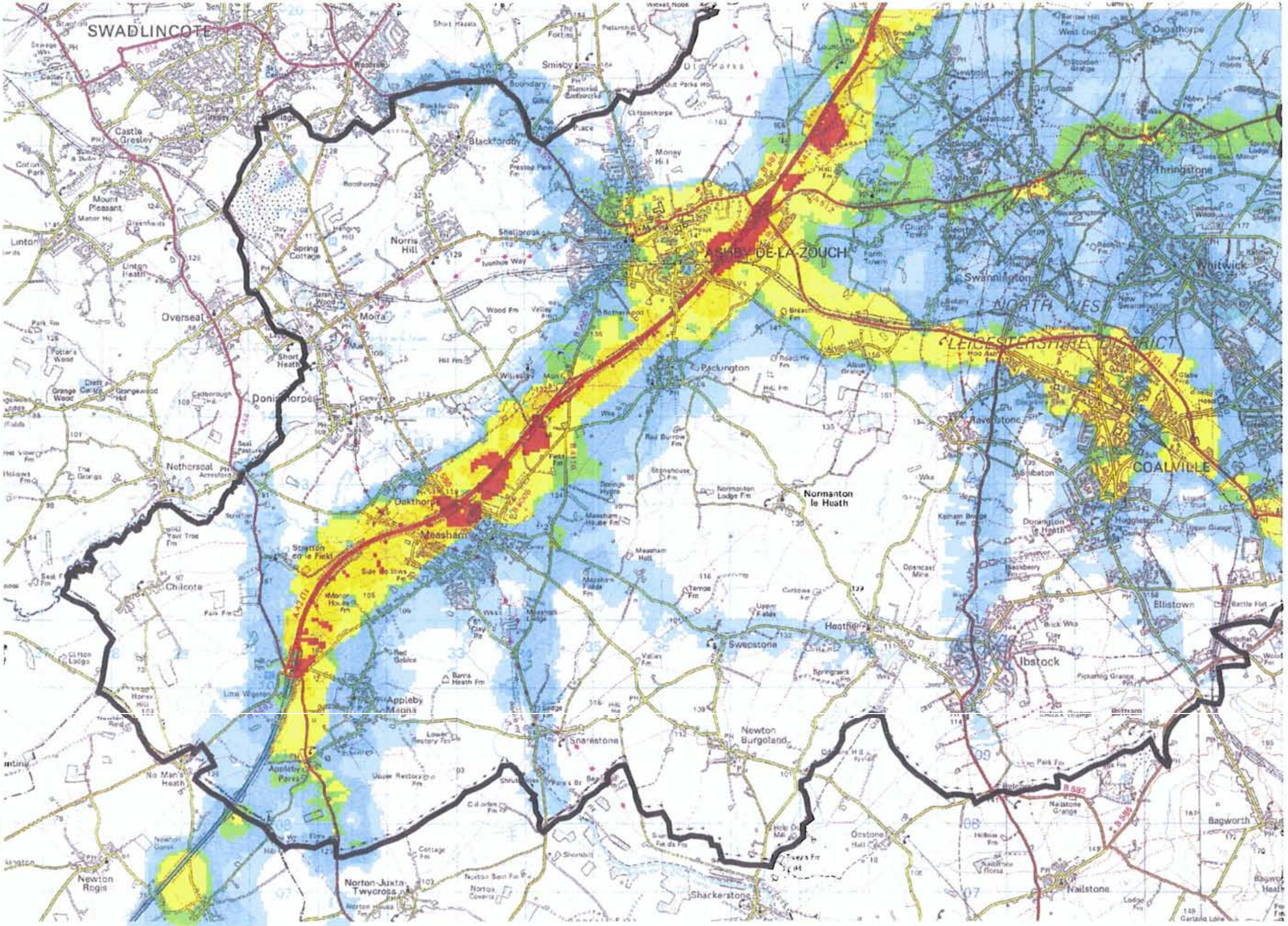
NO2 µg/m3

24.8 - 28.7	
28.7 - 29.6	
29.6 - 31.5	
31.5 - 32.5	
32.5 - 36.3	
36.3 - 40.0	
40.0 - 51.6	

Predicted levels of Nitrogen Dioxide in 1998 (Annual Mean)

Validation correction factor (0.9) applied

Ashby-De-La-Zouch and surrounding area

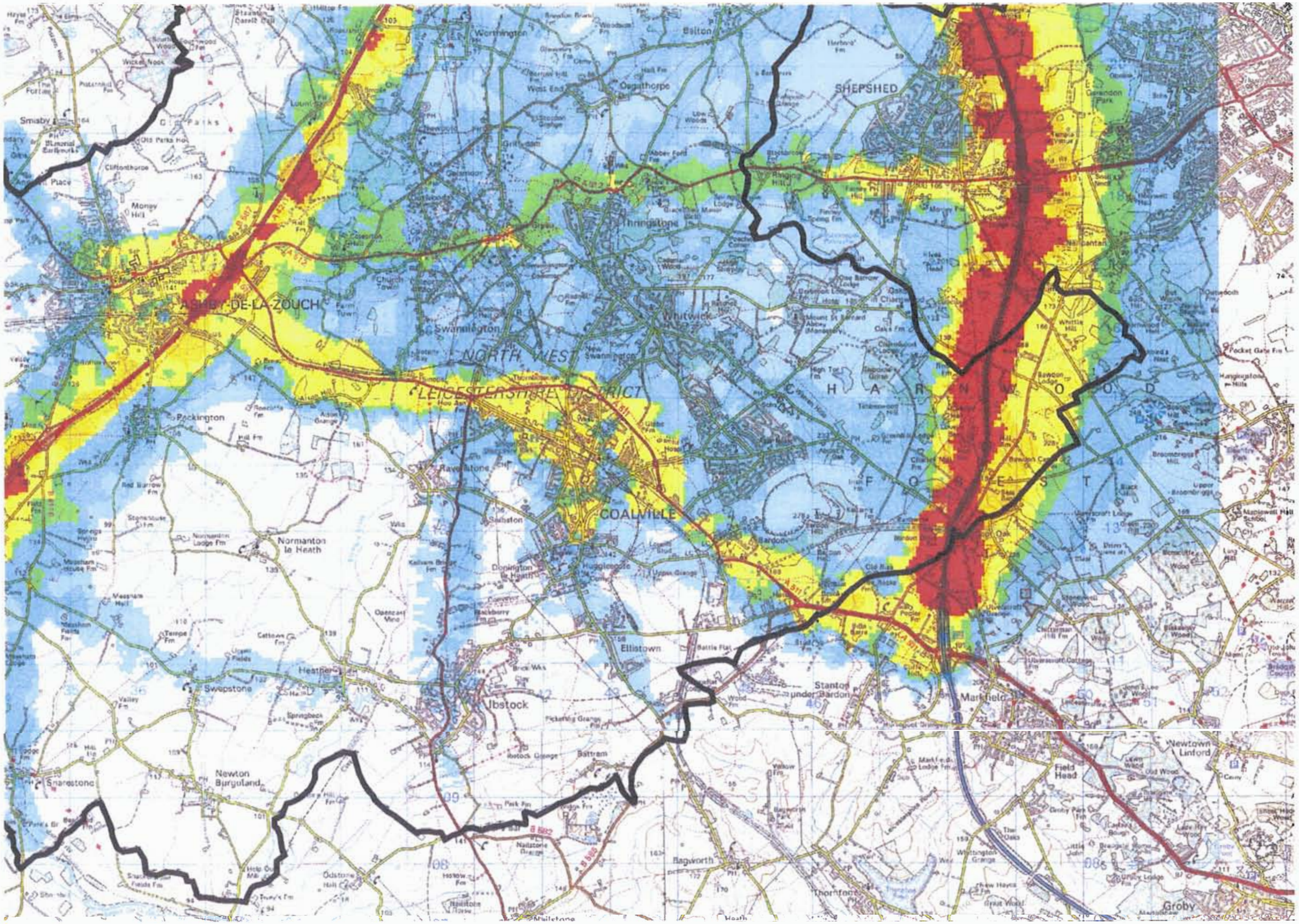


NO2 ppb	NO_2 µg/m³
13 - 15	24.8 - 28.7
15 - 15.5	28.7 - 29.6
15.5 - 16.5	29.6 - 31.5
16.5 - 17	31.5 - 32.5
17 - 19	32.5 - 36.3
19 - 20.9	36.3 - 40.0
20.9 - 27	40.0 - 51.6

Predicted levels of Nitrogen Dioxide in 1998 (Annual Mean)

Validation correction factor (0.9) applied

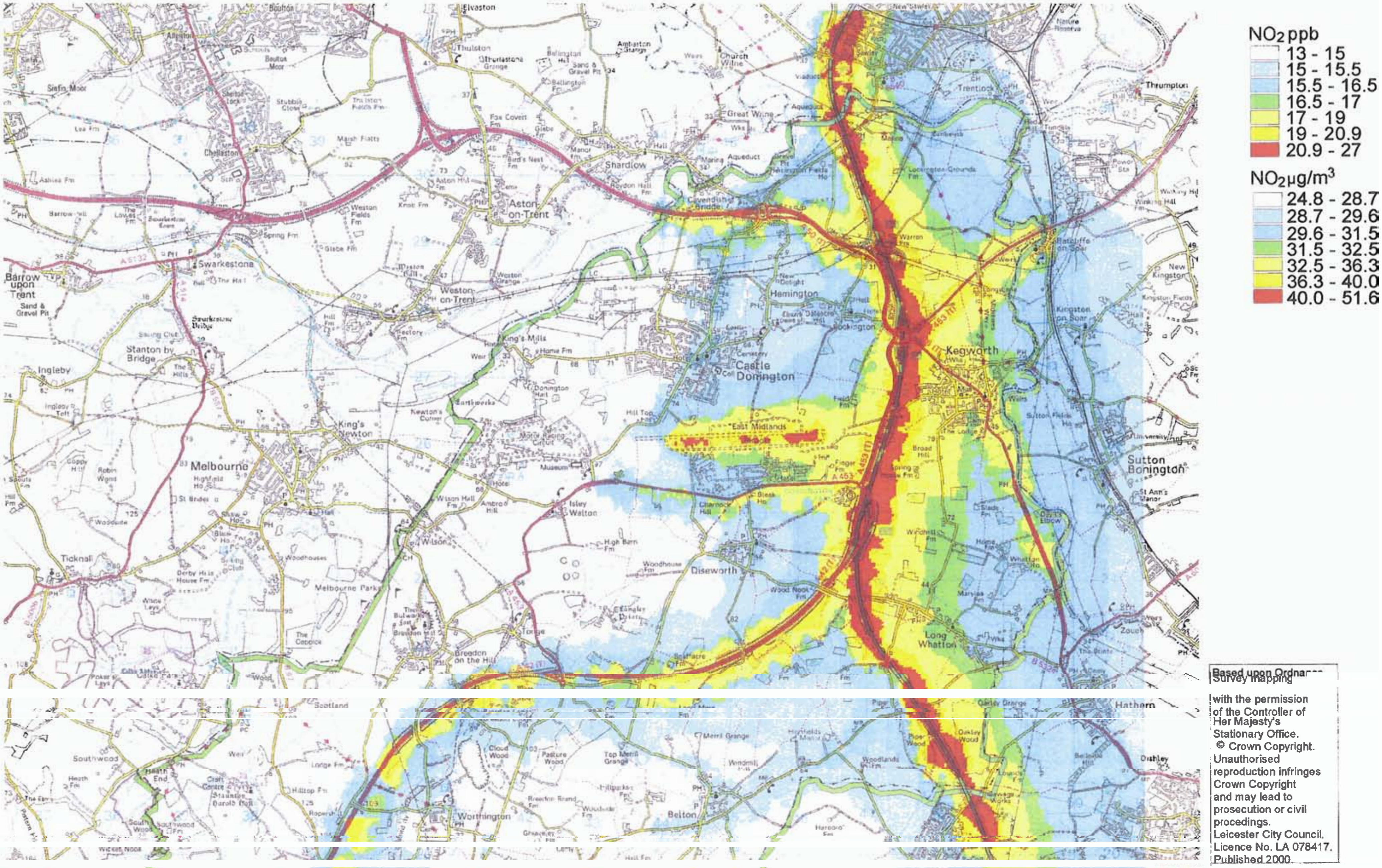
Coalville and surrounding area



NO_2 ppb	NO_2 µg/m^3
13 - 15	24.8 - 28.7
15 - 15.5	28.7 - 29.6
15.5 - 16.5	29.6 - 31.5
16.5 - 17	31.5 - 32.5
17 - 19	32.5 - 36.3
19 - 20.9	36.3 - 40.0
20.9 - 27	40.0 - 51.6

Predicted levels of Nitrogen Dioxide in 2005 (Annual Mean) **North of the District**

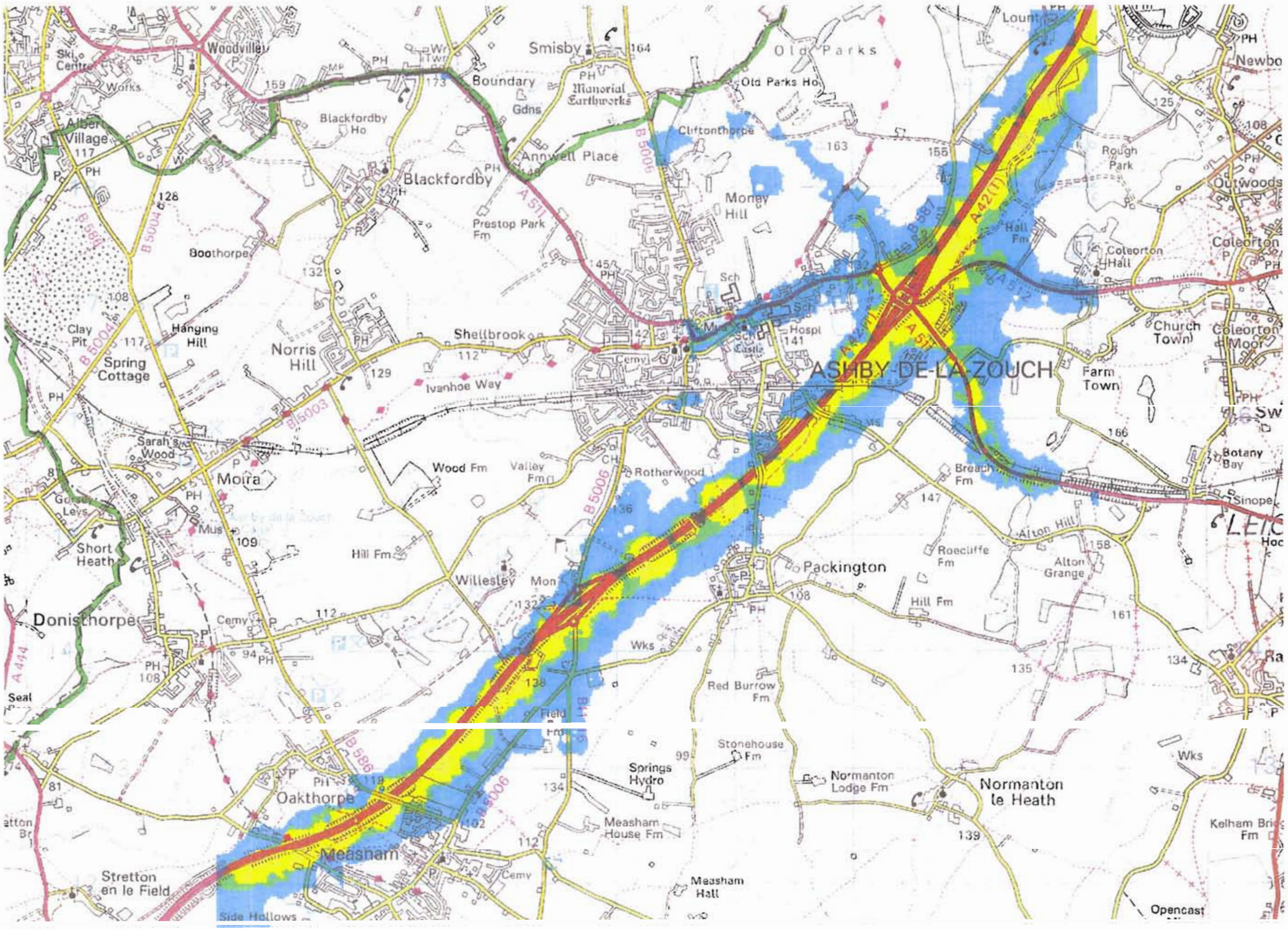
Validation correction factor (0.9) applied



Predicted levels of Nitrogen Dioxide in 2005 (Annual Mean)

Validation correction factor (0.9) applied

Ashby-De-La-Zouch and surrounding area



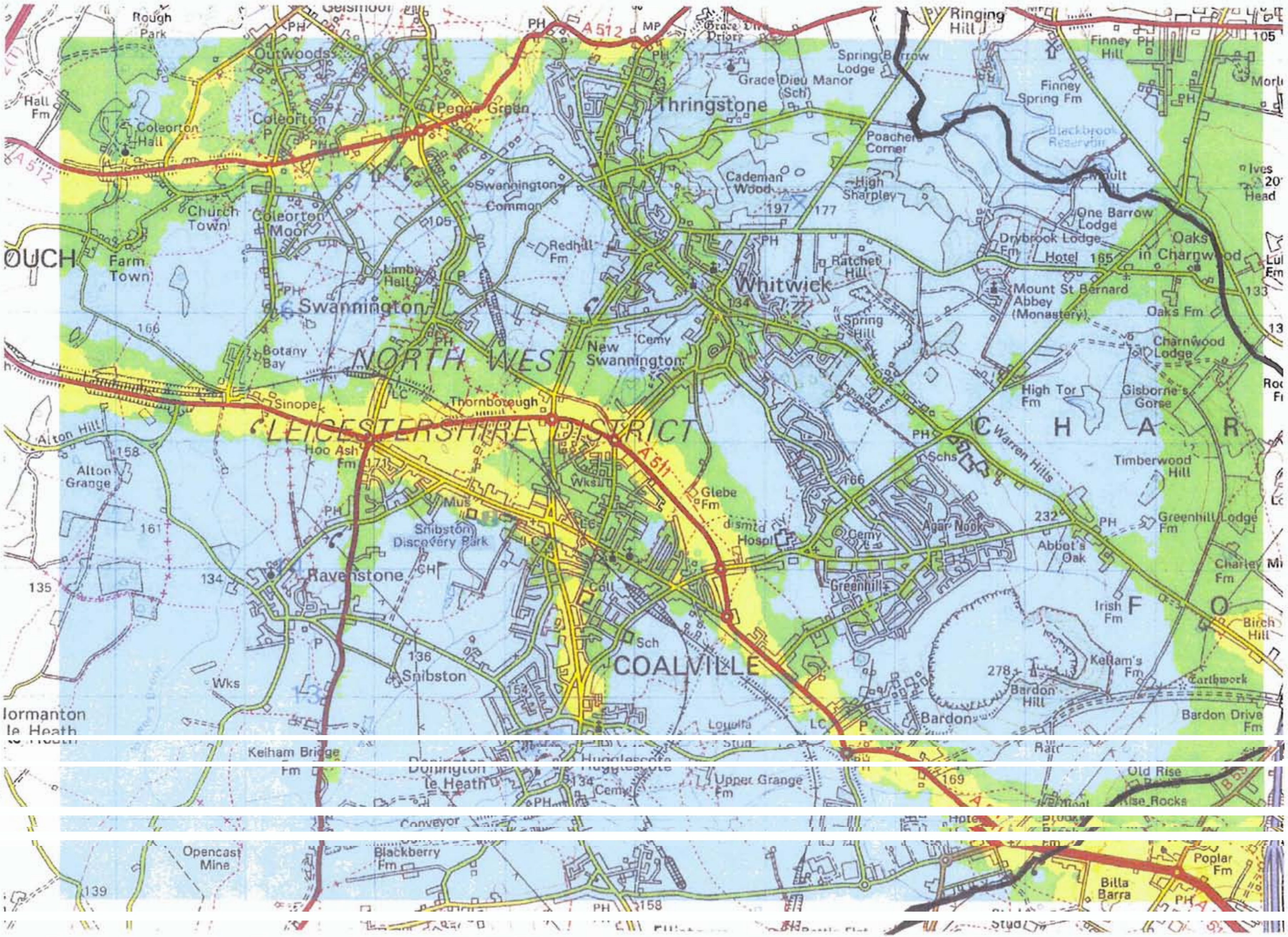
NO2 ppb

NO2 ppb	NO2 µg/m³
13 - 15	24.8 - 28.7
15 - 15.5	28.7 - 29.6
15.5 - 16.5	29.6 - 31.5
16.5 - 17	31.5 - 32.5
17 - 19	32.5 - 36.3
19 - 20.9	36.3 - 40.0
20.9 - 27	40.0 - 51.6

Predicted levels of Nitrogen Dioxide in 2005 (Annual Mean)

Validation correction factor (0.9) applied

Coalville and Surrounding Area



NO2 ppb

NO2 ppb
13 - 15
15 - 15.5
15.5 - 16.5
16.5 - 17
17 - 19
19 - 20.9
20.9 - 27

$NO_2\,\mu g/m^3$
24.8 - 28.7
28.7 - 29.6
29.6 - 31.5
31.5 - 32.5
32.5 - 36.3
36.3 - 40.0
40.0 - 51.6

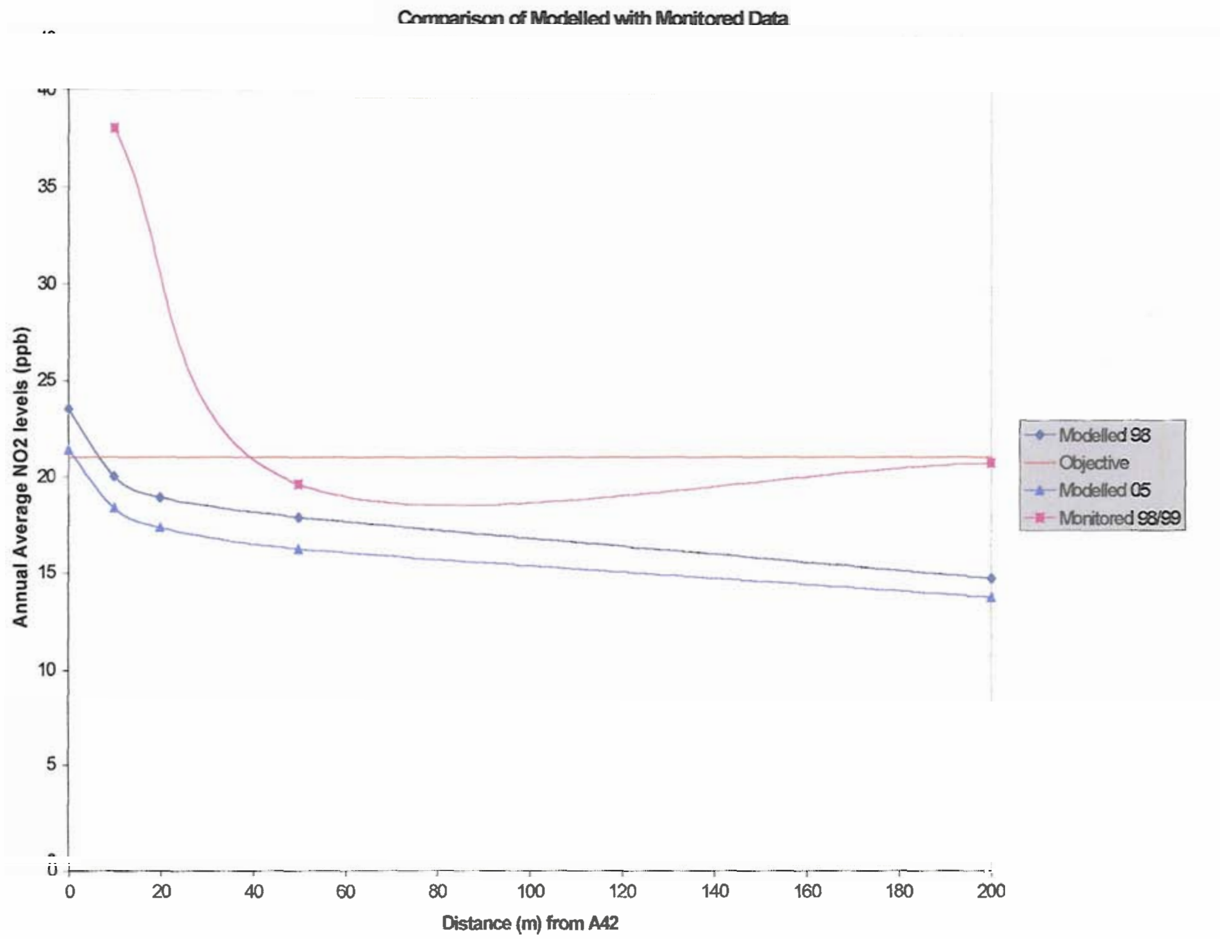


Chart 1 Comparison of modelled and monitored results Ashby A42

The chart above suggests that the raw model output is underpredicting compared with the diffusion tube results. The monitoring results suggest that presently levels of NO_2 are likely to be above 21ppb at about 40m from the A42. Although the model appears to be underpredicting it does however predict a general drop in NO_2 levels uniformly by about 3ppb in this location from 1998 to 2005. Considering the uncertainties of both the monitoring and modelling it would seem that there may be locations within about 30m of the A42 where the 21 ppb objective for annual mean NO_2 may not be met in 2005.

M1

Similar difficulties arise in the use of the modelling predictions for areas in the vicinity of the M1 as with the A42. There is a general view that dispersion models overpredict for concentration of pollutants around motorways. This is likely to be true for this model as Kenilworth House, Kegworth (500m from the M1) is shown on the model output to be in the band of land affected by drift of pollutant from the airport with a predicted 1998 annual mean of 17-19ppb. The August monitoring although only a 'snapshot of the picture' however measured a much lower 10.1ppb at this location. Also, the diffusion tube located alongside the M1 in Long Whatton currently (99/00) shows average levels of 19.5ppb (below the 21 ppb limit). However, this tube is located 20m away and 15m down from an elevated section of the motorway and therefore may be in the shadow of the embankment. The modelling results show a broad band of areas where the model predicts the objective will not be achieved in 2005 (coloured in red) roughly 200m to the east and 100m to the west of the motorway. This is with the 0.9 (background) correction applied. Even at locations such as Corner Farm, Copt Oak (some 50m from the M1) the model predicts 28.79ppb in 2005 (raw data no corrections). It is also important to note that the model predicts levels over the 104.6ppb hourly NO_2 objective but within the 18 permitted exceedances per year. It is likely that there will be areas alongside the M1 where the objective for annual average NO_2 will not be achieved by 2005. However due to the uncertainties associated with the model predictions and monitoring data available it would be very difficult to predict the distance to which this would extend. A cautionary approach would be to consider looking at receptors within 150m of the M1.

Market Street, Ashby

Although the flow of traffic along Market Street in Ashby is currently at 14,000 this is expected to fall to 11,000 by 2005 with the completion of the Ashby bypass. This would fall outside the flows used in the validation of the model and thus introduces uncertainties. However if the same 10m from kerb factor was used (1.5) then the model predicts levels of 23.65ppb (annual average) along Market Street even with the reduced flow of traffic. This would not represent the changes introduced by traffic calming measures and only a provisional new HGV content figure was used. The NO_2 results are presently 26.5ppb (99/00) but it would be expected fall below 21 ppb with the reduced flow of traffic, reduced congestion and reduced proportion of HGV's on top of the national reduction due to EU directives. It is therefore likely that the objective for annual NO_2 will be met by 2005 in Market Street, Ashby but continued monitoring will be required to confirm this.

The Vicinity of the Runway at East Midlands Airport

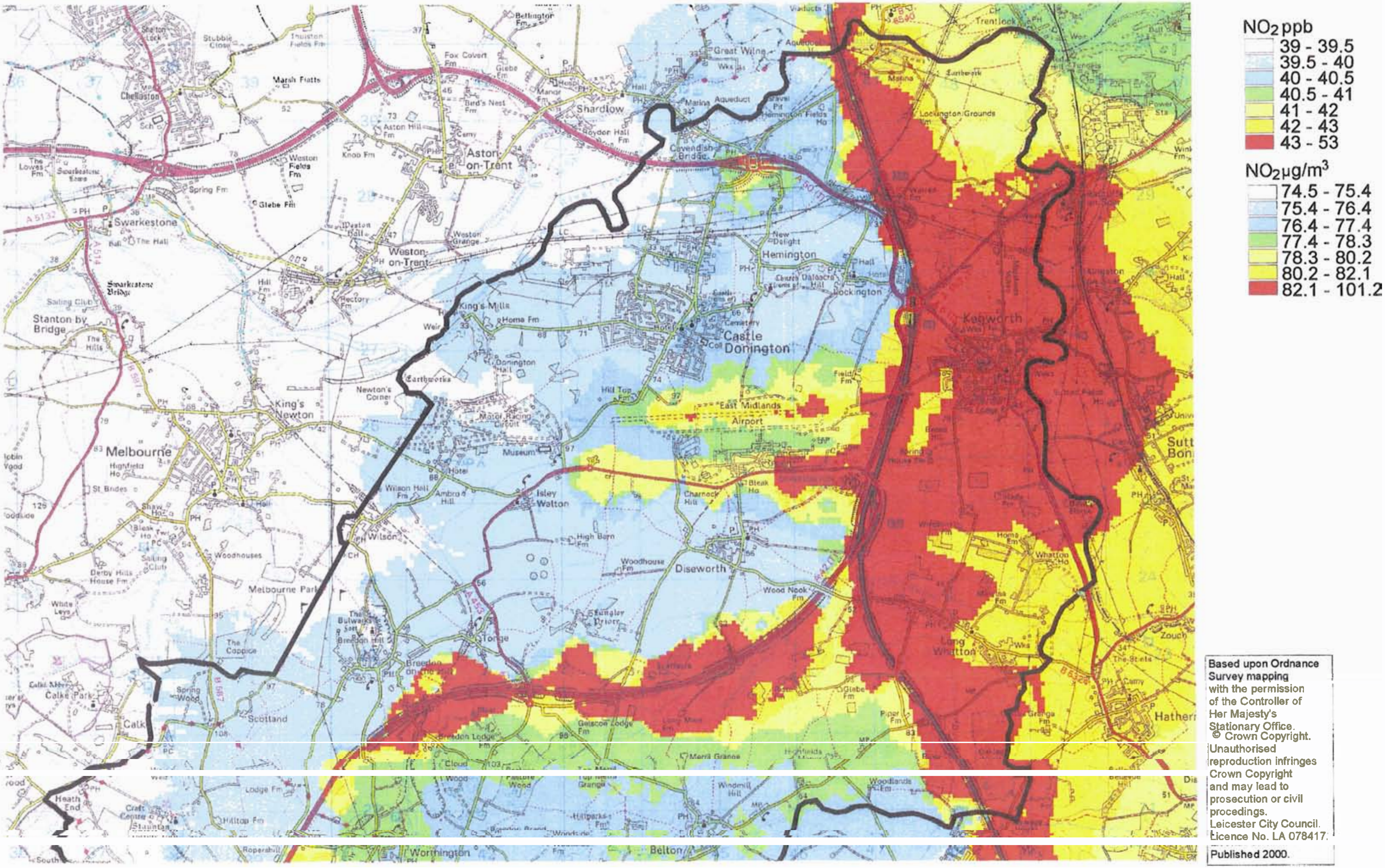
Perpendicular Distance (North) from Runway

The model validation and correction factors were only considered in relation to distance from roads. It would be unreasonable to apply the same factors to distance from the runway. Considerable work has been involved to try to predict the emissions from the airport and their influence on future ground level pollutant concentrations around the airport both by the council and EMA for their Environmental Statement for the Proposed Runway Extension[14]. The models used by both EMA and the council used the same predicted flight and airport use patterns and they generally produce similar results. There are some differences which are most likely to be the affect the different weather data used. The contour plot on page 47 shows the area likely to have the standard exceeded in red. However this map has had the 0.9 background correction applied for roads and thus the raw output map would show a slightly wider area of exceedance.

Although the aircraft will produce very high levels of NO_2 they will only be for short periods. Even over an hour these levels (such as those of 400ppb recorded at Kenilworth House August 2000, which are probably attributable to aircraft) are likely average out to well below the hourly average limit of 104.6ppb. The annual average will be affected but there appears (from both the modelling and monitoring results) to be a sharp fall in annual average levels of NO_2 with distance (perpendicularly) from the runway as shown by the graph below.

Predicted levels of Nitrogen Dioxide in 1998 (Hourly Mean) **North of the District**

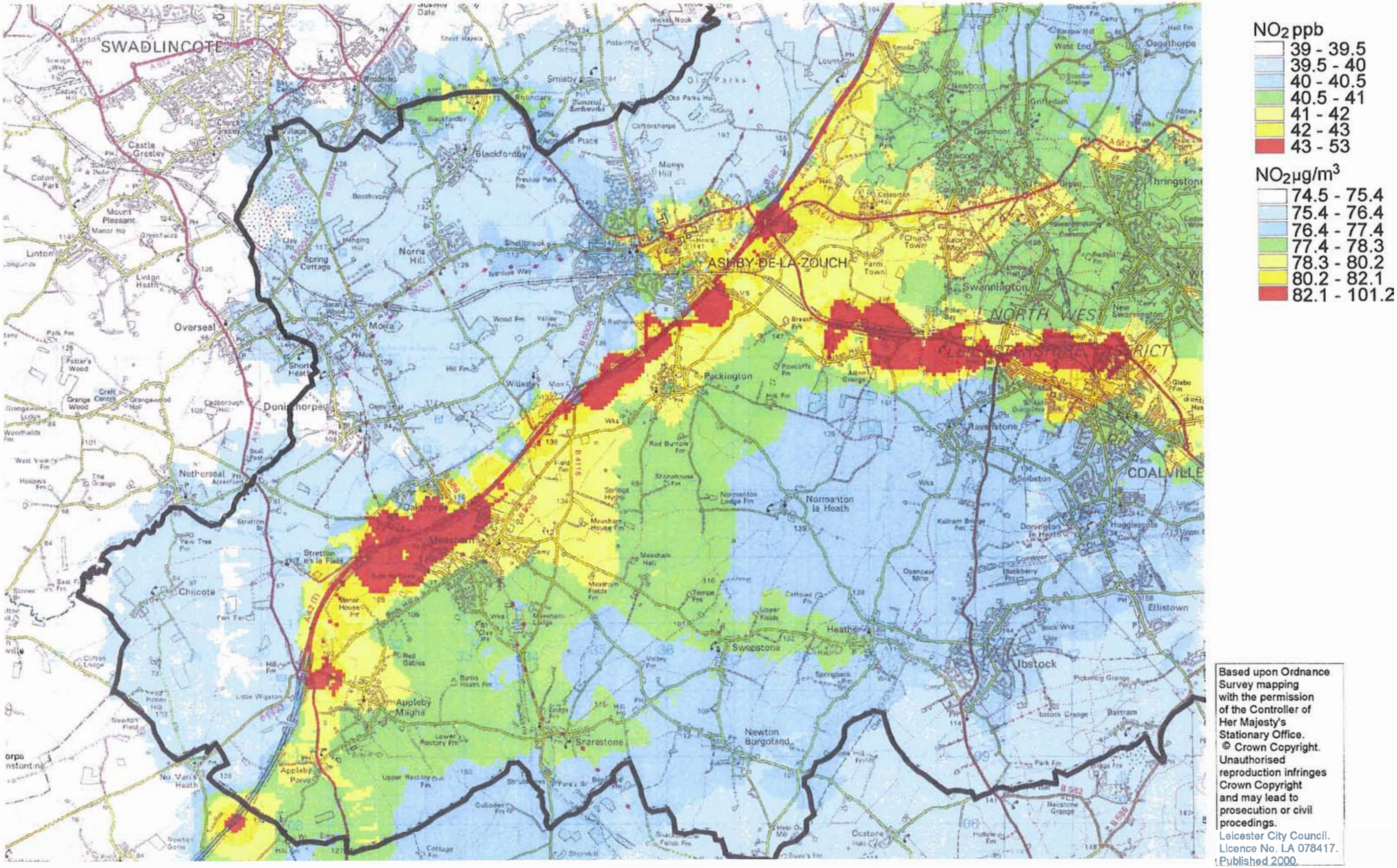
Validation correction factor (0.64) applied



Predicted levels of Nitrogen Dioxide in 1998 (Hourly Mean)

Validation correction factor (0.64) applied

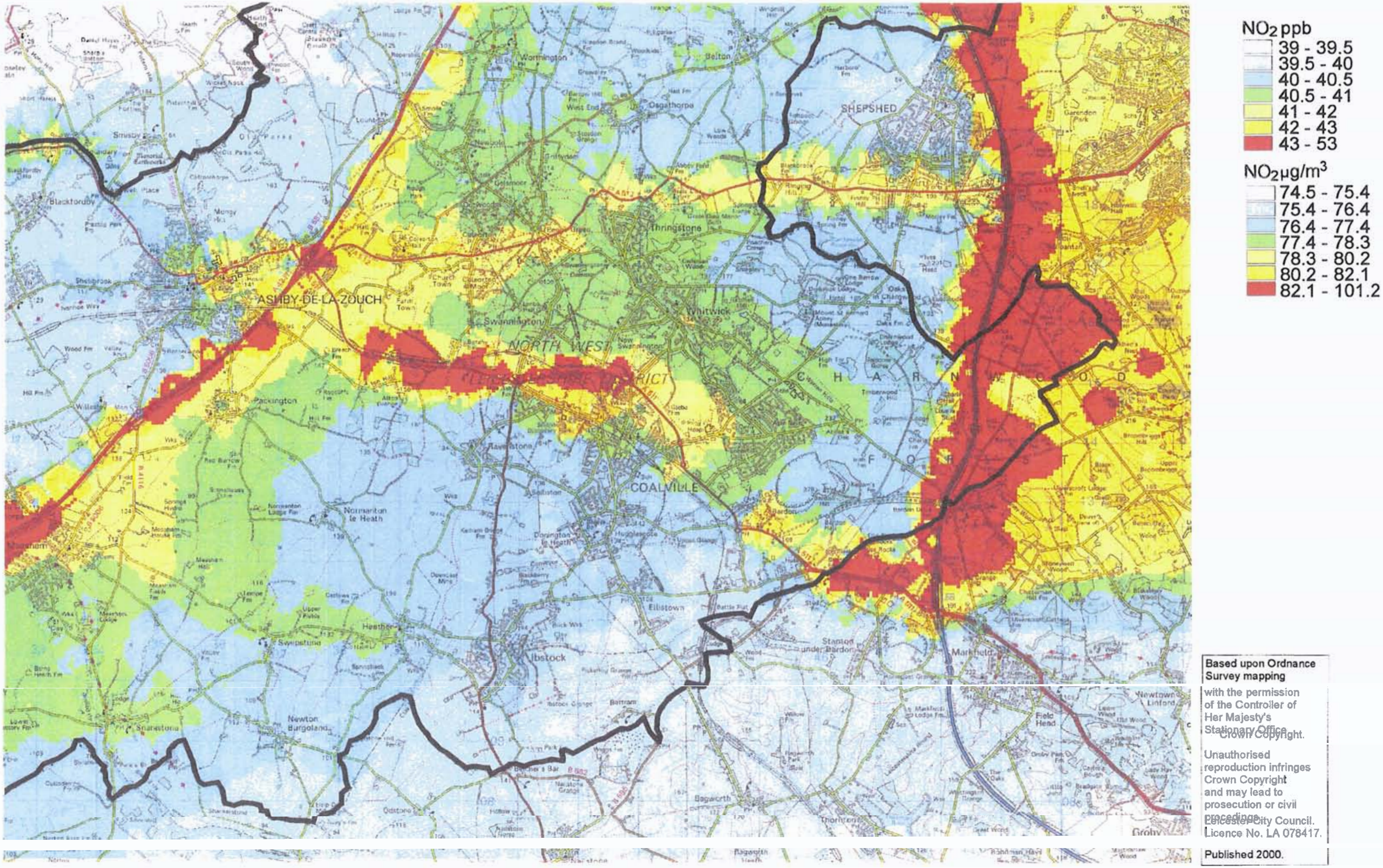
Ashby-De-La-Zouch and surrounding area



Predicted levels of Nitrogen Dioxide in 1998 (Hourly Mean)

Validation correction factor (0.64) applied

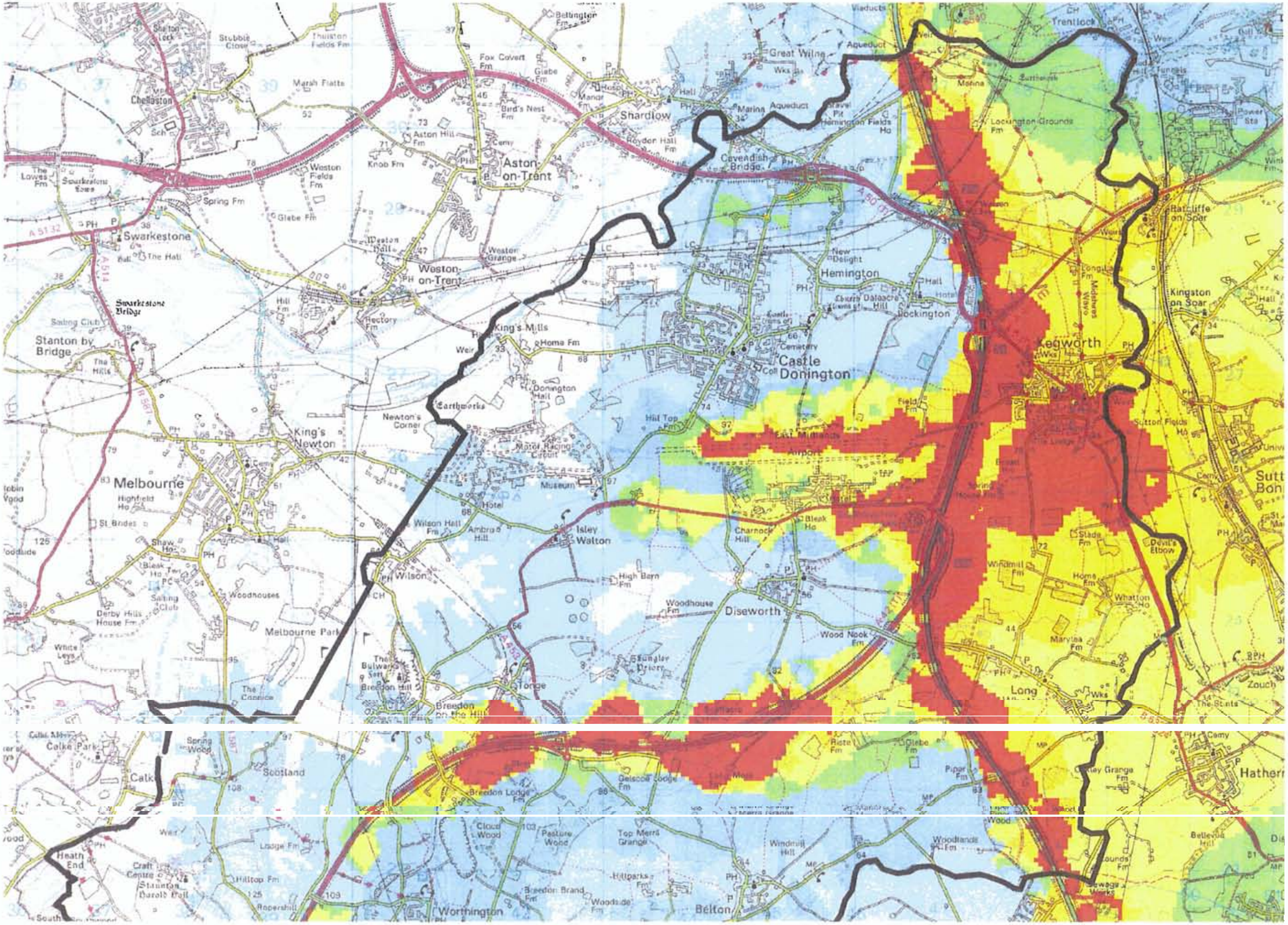
Coalville and surrounding area



Predicted levels of Nitrogen Dioxide in 2005 (Hourly Mean)

North of the District

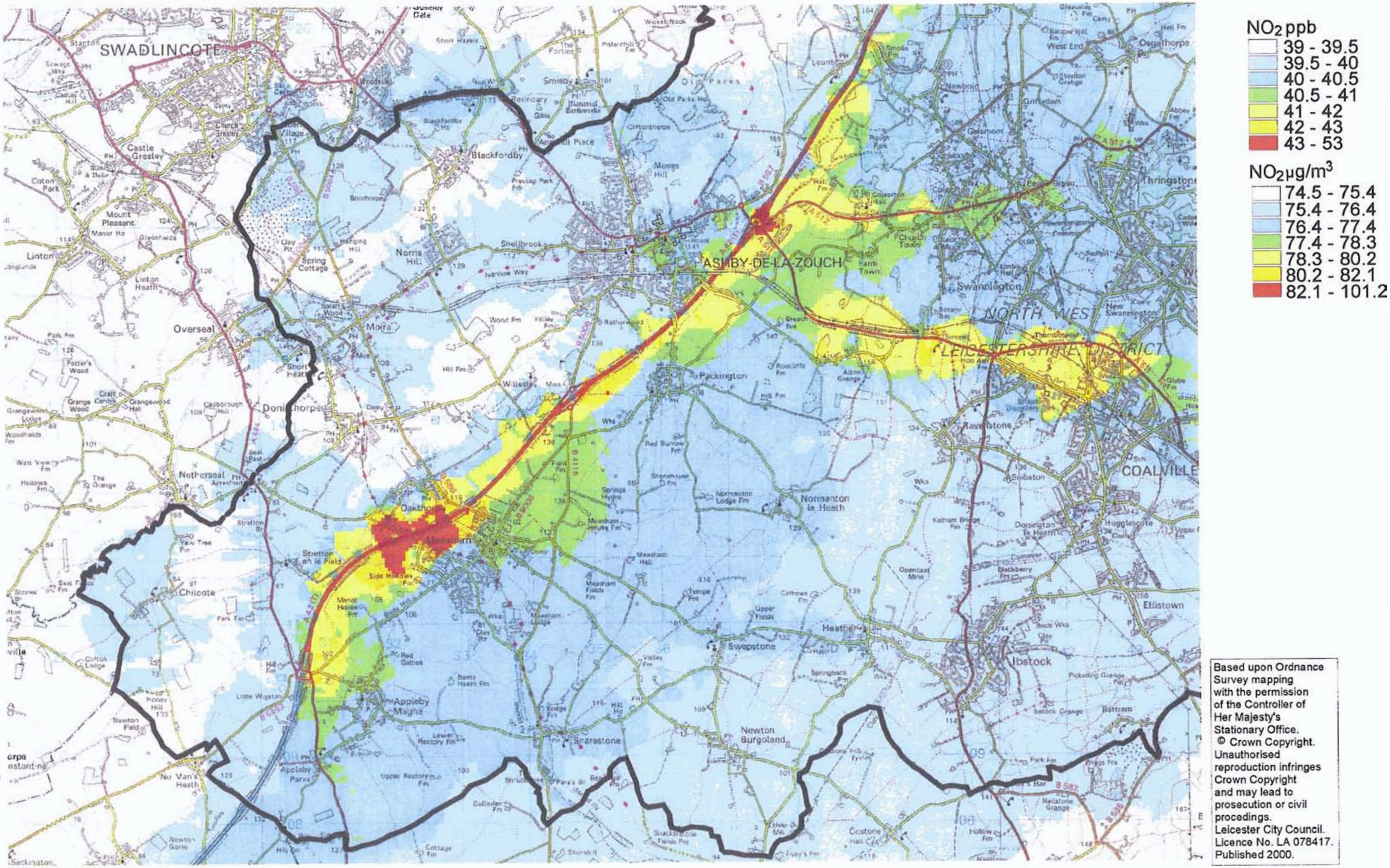
Validation correction factor (0.64) applied



Predicted levels of Nitrogen Dioxide in 2005 (Hourly Mean)

Validation correction factor (0.64) applied

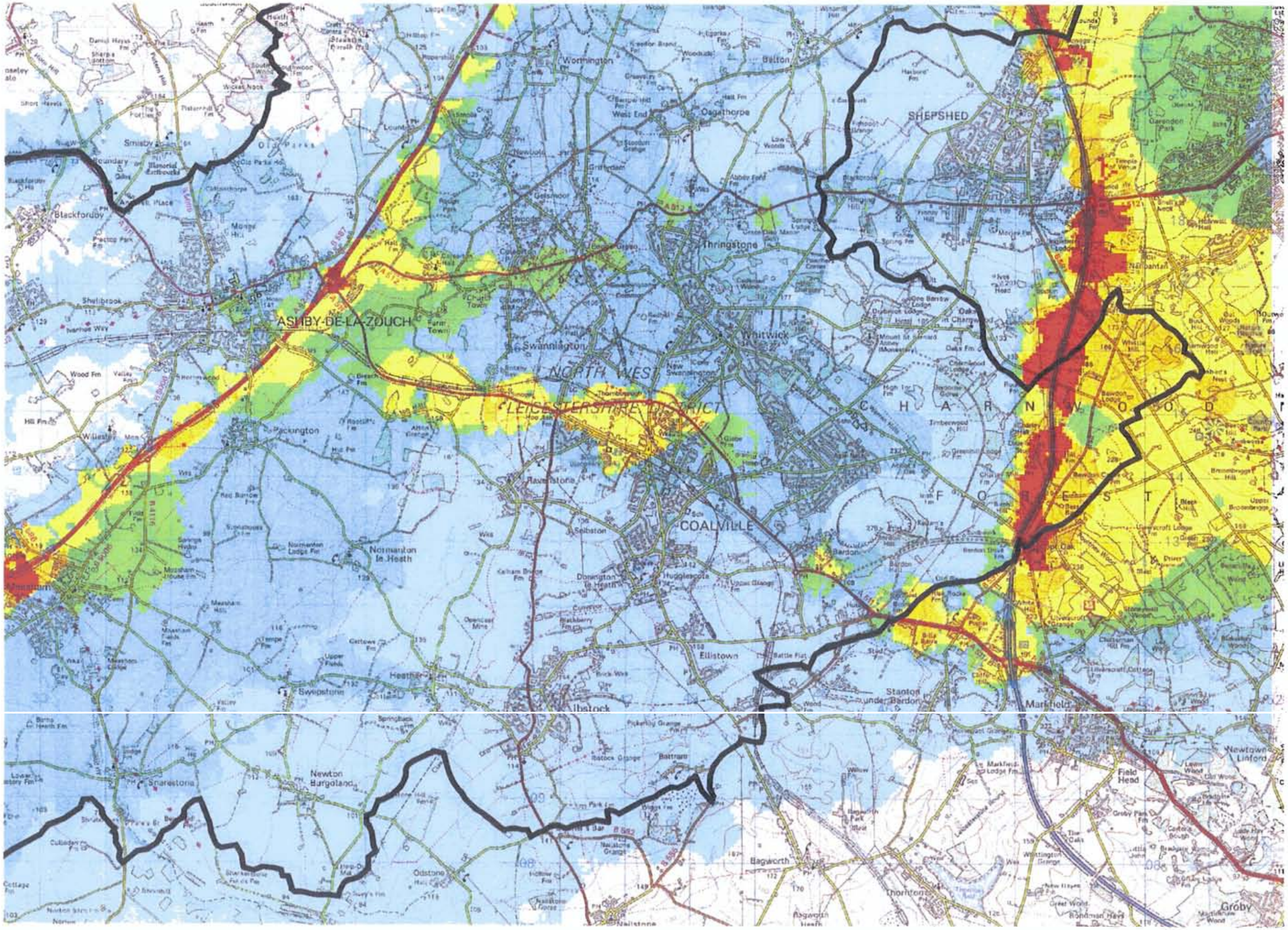
Ashby-De-La-Zouch and surrounding area



Predicted levels of Nitrogen Dioxide in 2005 (Hourly Mean)

Validation correction factor (0.64) applied

Coalville and surrounding area



NO2 ppb

NO2 ppb
39 - 39.5
39.5 - 40
40 - 40.5
40.5 - 41
41 - 42
42 - 43
43 - 53

NO2 µg/m³
74.5 - 75.4
75.4 - 76.4
76.4 - 77.4
77.4 - 78.3
78.3 - 80.2
80.2 - 82.1
82.1 - 101.2

The graph (appendix 8) shows that both models underpredict the 99/00 monitoring results by between 3 and 6ppb. Although both models predict that 2005/6 levels will be lower than 1998/2000 levels at distances of beyond 250m the Council model (data for EMA model not available for these locations) predicts that locations nearer than 300 meters will have higher levels of NO_2 in 2005 than 1998. The model results confirm an expected cross over point as the emissions from the airport are predicted to rise against background emissions (mostly from the surrounding roads) which are predicted to fall. It would appear from the modelling results that this cross over of influence will be at about 250m (perpendicularly) from the runway. Thus locations within 250m of the runway would expect to NO_2 levels to rise and locations beyond 250m would expect levels to have an overall decrease. This point of cross over of influence would be expected to move if rates of change of emission varied. For example if the emissions f[illegible]affic did not fall as quickly as predicted (such as increase in numbers overcompensating [illegible]crease due to less polluting vehicles) then the background influence would be stronger an[illegible]e cross over point nearer to the runway. Or conversely, if the traffic emissions decreased quicker or the airport emissions grew faster than expected, then the influe[illegible]ircraft would spread further from the runway. This is confirmed by the EMA mo[illegible]hi[illegible] predicts that levels on the runway increase from 13-17ppb (2000) to 17-21ppb (2006)[illegible]21-25ppb (2016). Yet, levels on the M1 at junction 24 decrease from 25-29ppb (2000) to 17-19ppb (2006) to 13-17ppb (2016).

As the monitoring results (although crude) suggest that the objective in not currently being met at locations within about 300m of the runway and the modelling results suggest that levels at locations nearer than 250m of the runway are unlikely to decrease, it seems likely that the annual objective for NO_2 will not be met at locations within 250m of the runway in 2005.

Airport Flight Paths

Both models predict a similar decline in predicted ground level concentrations of pollutants with distance from the runway along the take off and landing routes. For example, the point on the B6540 in line with the runway (about 1000m west from the main touch-down/take-off part of the runway, 400m west of the end of the runway) is predicted 13 – 15.5ppb (council model 1998) and <13ppb (EMA model 2000) however a diffusion tube at this point measures 20.0ppb (2000). This again suggests that the model is underpredicting but that at this location the air quality object is currently being met. Similar to locations of this distance but perpendicular to the runway levels are expected to fall by 2005. Again there will be a point of cross over of influence which will vary depending on the length of runway used. The modelling results suggest that this point is likely to be less than 400m from the west end of the runway even by 2016. The East end of the runway has more use but pollutant levels are much more influenced by the M1 however, the modelling results again suggest that the influence of the aircraft emissions will not extend beyond about 400-500m from the end of the runway. Diffusion tube results here again are 20ppb (2000) suggesting that the objective is currently met at these locations. This is further supported by the diffusion tube monitoring at Kegworth, Whatton Road which even with the M1 have levels below the objective (19.8ppb 1999). Similarly, the August 2000 monitoring at Kenilworth House, Kegworth which is directly under the current principal flight path and about 1800m from the end of the runway had a monthly average of 10.1 ppb.

Modelling and even monitoring are not an exact science however, taking a cautionary approach it appears likely the objective for annual mean NO_2 will not be met in 2005 at locations within approximately 400m east and west of the runway.

3.3 Review and Assessment of PM_{10} Particulates

3.3.1 Introduction

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*].

3.3.2 National Trends

Detailed monitoring of PM_{10} has only been carried out for the last few years. however this has indicated that there are widespread breaches of the objective across the UK. However, 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. The revised Objective (to be compliant by the end of 2004) 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).*

The Objective for PM_{10} particulates (revised in early 2000) 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).

However, table 6 (following) shows the predicted national reduction of primary emissions from road transport over the next 25 years.

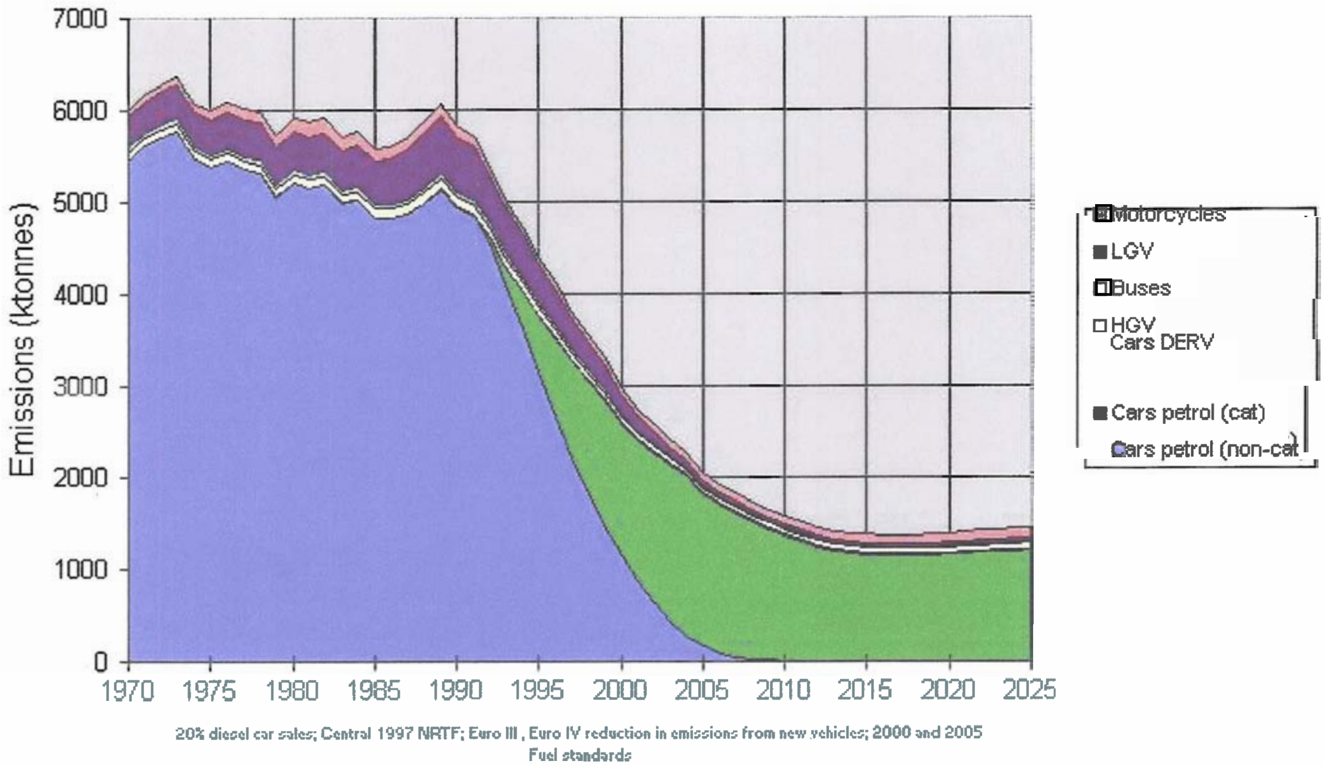


Table 6, UK urban road transport primary emissions of PM10 particulates, 1970 - 2025.

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

3.3.3
Monitoring Results

The monitoring results for the light scatter PM_{10} monitors located in Kegworth (Road Source) and Donisthorpe (opencast mining source) (see section 2.2.3) are shown in Table 6 (following) From chart 4 which compares the two data sets it can be seen that the changes in PM_{10} levels at both the sites are very similar although the levels are generally lower in Donisthorpe. Considering that there are some 20km between the 2 sites it would appear that local sources of PM_{10} are not significant in determining overall levels. It is likely that secondary particulates and/or wind direction are the dominant factors in determining overall levels of PM_{10} at these locations. The road source 2m from the monitor at Kegworth may be adding to the background levels but would be unlikely to be more than 9µg/m^{-3} (the lowest reading where the normal weekday traffic source has been present). The 1.3 correction factor should be applied as the monitor uses a heated inlet and filter, however this factor should be used with caution for this instrument as it was designed mainly for the gravimetric methods of sampling. There has also been recent debate as to use of this factor as latest research shows that the relationship between gravimetric and TEOM measuring methods depends on site location and season. However, using this correction factor means that there is currently an exceedance of both the daily and annual objective at the Kegworth Site whereas there is no exceedance when the correction factor is not applied. . .

Location	Annual Average µg/m³	Annual Average µg/m³ (Corrected by 1.3)	No. of exceedances of the daily objective per year	No. of exceedances of the daily objective per year (Corrected by 1.3)
Kegworth (Road Source) 1999/2000	31.3	40.6	32	80
Donisthorpe 2000 (6 mo.) Data	18.0	23.2	5	12

Table 4 PM_{10} Monitoring Results.

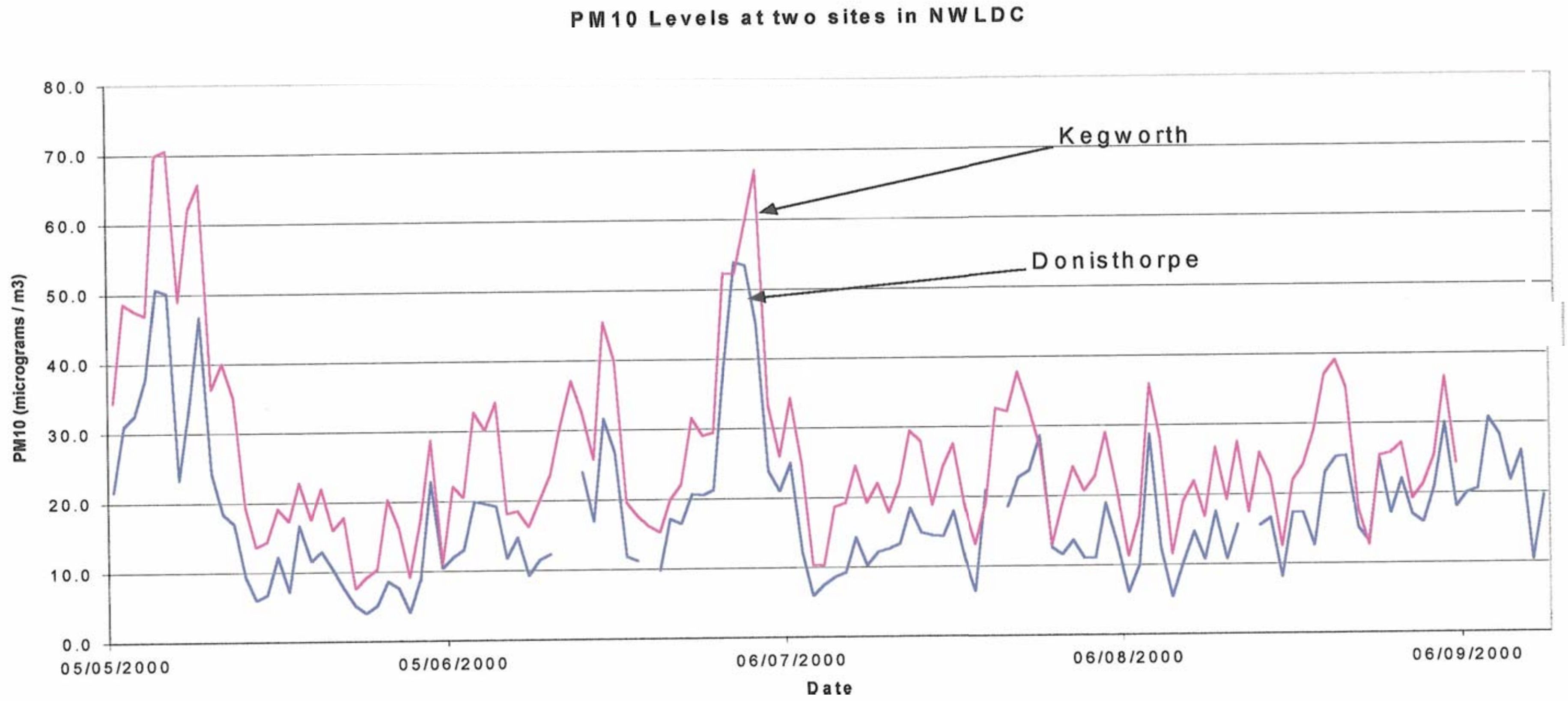
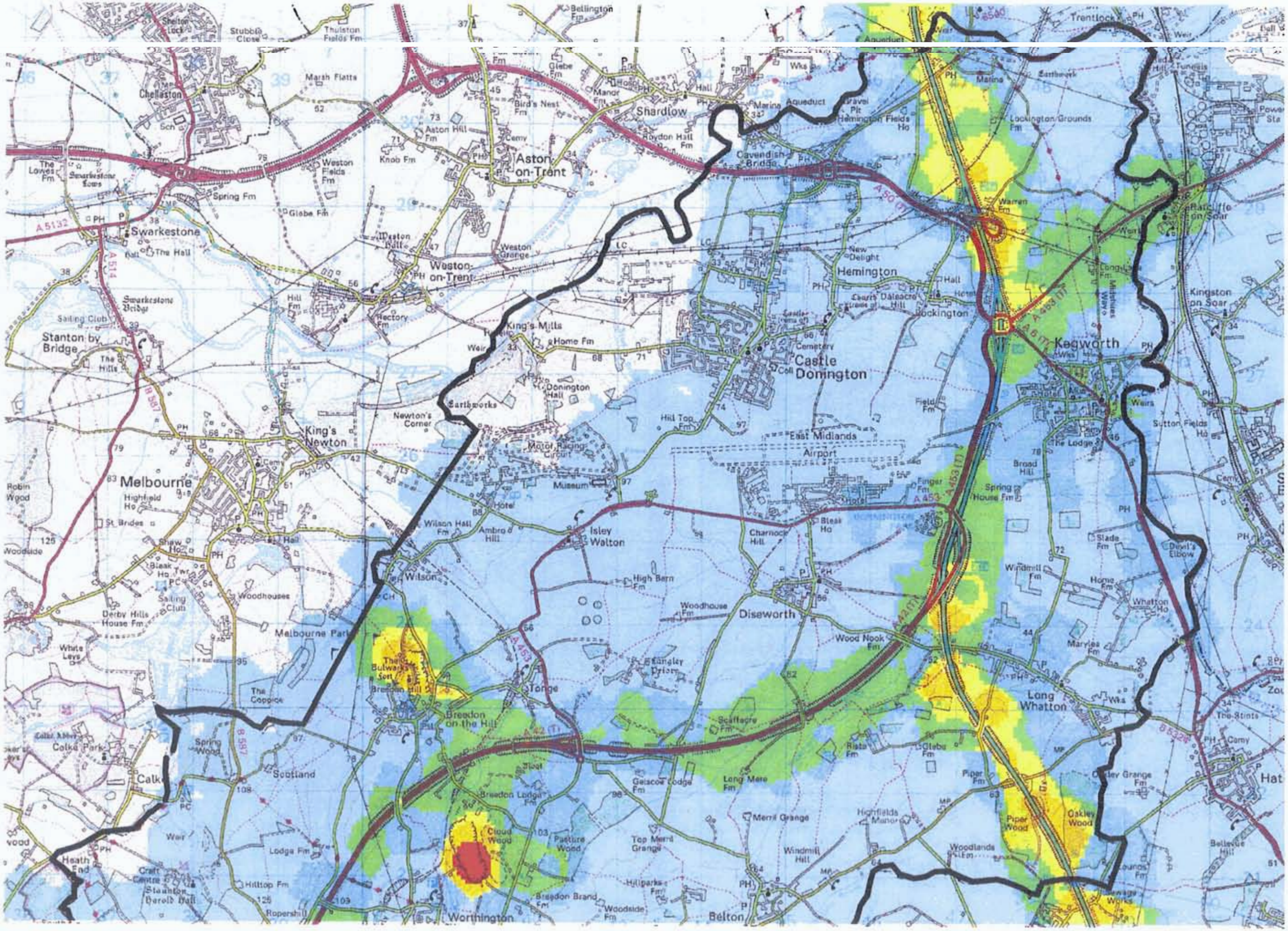


Chart 2 Comparison of PM_{10} levels at Kegworth and Donisthorpe.

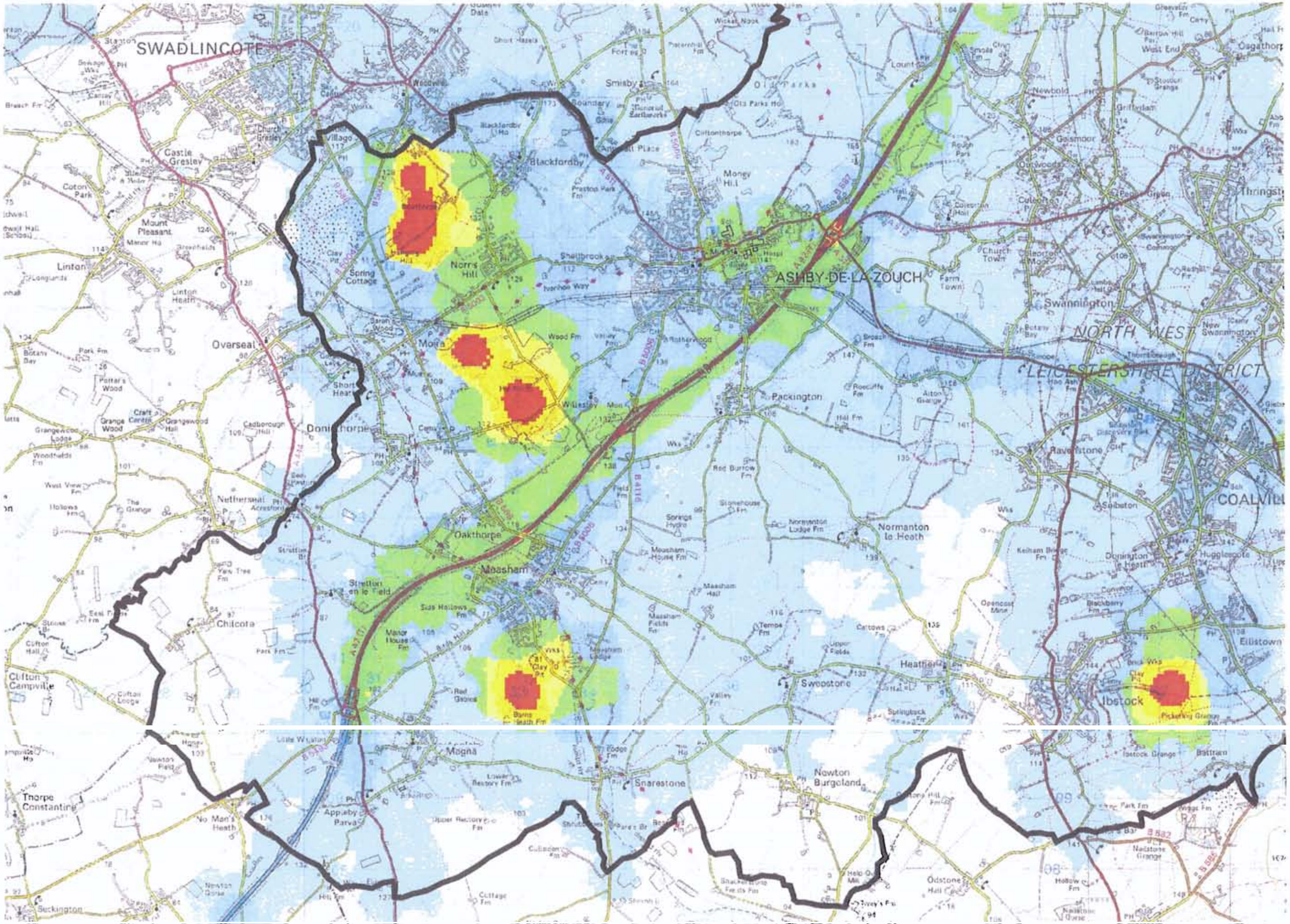
Predicted levels of PM10 Particulates in 1998 (Annual Mean) **North of the District**



PM$_{10}$ µg/m^3

- 29 - 30
- 30 - 30.5
- 30.5 - 31
- 31 - 33
- 33 - 35
- 35 - 40
- 40 - 55

Predicted levels of PM10 Particulates in 1998 (Annual Mean) **Ashby-De-La-Zouch and surrounding area**

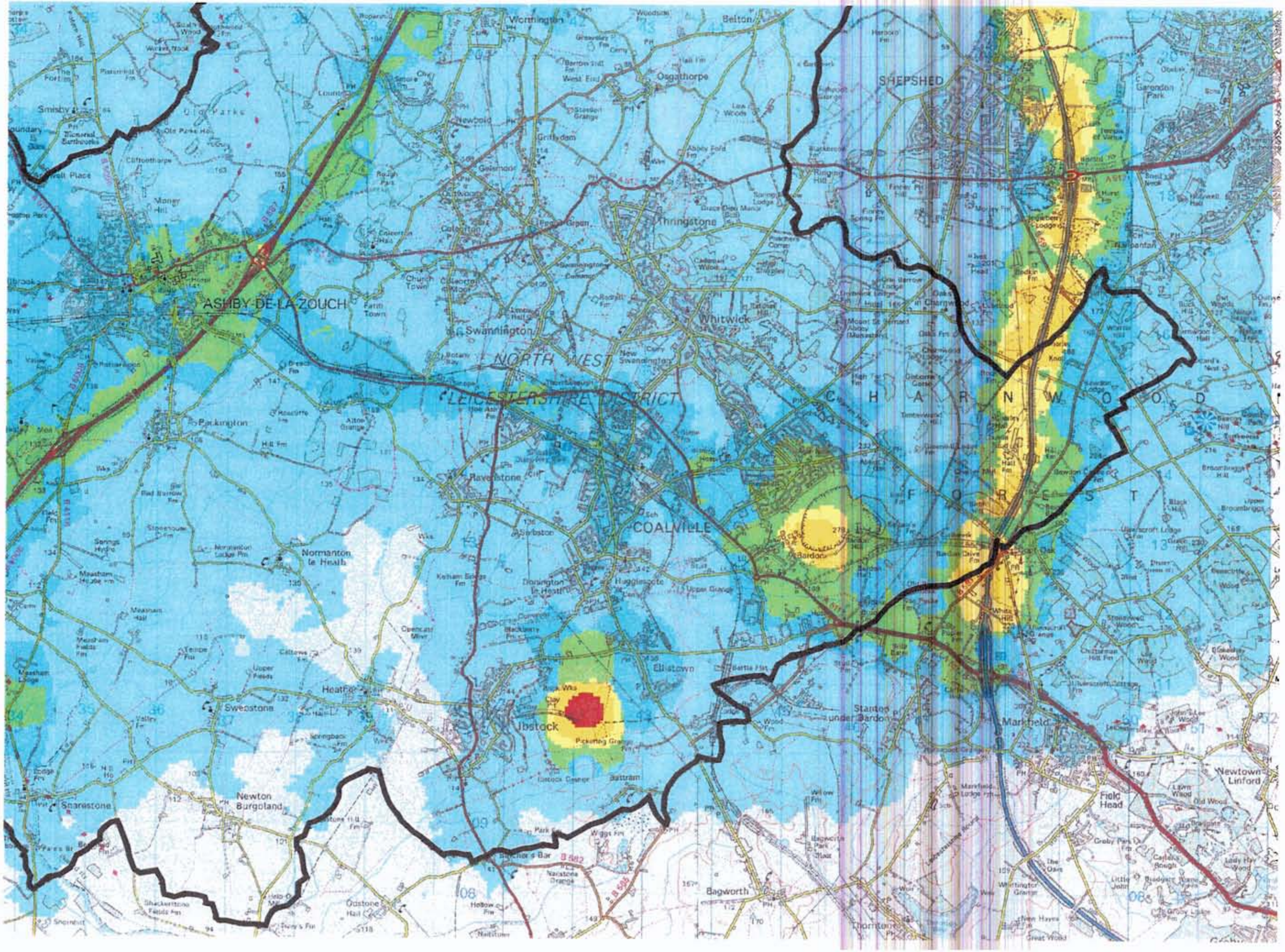


PM $_{10}$ µg/m ^{3}

- 29 - 30
- 30 - 30.5
- 30.5 - 31
- 31 - 33
- 33 - 35
- 35 - 40
- 40 - 55

Predicted levels of PM10 Particulates in 1998 (Annual Mean)

Coalville and surrounding area

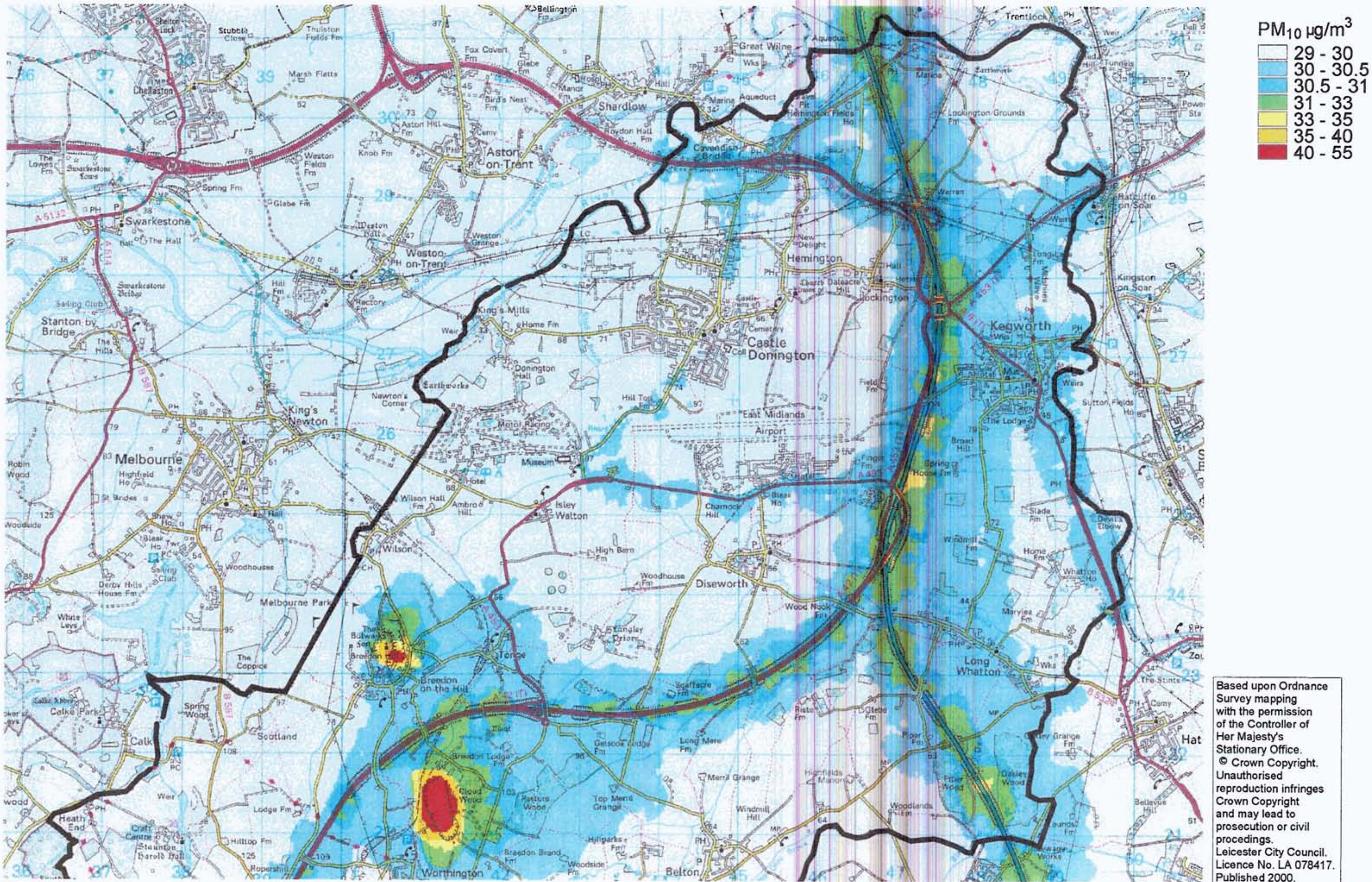


PM_{10} µg/m³

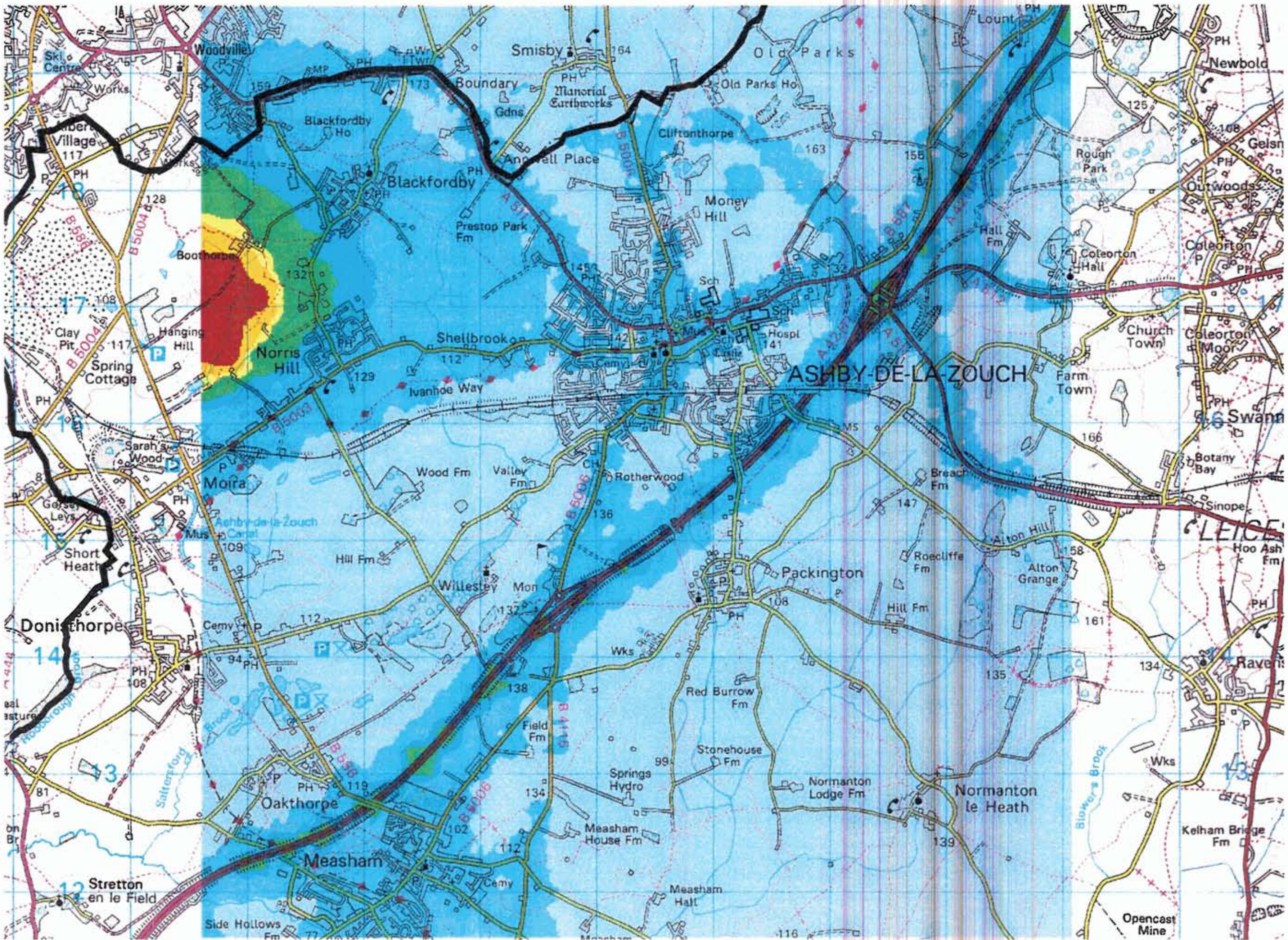
- 29 - 30
- 30 - 30.5
- 30.5 - 31
- 31 - 33
- 33 - 35
- 35 - 40
- 40 - 55

Predicted levels of PM10 Particulates in 2005 (Annual Mean)

North of the District



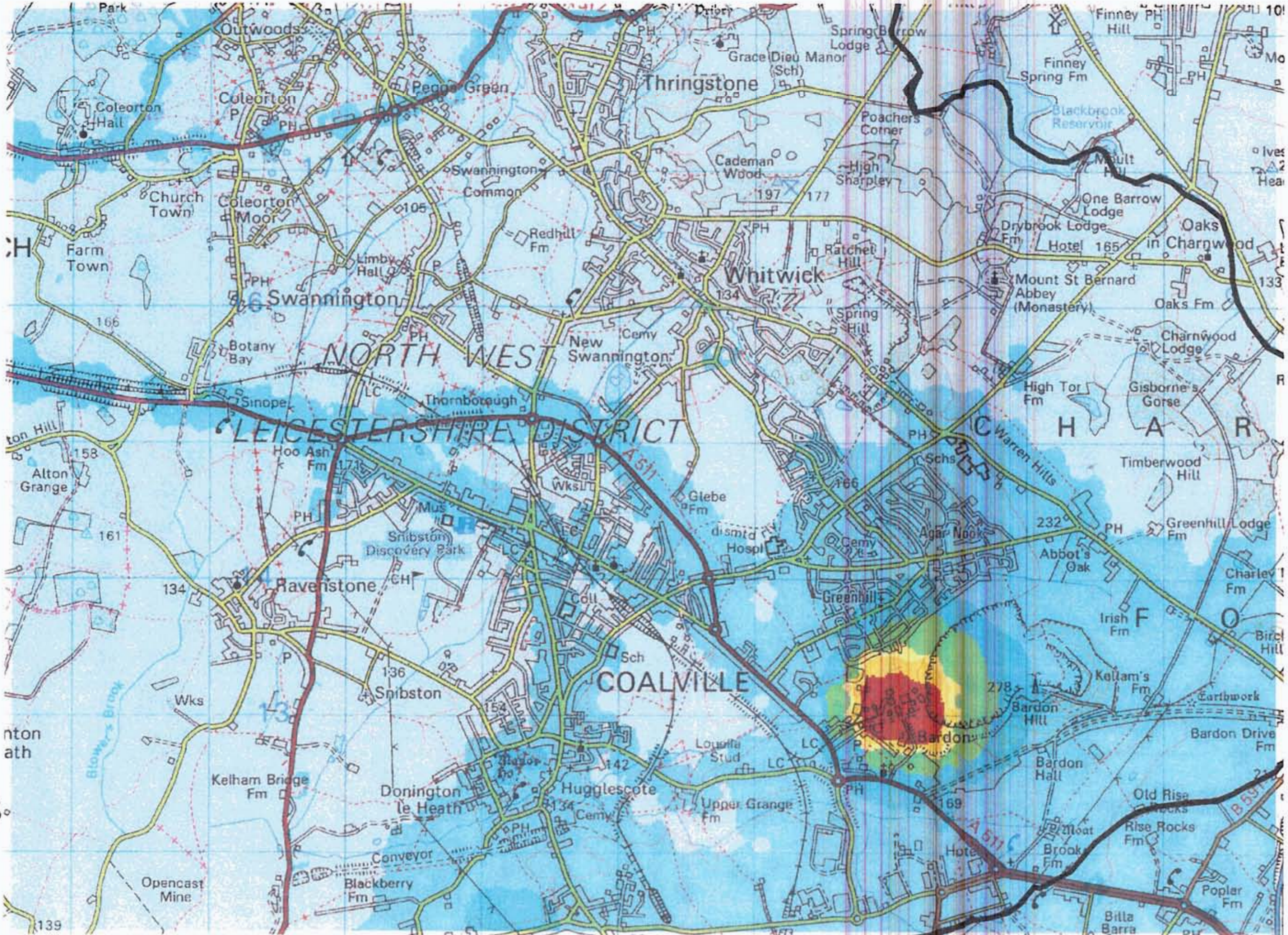
Predicted levels of PM10 Particulates in 2005 (Annual Mean) Ashby-De-La-Zouch and surrounding area



PM$_{10}$ µg/m^3

- 29 - 30
- 30 - 30.5
- 30.5 - 31
- 31 - 33
- 33 - 35
- 35 - 40
- 40 - 55

Predicted levels of PM10 Particulates in 2005 (Annual Mean) **Coalville and surrounding area**



PM$_{10}$ µg/m^3

- 29 - 30
- 30 - 30.5
- 30.5 - 31
- 31 - 33
- 33 - 35
- 35 - 40
- 40 - 55

3.3.4 Modelling Results

The contour plots from the modelling for annual average PM_{10} can be seen on pages (64 - 69). Due to the problems with validation of the model the predicted concentration values should be considered with caution. However, the model does show the typical annual spread of the pollutant especially from quarries. The raw output of the model predicts exceedances of the objective surrounding the mineral extraction sites but not extending to residential areas.

3.3.5 Discussion of the Results

Road Sources

The uncertainties associated with the modelling would means that although the model underestimates, predictions could not be made on levels of PM_{10} in 2005 with a reasonable degree of confidence. However, the monitor at Kegworth could be said to be in a 'worst case' location and represent the majority of roads in the district except the M1 and M42. As the results from this monitor are currently only above the objective with the 1.3 correction applied and PM_{10} emissions from traffic are predicted to significantly decline then it is unlikely that the objective will be breached at this location due to local emissions in 2005. The M1 and A42 both have a similar spread of PM_{10} predicted by the model as for NO_2. Therefore although there is not sufficient evidence to declare Air Quality Management Areas for PM_{10} it is likely that any areas where PM_{10} levels are above the objective in 2005 (due to traffic sources) will already be included in Air Quality Management areas for NO_2.

Mineral Extraction Sources

Hick Lodge open cast coal mine near Donisthorpe is typical of the mineral extraction sites in the district except for Bardon Quarry. As the objective is not presently exceeded at Donisthorpe (within 200m of the mining operations) it is unlikely that the objective will not be met at locations in the vicinity of mineral extraction sites in 2005 unless there is significant new development (none of which is planned). This is confirmed by the model which only shows exceedances of the objective within the immediate vicinity of the quarries. Although Bardon Quarry is likely to be a significant source of PM_{10} (especially as the council continues to receive complaints regarding dust, allegedly from this source) the developments outlined in section 2.2.3 will mean that it is likely that the objective will be met by 2005 at residential locations neighbouring the quarry. However, in early 2001 a PM_{10} monitor similar to the monitors at Kegworth and Donisthorpe will be installed on the Bardon Quarry site perimeter to confirm this.

3.4 Review and Assessment of Sulphur Dioxide

3.4.1 Introduction

Sulphur dioxide (SO_2) is a soluble gas consisting of one sulphur and two oxygen atoms. On dissolving in water it gives rise to an acidic solution of sulphuric acid.

The principal source of SO_2 is the electricity generating power stations (67%) followed by other industrial combustion plant - in particular refineries and iron and steel processes. Domestic sources of SO_2 can be significant in areas where there is still extensive use of solid fuel fires.

Sulphur dioxide gives rise to concerns due to its local and global effect. Trans-national transport of SO_2 in the atmosphere followed by its dry and wet deposition ("acid rain") has accounted for deforestation and lake acidification in continental Europe. In terms of its local effects the acidic nature of dissolved SO_2 causes irritation to lung tissue and may provoke attacks of asthma. The onset of clinical effects upon exposure can be very rapid.

In considering the desirable Air Quality Standards for SO_2 EPAQS took consideration of the rapid onset of symptoms and considered that exposure should be considered over 15 minute averaging periods. A concentration of below 100 ppb was considered unlikely to have significant health effects in humans. This has been calculated to be comparable to an annual 98th percentile of daily values of 19 ppb or a maximum daily average of 28 ppb. Following the review of the National Air Quality Strategy in 1999 the daily mean objective was set at 46.8 ppb (125 $\mu g/m^{-3}$) not to be exceeded more than 3 times per year by 31 Dec 2004.

The EU air quality daughter directive also specifies a 15 minute averaging period with a limit of 100 ppb (267 $\mu g/m^{-3}$).

3.4.2 National Trends

The move throughout the middle part of the century to relocate heat and power raising sources from multiple small, solid fuel fired units (e.g. domestic coal fires and solid fuel boilers) to large, rural, closely controlled sources (e.g. power stations) has dramatically decreased ground level SO_2 concentrations in the UK. Ever since 1970 there has been a 63% decrease in total SO_2 emissions. The risk of exceedances of the National Air Quality Standard for SO_2 is therefore greatly dependent upon the influence of individual local combustion sources and the type of fuel used.

3.4.3 Monitoring Results

The results of the 3 Sulphur Dioxide Bubblers and automatic monitoring stations are shown are shown in table 8 below.

Location	Coalville, Council Offices (Jan-Dec 1999)	Castle Donington, Parish Council (Mar–Oct 2000)	Moira, Woulds Court (Mar-Oct 2000)	Kegworth, Kenilworth House (August 2000)	Weston-on-Trent Automatic Apr 98-Mar 99
Maximum Daily Average ($\mu g/m^{-3}$)	32	61	48		
Mean Daily average ($\mu g/m^{-3}$) (specified period)	14.0	16.6	22.4	3.2	8.8
No of days above maximum daily 125 $\mu g/m^{-3}$	0	0	0		
Maximum hourly mean ($\mu g/m^{-3}$) (specified period)				90.7	843
No of hours above maximum hourly 350 $\mu g/m^{-3}$				0	7

Table 8. Summary of SO_2 monitoring results.

Table 8 shows that of the semi-autimatic bubblers the highest daily averages are recorded at Castle Donington yet the overall highest results (mean of daily averages) are recorded at Moira. However there are currently no exceedances of the daily or hourly objectives for SO_2 at any of the locations.

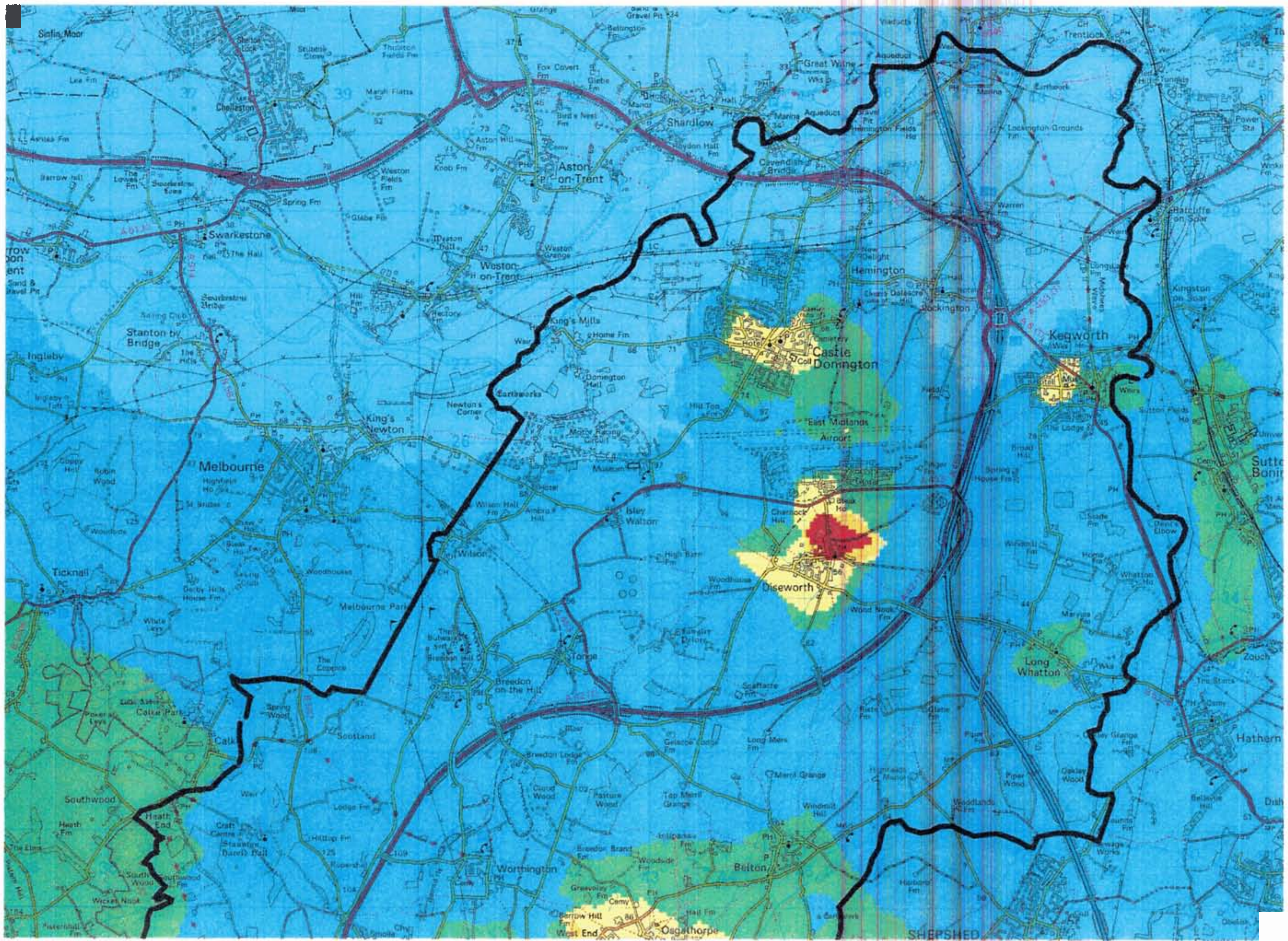
3.4.4 Modelling Results

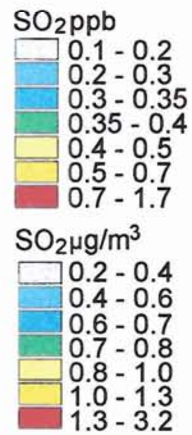
Contour plots on pages 73 to 78 show the results of the modelling as annual mean concentration with the 0.347 validation factor applied. When the model was used to predict worst case hourly means, the contour plots showed classic plume traces from either of the power stations (depending on wind direction). These have not been included in this report as the dependency on wind direction meant that they were unrepresentative of typical conditions. However for the point locations the hourly and annual results are shown in $\mu g/m^3$ (with and without the validation factor applied) in table 9 below.

Predicted levels of Sulphur Dioxide in 1998 (Annual Mean)

North of the District

Validation correction factor (0.347) applied

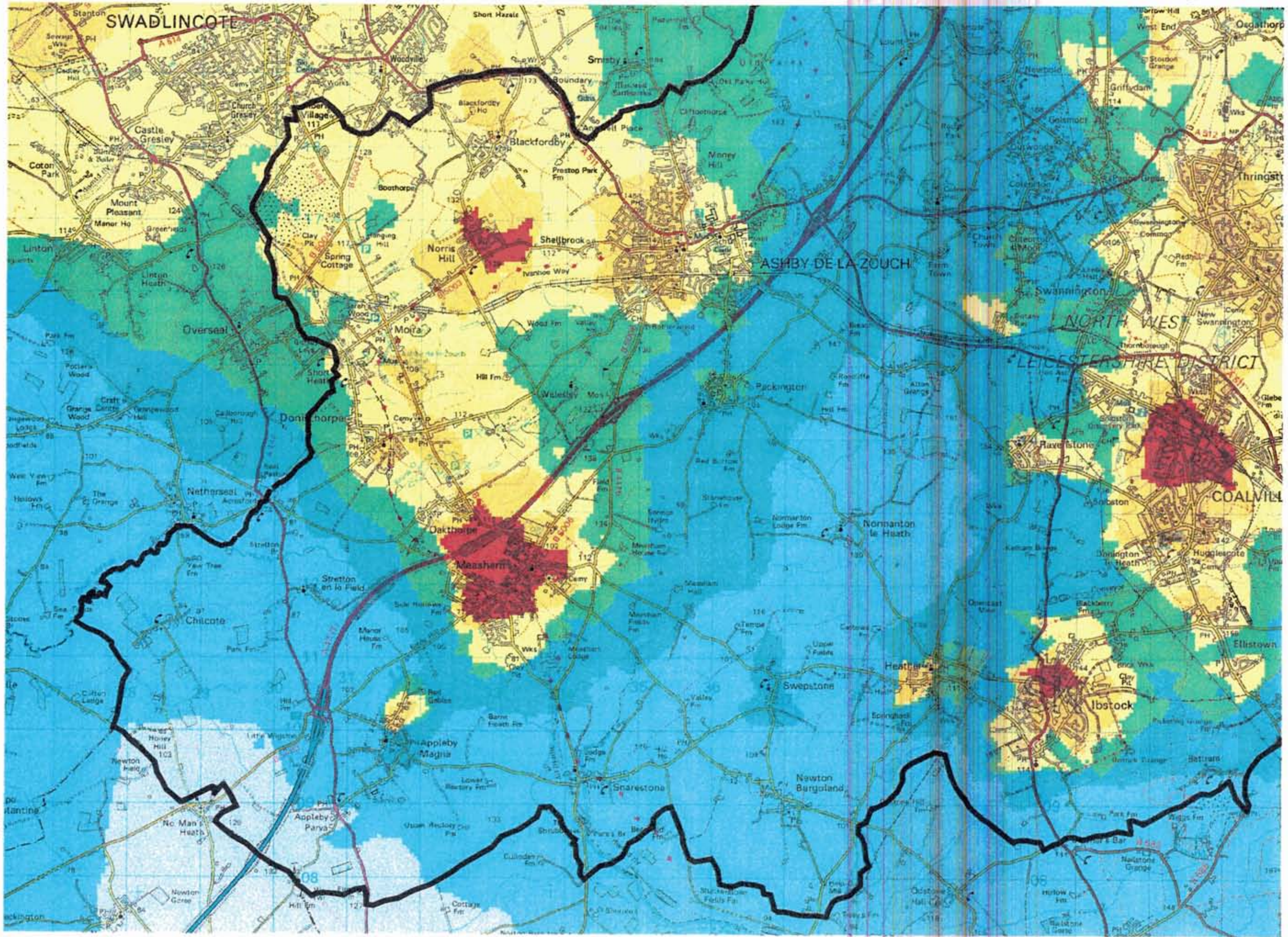




Predicted levels of Sulphur Dioxide in 1998 (Annual Mean)

Validation correction factor (0.347) applied

Ashby-De-La-Zouch and surrounding area



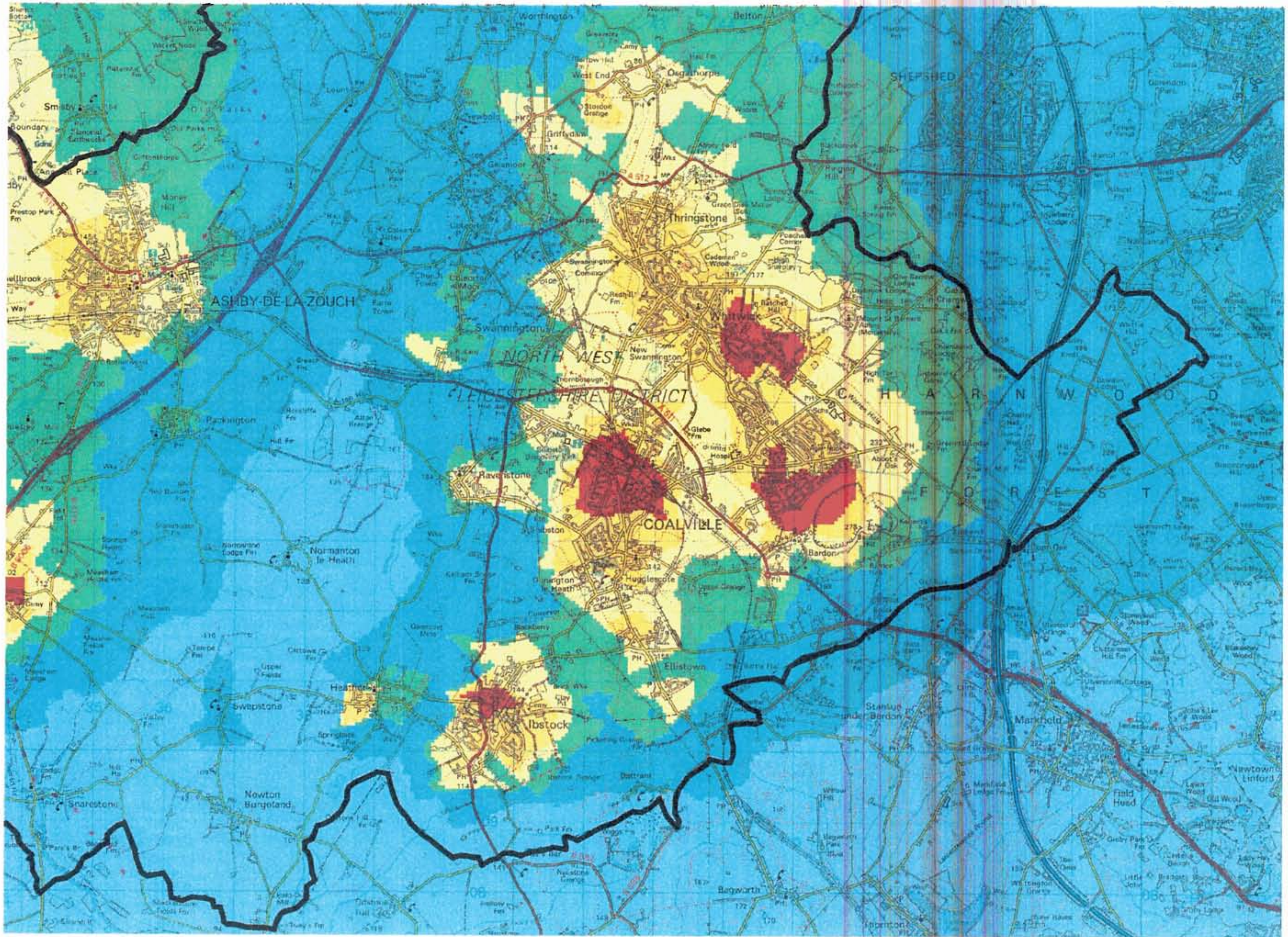
SO_2 ppb
0.1 - 0.2
0.2 - 0.3
0.3 - 0.35
0.35 - 0.4
0.4 - 0.5
0.5 - 0.7
0.7 - 1.7

SO_2 µg/m^3
0.2 - 0.4
0.4 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 1.0
1.0 - 1.3
1.3 - 3.2

Predicted levels of Sulphur Dioxide in 1998 (Annual Mean)

Validation correction factor (0.347) applied

Coalville and surrounding area



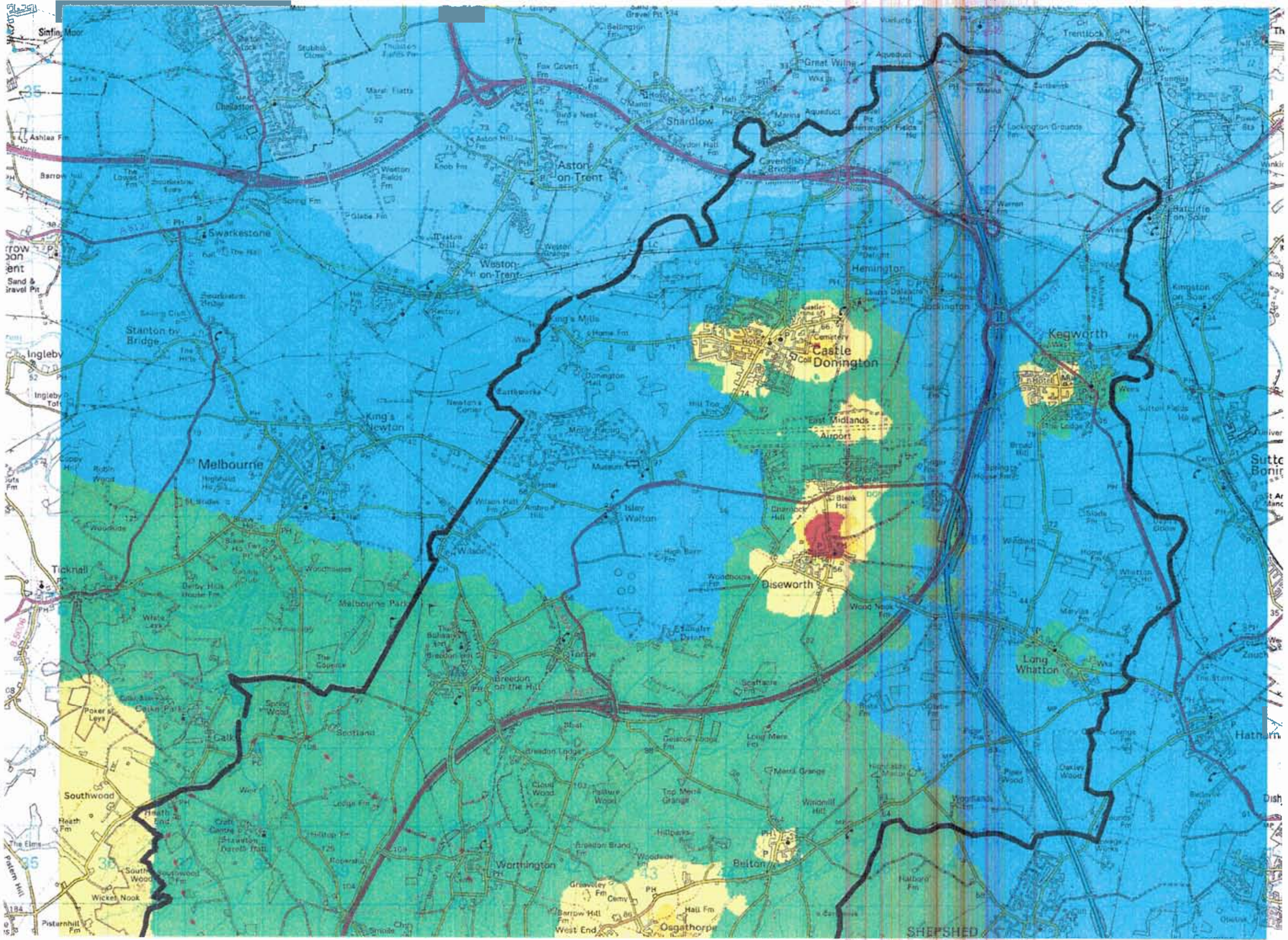
SO_2 ppb
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.35
- 0.35 - 0.4
- 0.4 - 0.5
- 0.5 - 0.7
- 0.7 - 1.7

SO_2 $\mu g/m^3$
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 1.0
- 1.0 - 1.3
- 1.3 - 3.2

Predicted levels of Sulphur Dioxide in 2005 (Annual Mean)

North of the District

Validation correction factor (0.347) applied



SO2 ppb

- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.35
- 0.35 - 0.4
- 0.4 - 0.5
- 0.5 - 0.7
- 0.7 - 1.7

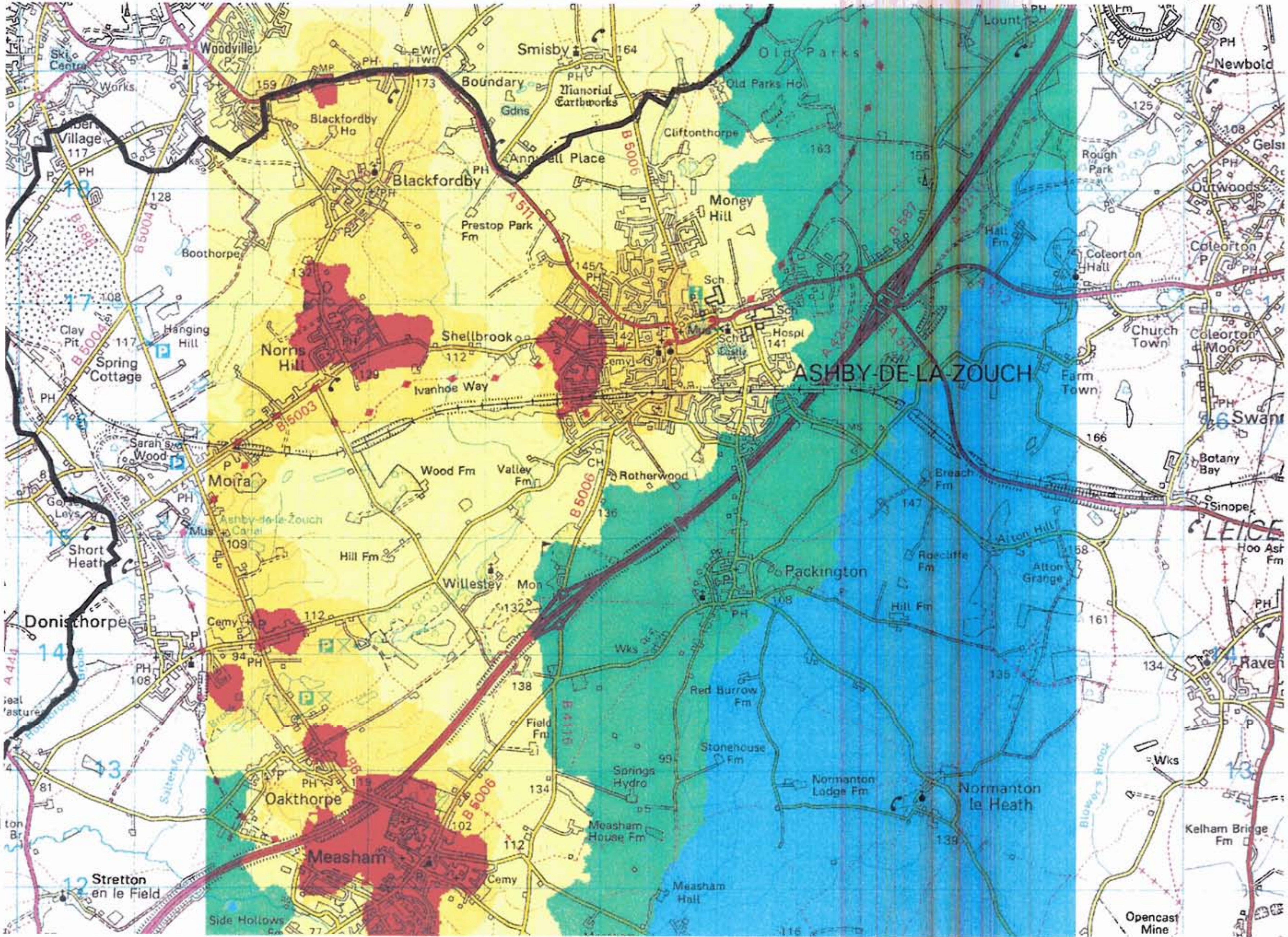
SO2 µg/m3

- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 1.0
- 1.0 - 1.3
- 1.3 - 3.2

Predicted levels of Sulphur Dioxide in 2005 (Annual Mean)

Validation correction factor (0.347) applied

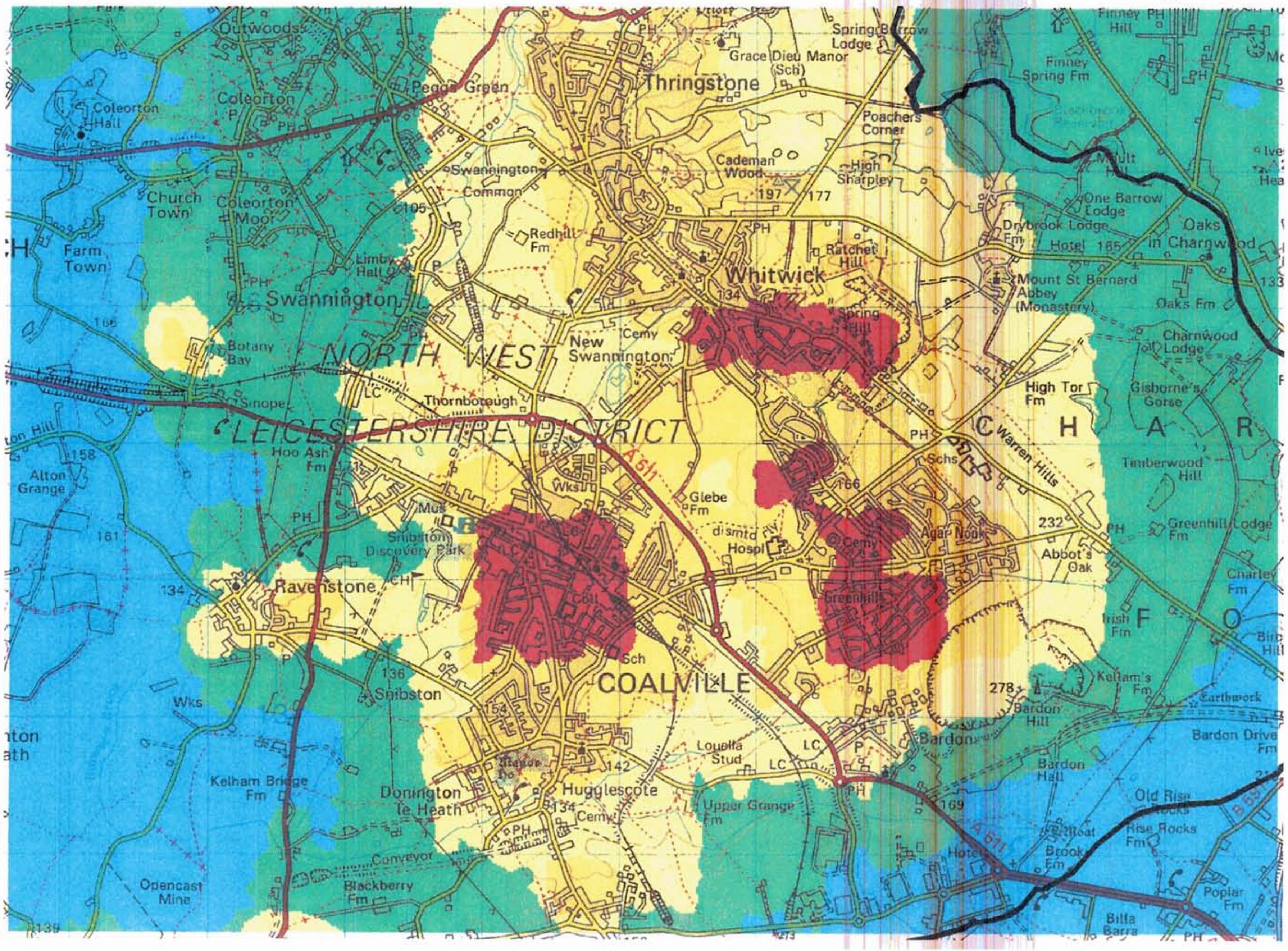
Ashby-De-La-Zouch and surrounding area



Predicted levels of Sulphur Dioxide in 2005 (Annual Mean)

Validation correction factor (0.347) applied

Coalville and surrounding area



SO$_2$ ppb
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.35
- 0.35 - 0.4
- 0.4 - 0.5
- 0.5 - 0.7
- 0.7 - 1.7

SO$_2$ µg/m^3
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 1.0
- 1.0 - 1.3
- 1.3 - 3.2

North West Leicestershire SO_2 Modelling Results (all $\mu g/m^3$)

	1998								2005							
	Raw Data					0.35 Correction Factor Applied			Raw Data					0.35 Correction Factor Applied		
Location	Annual Mean	Max Hourly	Max Daily	Number of hours >350 $\mu g/m^3$	Number of days >125 $\mu g/m^3$	Annual Mean	Max Hourly	Max Daily	Annual Mean	Max Hourly	Max Daily	Number of hours >350 $\mu g/m^3$	Number of days >125 $\mu g/m^3$	Annual Mean	Max Hourly	Max Daily
Keg A6 (NO_2)	6.4	1258.8	66.8	4	0	2.2	436.8	23.2	4.8	95.0	28.7	0	0	1.7	33.0	10.0
Keg A6 (Pm_{10})	5.7	1531.2	75.2	4	0	2.0	531.3	26.1	4.0	91.5	28.2	0	0	1.4	31.8	9.8
Ashby A42	6.6	753.5	155.4	27	1	2.3	261.5	53.9	3.7	114.9	20.1	0	0	1.3	39.9	7.0
Ashby Mkt St.	7.4	733.1	151.8	26	1	2.6	254.4	52.7	4.5	113.3	32.2	0	0	1.6	39.3	11.2
Diseworth Sch.	8.5	498.9	91.8	8	0	3.0	173.1	31.9	6.8	97.1	27.3	0	0	2.4	33.7	9.5
C/Don Hilltop	5.1	467.3	87.8	7	0	1.8	162.2	30.5	3.5	93.8	21.5	0	0	1.2	32.6	7.5
M1 Long Whatt.	5.5	553.7	81.7	9	0	1.9	192.1	28.4	3.6	91.5	27.7	0	0	1.3	31.8	9.6
C/Don Stonehill	5.6	464.3	85.2	7	0	1.9	161.1	29.6	4.0	94.5	22.5	0	0	1.4	32.8	7.8
Keg Whatt Rd	5.3	1072.6	68.9	4	0	1.9	372.2	23.9	3.7	94.0	28.1	0	0	1.3	32.6	9.8
Wilson	5.2	495.7	106.8	11	0	1.8	172.0	37.1	3.4	91.7	26.1	0	0	1.2	31.8	9.0
Ashby Marl	4.2	93.2	31.8	0	0	1.4	32.4	11.0	4.3	109.4	38.5	0	0	1.5	38.0	13.4
Boundary	4.6	123.0	30.6	0	0	1.6	42.7	10.6	4.8	153.8	36.8	0	0	1.7	53.4	12.8
Norris Hill	12.7	134.7	31.0	0	0	4.4	46.8	10.8	12.8	163.1	35.6	0	0	4.4	56.6	12.4
Measham	6.3	95.5	27.2	0	0	2.2	33.2	9.5	6.3	114.7	30.9	0	0	2.2	39.8	10.7
Ibstock	6.4	100.7	34.8	0	0	2.2	34.9	12.1	6.3	110.4	32.2	0	0	2.2	38.3	11.2
C/V Belvoir	6.8	111.1	32.6	0	0	2.4	38.5	11.3	6.7	89.1	30.5	0	0	2.3	30.9	10.6
C/V Jackson	6.8	110.1	32.7	0	0	2.4	38.2	11.3	6.7	87.4	30.5	0	0	2.3	30.3	10.6
C/V Council Off	6.4	107.7	32.0	0	0	2.2	37.4	11.1	6.3	87.3	29.8	0	0	2.2	30.3	10.4
C/V Oxford	5.8	103.2	32.4	0	0	2.0	35.8	11.3	5.6	85.2	30.2	0	0	2.0	29.6	10.5
C/V Abbotts	5.9	93.1	32.0	0	0	2.0	32.3	11.1	5.7	83.0	30.1	0	0	2.0	28.8	10.4
C/V Bardon	5.0	96.2	35.0	0	0	1.7	33.4	12.1	4.8	87.6	32.9	0	0	1.7	30.4	11.4

From table 9 it can be seen that even without the 0.35 validation factor applied, none of the locations are predicted to exceed the hourly or daily objectives in 2005. The 2 locations that have predicted exceedances of the objectives in 1998 are both close to major roads and predicted levels fall below the limit reduced with the validation factor applied.

3.4.5 Discussion

Emissions from the power stations may be the cause of peak levels in rural locations such as Weston-on-Trent and Castle Donington and the domestic coal burning is likely to cause the elevated mean levels in locations such as Moira. However, both the monitoring and modelling results suggest that there will be no exceedances of the objectives in 2005 and therefore there air quality management areas will not be required due to this pollutant.

There is still some concern regarding domestic coal burning. Studies based on a housing estate in Rugeley where a high proportion of domestic coal burning overlaps with power station emissions show that at a very small scale (within one or two meters from individual chimneys) there is likely to continue to be exceedances despite levels well within the objectives further away from the chimneys. However, the National Air Quality Strategy is designed to manage ambient air quality and is the best approach for this type of problem. It would be unreasonable to declare each coal burning household as an air quality management area.

4. Conclusions

4.1 Main Conclusions

4.1.1 Lead

The concerns with lead outlined by the Stage 1 review were with the area in the vicinity of Midland Lead Manufacture Ltd. (within South Derbyshire District). The report from South Derbyshire District Council has predicted "that it will be unlikely that the air quality objective for lead will be breached in the vicinity of Midland Lead." It is concluded that it would not be justified to designate an Air Quality Management Area in respect of lead.

4.1.2 Particulate Matter (PM_{10})

PM_{10} monitors sited on the A6 in Kegworth (traffic source) and at Donisthorpe School (Coal extraction source) show that the air quality standard is currently not exceeded. The results of the modelling show that although there may be some exceedances of the objective in 2005 these should only be within the immediate vicinity of the quarries and open cast coal mines as this assessment does not include consideration for occupational exposure. Uncertainties in the model validation give difficulties in predicting roadside PM_{10} levels so although there are no recommendations for Air Quality Management Areas for PM_{10}.any possible roadside exceedances of the objective are likely to be contained within air quality management areas for NO_2.

4.1.3 Sulphur Dioxide (SO_2)

The major sources of SO_2 are from the Power Stations and domestic coal burning. The Environment Agency has issued revised authorisations that will ensure that emissions from power stations alone will not cause an exceedance to the air quality objectives. This district has a high bituminous coal use as a legacy of past coal mining and there are no smoke control areas. The main concerns have been with the combination of high domestic coal burning in the vicinity of the power stations. However the modelling results predict no exceedances of the objectives in 2005 in these areas and the monitoring sites currently show levels well below the daily average. Therefore there will be no recommendations for Air Quality Management Area's due to SO_2.

4.1.4 Nitrogen Dioxide (NO_2)

The major sources of NO_2 are from combustion including traffic and aircraft engines. The modelling results predict that there will be exceedances of the objective for annual mean NO_2 ($40\mu g/m^3$). These are particularly in the vicinity of the M1. However the validation of the model has shown that the model under-predicts within 10m of busy (greater than 20,000 vehicles per day) roads and over-predicts the background. This means that for these roads the discrepancy needs to be corrected. After this correction the modelled NO_2 levels for 1998 are much closer to the levels found at the monitoring sites in 1998. The predictions for 2005 allow for the impact of the Ashby Bypass and an element of increased traffic from proposed developments around Castle Donington. From these results 7 Air Quality Management Areas within the district have been identified for designation.

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. How optimistic or pessimistic projected levels of activity and emission factors may be is difficult to determine. Also, 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 such as the Ashby traffic data 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 can only claim to have identified 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 implications for future policy a cautionary approach has been taken

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 (see sections 2.4 and 2.5). This therefore gives North West Leicestershire District Council confidence in the predictions on which the recommended Air Quality Management Areas are based.

4.3 Determination of Air Quality Management Areas

General

"*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 with the clearest and widest exceedance is for annual average for NO_2. This has been used to delineate the 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. 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 precautionary approach has been taken in applying estimates of modelling error to the drawing of boundaries. In addition, the areas of exceedance identified have been adjusted outwards to logical, clearly-identifiable boundaries, when outlining Air Quality Management Areas.

The exact boundaries will not be finalised until after the consultation process. It should also be noted that as the predicted exceedances are for annual average NO_2 levels they only apply to residential properties (long term exposure).

The M1 Problem

Air Quality Management Areas may be influenced by factors far beyond their boundaries and subsequent Action Plans will reflect this. In particular the M1 as an emission source crosses several local government boundaries. Although consultation with other authorities has continued and it would be best for all the authorities to has the same distances from the M1 for AQMA's this has proved difficult. For example Erewash Borough Council (to the North) have used a 30m distance, Blaby District Council (to the south) have AQMA's extending to 150m and Charnwood Borough Council (in between the 2 sections of M1 in this district) have yet to publish their stage 3 Review and Assessment. Also, it is to be noted that the flows of traffic between junction 23A and 24A including the parallel A453 are considerably higher than sections of the M1 in other neighbouring districts but that the receptors in North West Leicestershire (being mostly isolated farms or properties on single streets) are different than from the housing estates adjacent to the M1 in other districts. For the process of consultation the cautionary 150m from the M1 has been taken although it is recognised that this may change following full consultation.

Air Quality management Orders

The Order declaring AQMA's for North West Leicestershire 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 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.

Thus, the end-product of this Review and Assessment is the following proposed Air Quality Management Areas described below and shown on pages ** to **:

1. Vicinity of M1 — Residential properties within 150m of M1
   - 7 Properties in Long Whatton
   - 12 Properties in Copt Oak
   - 3 Isolated Farms

2. Kegworth A6 — Residential properties with frontage within 10m of A6
   - Approx. 60 Properties

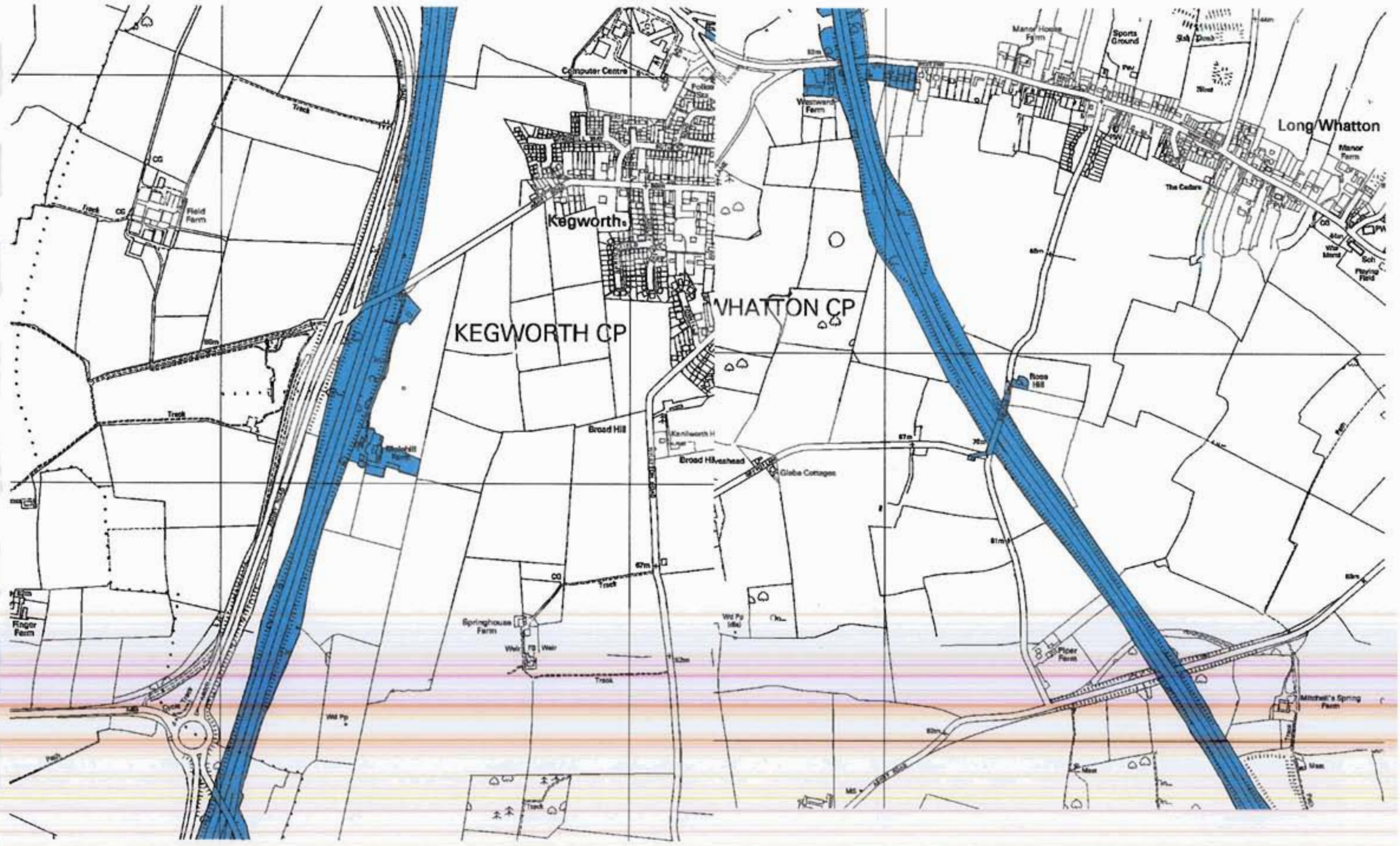
3. A511 — Residential properties with frontage within 10m of A511
   - 9 Properties Sinope and Hoo Ash
   - 3 Properties Broom Leys Road
   - 45 Properties Bardon Road
   - 4 Properties Bardon Hill

4. Belvoir Road, Coalville — Residential flats and pedestrian area between High Street Junction and disused railway line

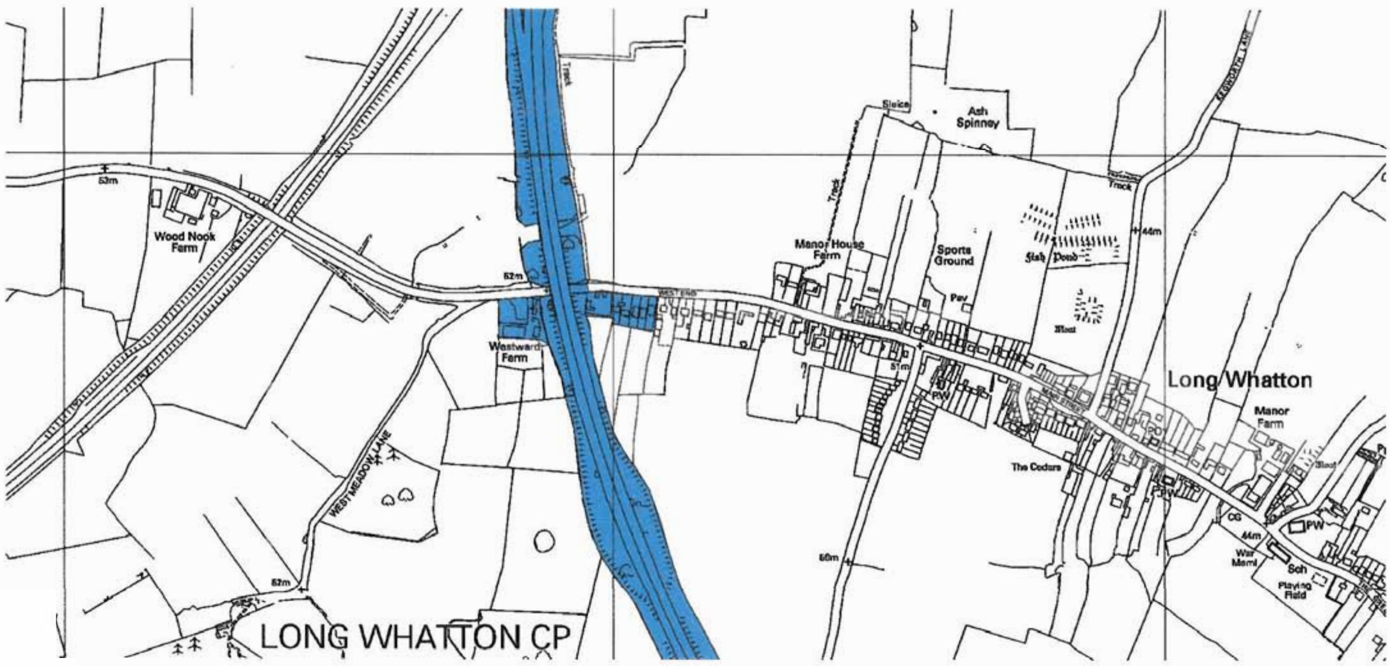
5. Castle Donington, Diseworth Road
   - 3 Properties

Vicinity of A50 — Residential properties within 15m of A50
   - 1 Property

7. Vicinity of A42/M42 — Residential Properties within 20m of A42/M42
   - 1 Property



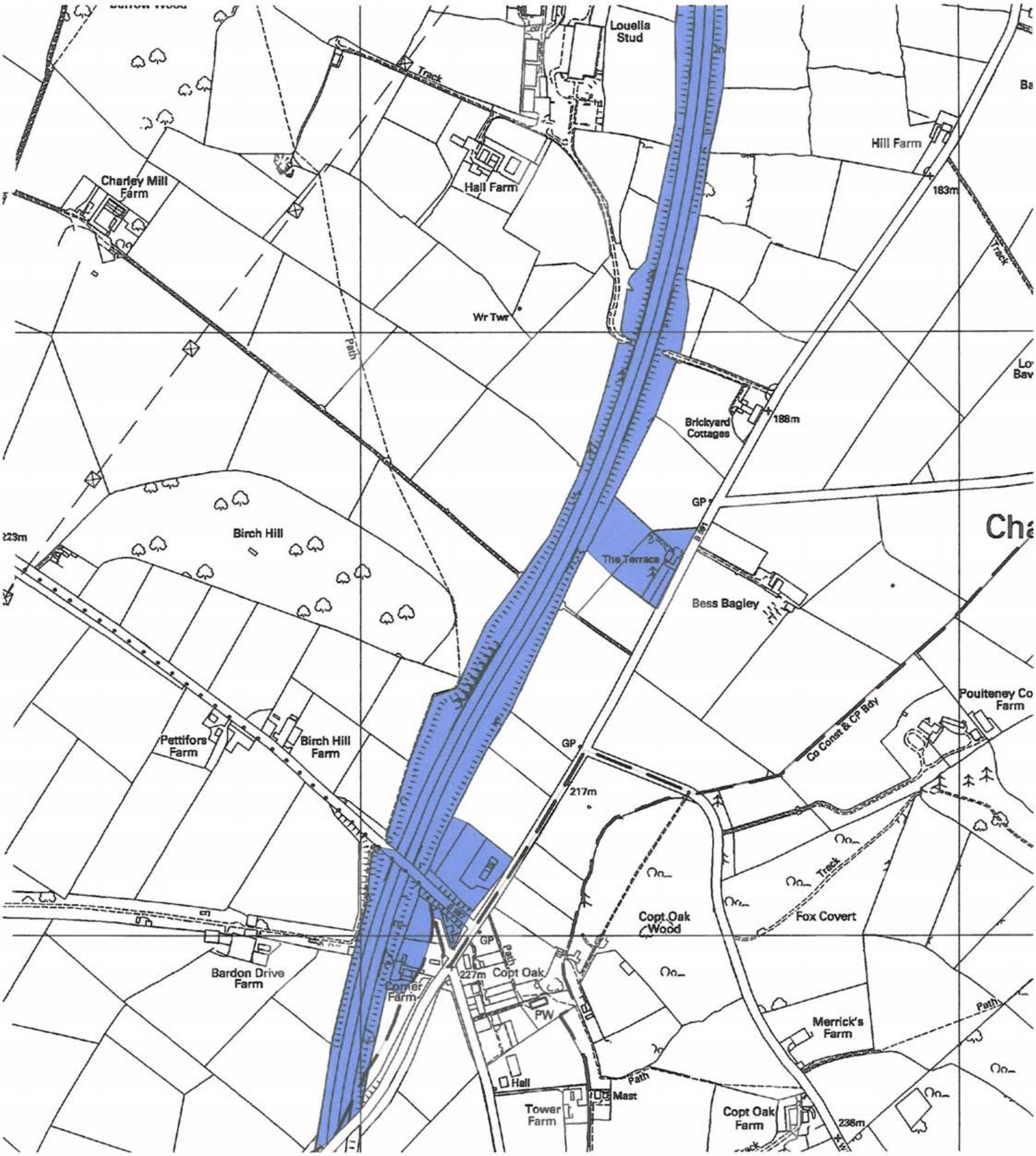
500 0 500 Meters



M1 (North) Proposed Air Quality Management Area

300 0 300 Meters

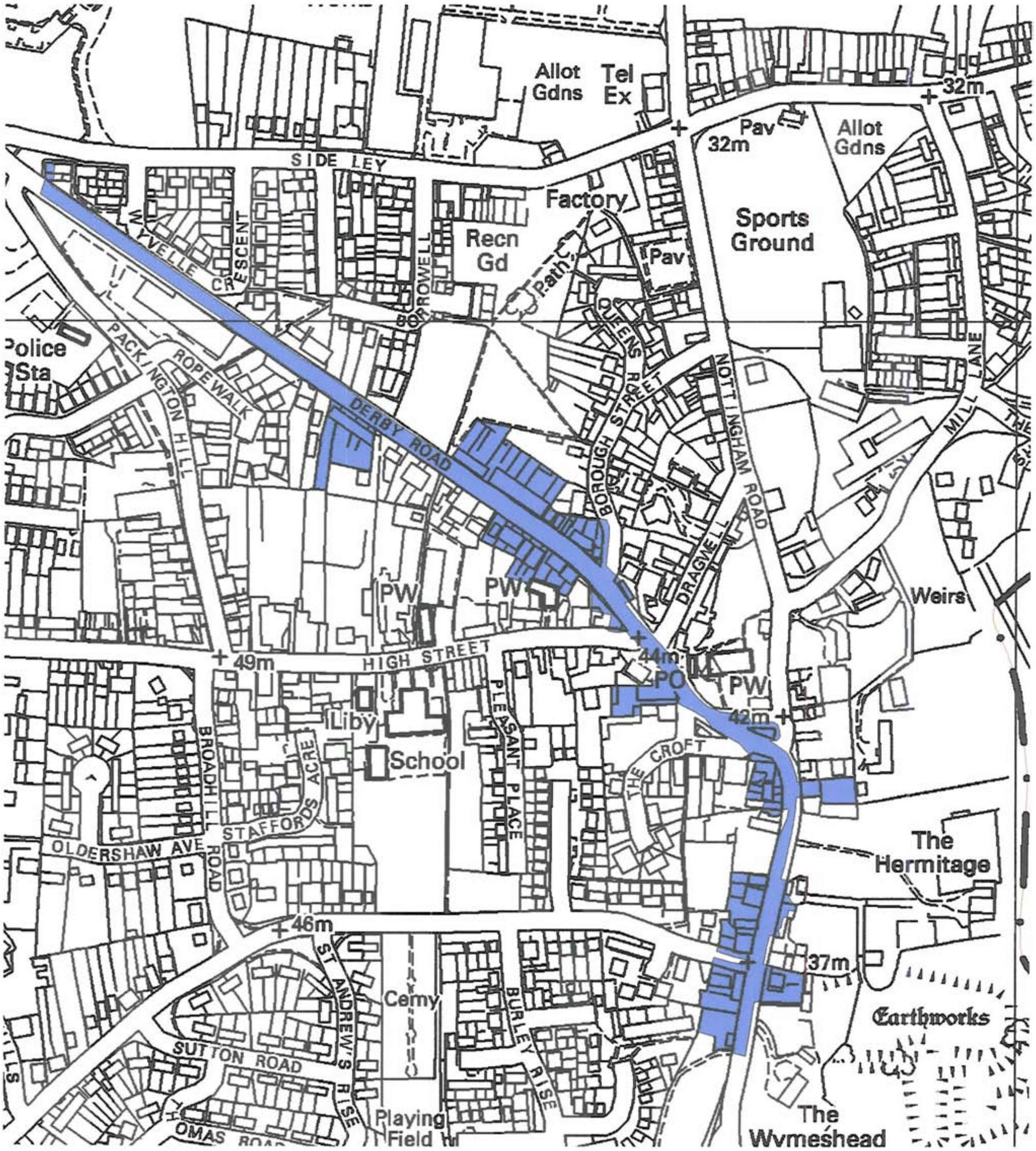
N



M1 (South) Proposed Air Quality Management Area

200 0 200 400 Meters

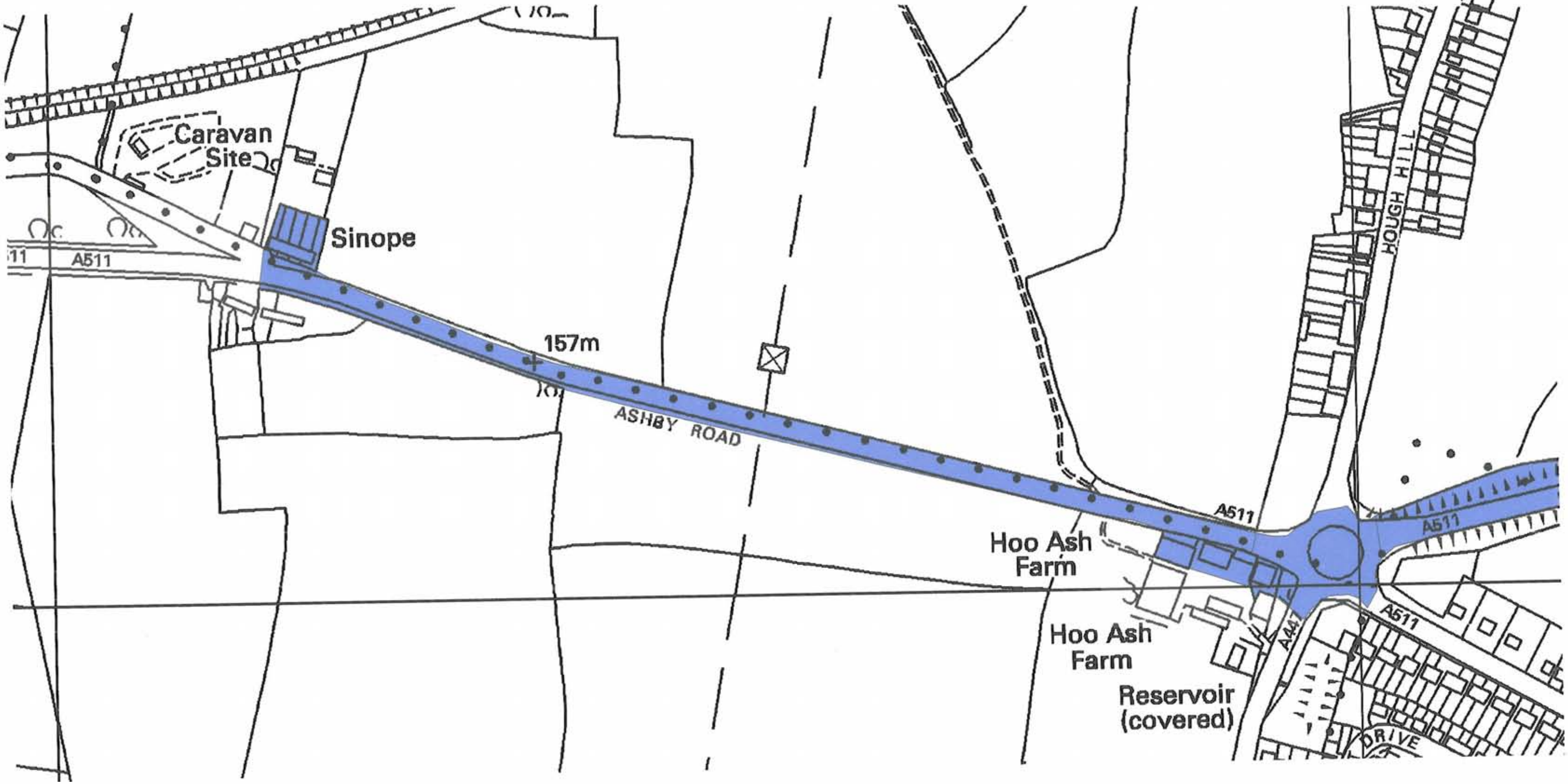
N



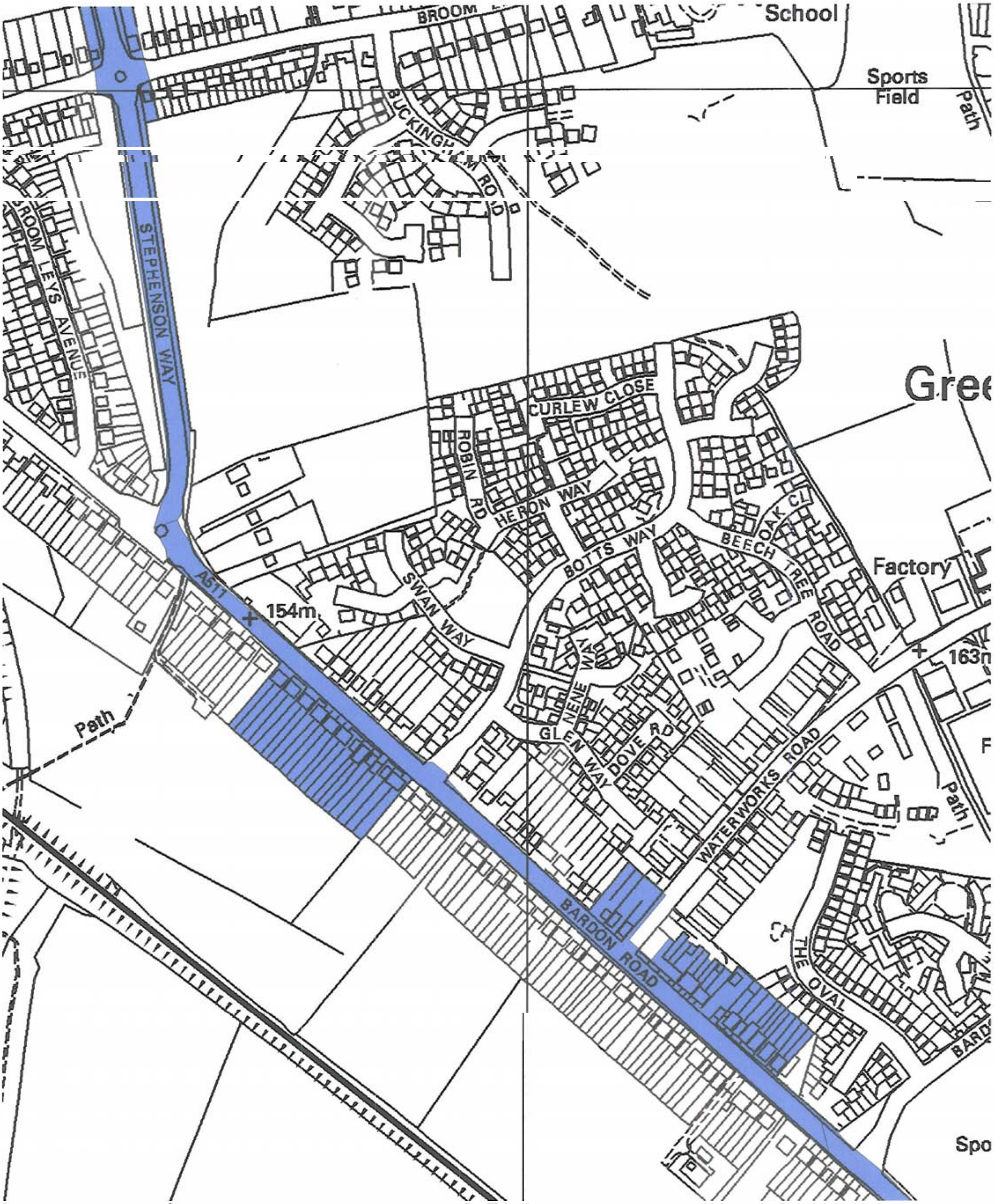
Kegworth Proposed Air Quality Management Area

100 0 100 Meters

N



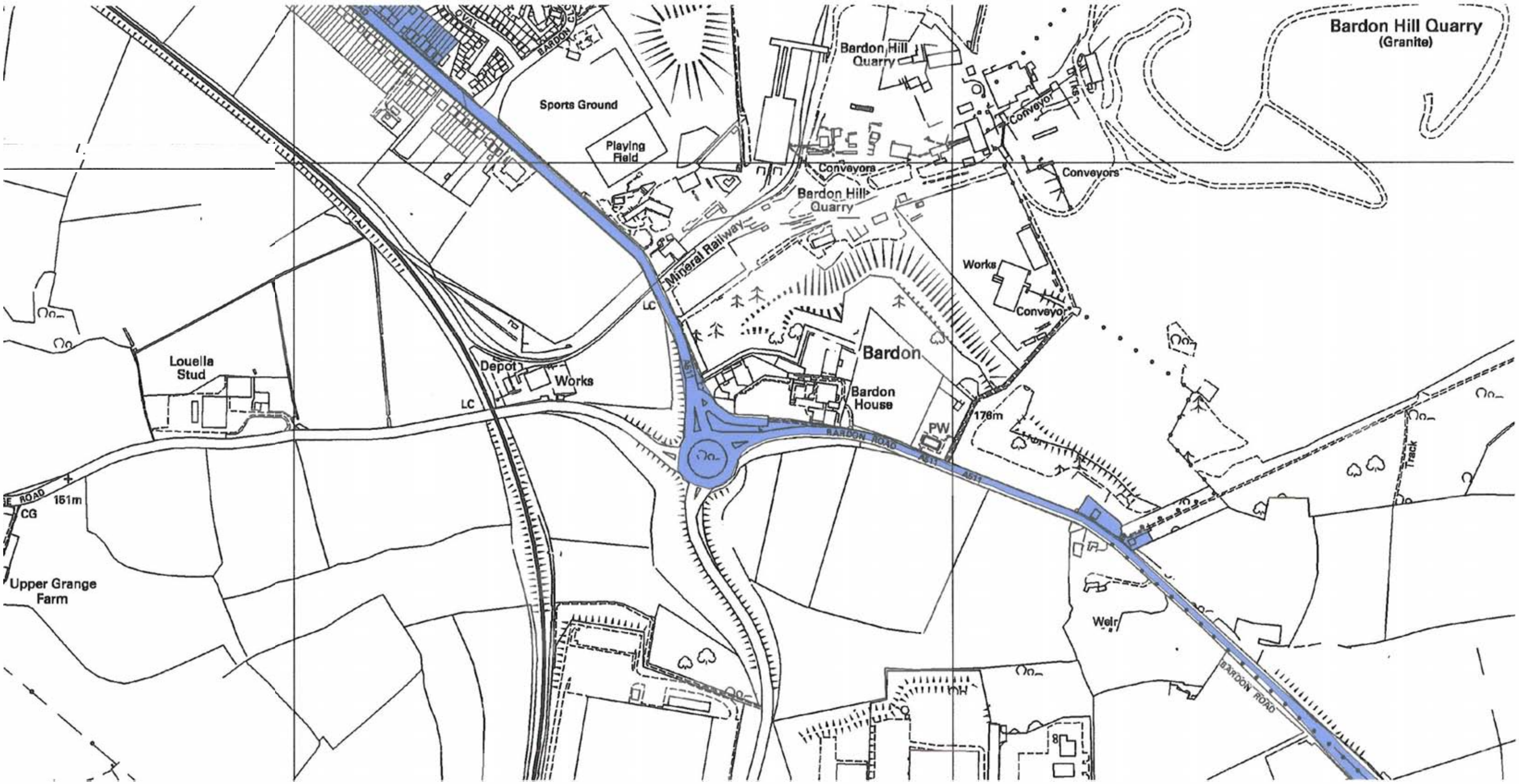
A511 Sinope and Hoo Ash Proposed Air Quality Management Area



A511 (Broom Leys and Bardon Road) Proposed Air Quality Management Area

200 0 200 Meters

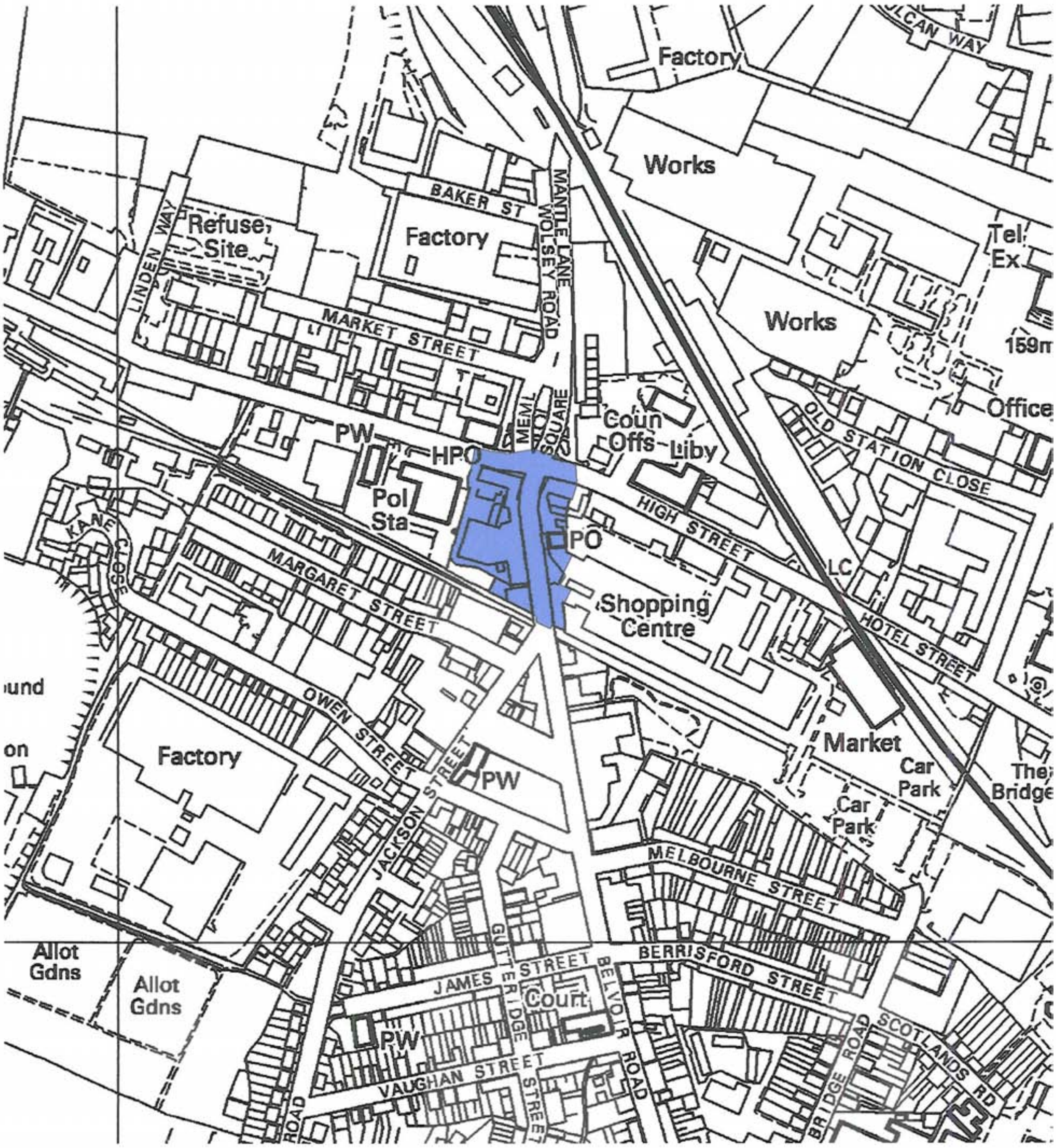
N



A511 (Bardon Hill) Proposed Air Quality Management Area

300 0 300 Meters

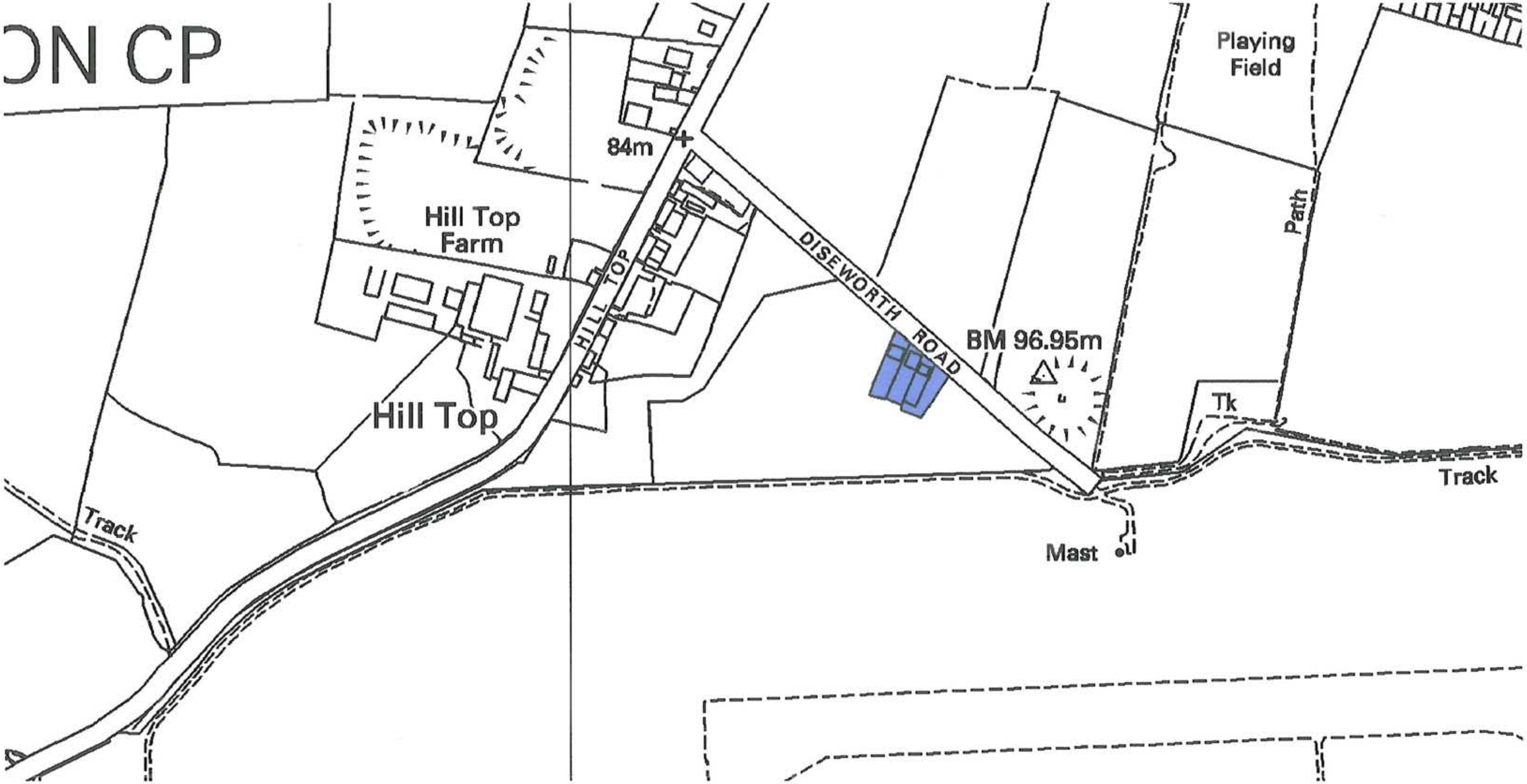
N



Belvoir Road Proposed Air Quality Management Area

N

200 0 200 400 Meters

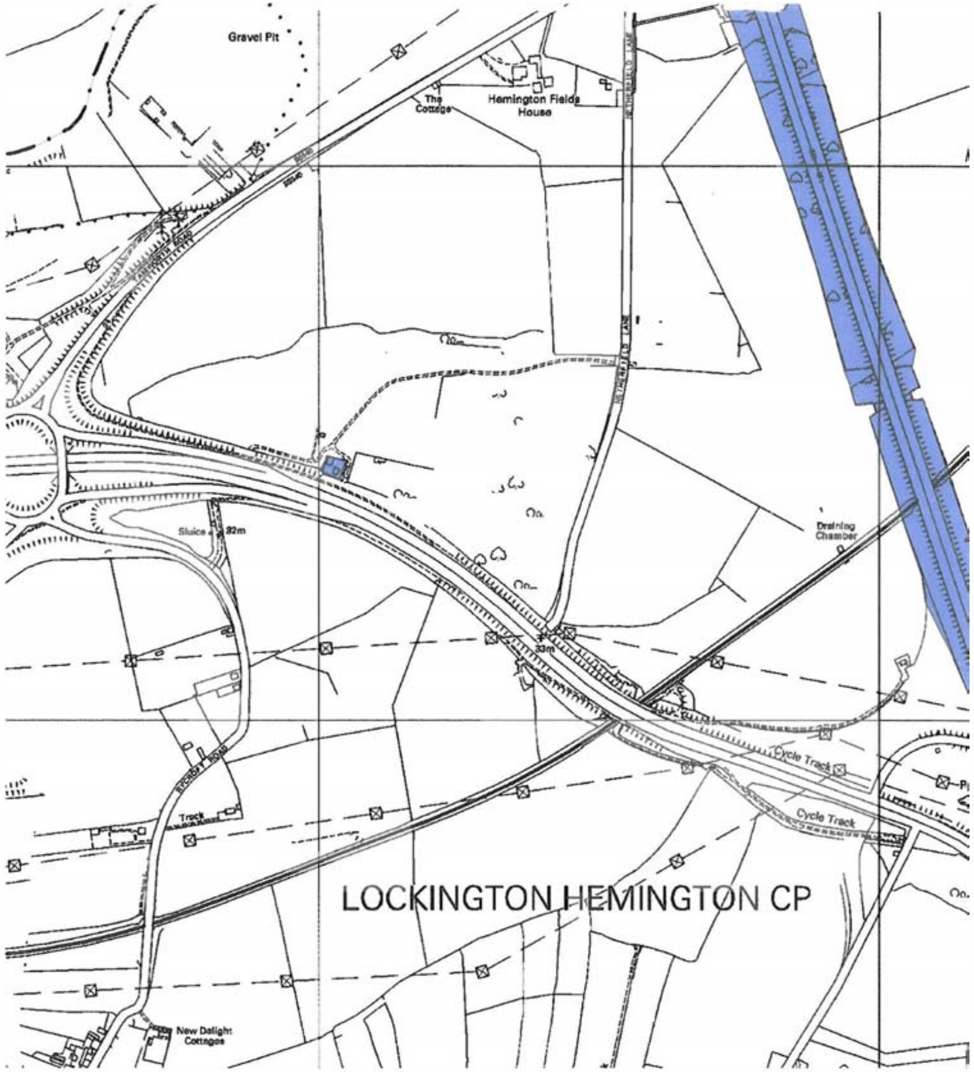


Castle Donington Proposed Air Quality Management Area

200 0 200 Meters

N

93



A50 Proposed
Air Quality Management Area

500 0 500 Meters

A/M42 Proposed
Air Quality Management Area

N

4.4 The Next Stages

Under Section 83 (1) of the Environment Act the local authority is required to designate those parts of the District identified by the review and assessment as Air Quality Management Areas through the making of an official order. This should be done within three months of the completion of the final review and assessment.

Air Quality Management Areas will be the subject of more detailed pollution monitoring to check the current levels of pollution and verify the accuracy of the model predictions. Within 18 months an Action Plan has to be produced which will set out steps to reduce the levels of NO_2 in the areas. This plan is likely to include land use planning controls and transport management measures. The results from further monitoring and the Action Plans will also be subject to further consultation with at least one further review and assessment before the end of 2003.

The guidance issued by the Department of Environment Transport and the Regions (LAQM(G2)(00) states that in developing an action plan local authorities should ensure that the potential wider environmental, economic and social consequences of each of the options considered are appraised, and where possible quantified. The current modelling work has identified traffic as the main pollutant source. Precise real time monitored pollution levels have not been recorded within the proposed Air Quality Management Areas. The absence of this validation data may need to be addressed at a later stage by provision of new long term monitoring station(s).

Appendix 1

Nitrogen Dioxide Tube Locations

Site Definition	Roadside (U2)	Urban Centre (U3)	Urban Backgrd (U4)	Suburban (SU)	Roadside (U2)	Roadside (U2)	Roadside (U2)	Suburban (SU)	Roadside (U2)	Roadside (U2)	Special (SP)	Roadside (U2)	Roadside (U2)	Special (SP)	Roadside (U2)
Env Ag code	L21 Urban Kerb	L22 Urban Inter.	L23 Urban Backgrd	L23 Urban Backgrd	L21 Urban Kerb	L21 Urban Kerb	L26 M/way corrid	L23 Urban Backgrd	L21 Urban Kerb	L21 Urban Kerb	L25 Industrial	L21 Urban Kerb	L21 Urban Kerb	L25 Industrial	L26 M/way corrid
AEA code	Kerb A	Inter A	Urban A	Urban B	Kerb E	Kerb F	Inter D	Urban C	Kerb B	Kerb G	Urban D	Kerb C	Kerb H	Urban E	Inter E
Location	Coalville Belvoir	Coalville Jackson	Coalville Oxford St.	Coalville Broughton	Ibstock, A447	Measham, High	Ashby A42	Ashby Marlborough	Ashby Market St.	C/Don High St	C/Don E.M.A	Kegworth A6	Bardon Rd C/V	Whatton Rd Keg	M1 Long Whatton
Average 95	33.0	24.2	19.5	16.6				22.6	29.6			27.3			
Average 96	31.7	24.2	19.2	17.0				16.9	30.2			27.8			
Average 97	33.0	24.9	18.9	17.2				17.4	29.4			25.2			
Average 98	34.6	23.9	22.8	20.6	20.7	23.9	38.0	20.7	31.6	23.6	16.0	31.3			
Average 99	32.0	22.1	21.2	20.6	23.0	23.5	19.6	23.2	27.9	26.4	17.8	31.8	32.6	19.8	21.8
Average 00	21.5	17.7	17.0	15.9	17.8	13.3	14.2	13.9	22.7	18.9	12.4	23.2	20.7	15.5	16.5

Appendix 2 & 3

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.

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 (2σ)	Accuracy Objective in LAQM.TG1 (00)	Precision (2σ) 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%	± [illegible]ppb (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).

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.

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.

Appendix 4 : Modelling: Methods, Validation and Interpretation.

The ADMS-Urban Dispersion Model (Version 1.53).

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.

Model Inputs

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 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:

SO_2
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.

Meteorological Data

For the purpose of the National Air Quality Strategy Review and Assessment, data for the meteorological year 1998 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.

Validation of Model Runs.

Nitrogen dioxide

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 + hυ	→	RP + ROC
(2)	RP + NO	→	NO_2
(3)	NO_2 + hυ	→	NO + O_3
(4)	NO + O_3	→	NO_2
(5)	RP + RP	→	RP
(6)	RP + NO_2	→	SGN
(7)	RP + NO_2	→	SNGN

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).

Background Correction

It has been suggested that a value for "suburban" background should be added on to predictions for urban receptor points. However we had concerns about this as an urban background will contain emissions accounted for in the emissions inventory and thus may 'double count' these emissions. When Leicester City used suburban backgrounds they found that the model seriously over estimated NO_2 levels. Therefore a rural background has been added based on the 1999 annual mean from the Ladybower rural nitrogen dioxide monitoring site.

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).

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.

Estimated systematic error corrections (annual mean)

Table (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		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	0.24	60.4 (31.6)
Mean:				**1.51**		
Bassett St	11.8	40.1 (21)	43.9 (23)	0.91		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	0.15	28.3 (14.8)
Mean:				**0.87**		

*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.

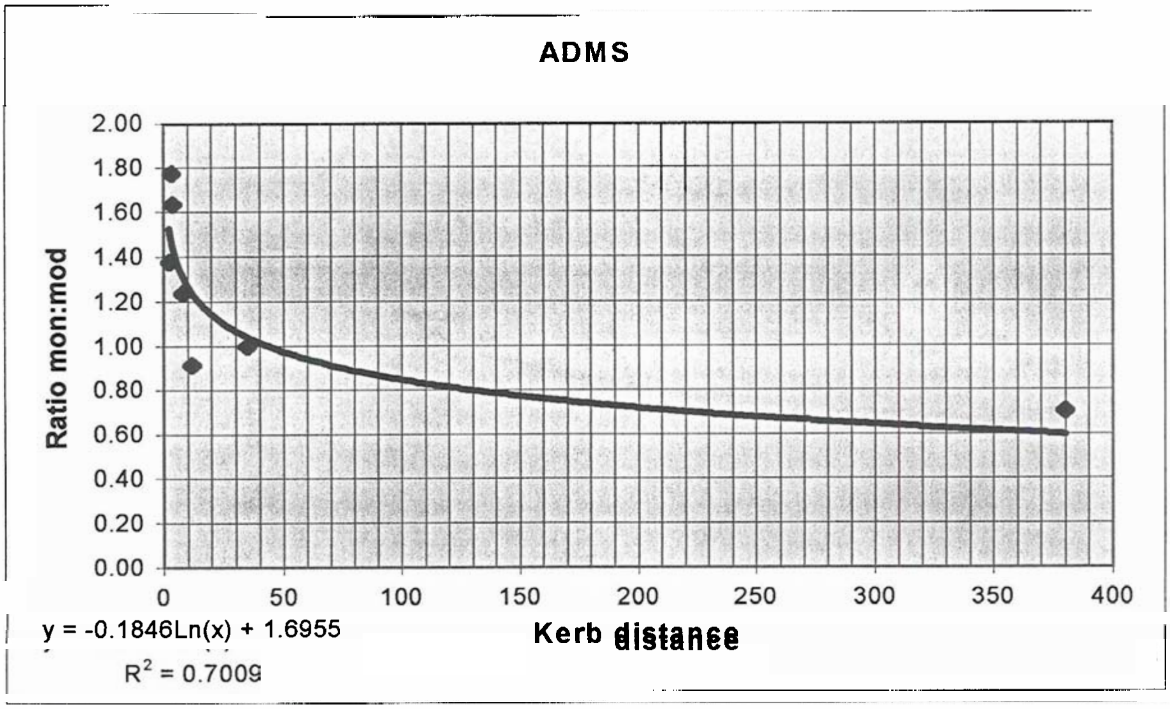
It must be borne in mind that, where people *are* exposed to traffic-generated Nitrogen dioxide at distances of less than 10 metres from the kerb, they will be exposed to significantly higher levels since it is estimated that values predicted by the models will be too small by approximately 50%.

(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).



PM_{10} Particulates

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:

$$PM_{10} \text{ value} = \text{ADMS modelled} + (\text{measured sulphate} * 7.5) + 5 \text{ (coarse)}$$

All values are in micrograms per cubic metre.

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: Modelling Outputs Compared to 1999 Monitoring Data

ADMS Modelling PM10		Annual means*		Max. 24-hour means*		Number of 24-hour means > 50*	
TEOM Site (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: 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
	2.9	**←(Mean)**	
BAM	**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.

Midland Lead Manufacturers Limited, Woodville

Details	Assessment	Comments
Process	Part A - Reclamation of Lead from non-ferrous Scrap.	
Pollutants Assessed	Lead, SO_2,	
Surface Roughness	0.5 m	Parkland, Open Suburbia
Meteorological Type	1	Inland Area
Stack Height	43 m	
Flue Radius	0.8 m	
Mass Emission Rate	Lead, 0.0037 g/s SO_2, 0.434 g/s	Public Register
Release Temperature	299k	
Release Velocity	6.18 m/s	
Volume Flow	[illegible]	
Efflux Heat	0.23 MW	
Efflux Momentum	72.38 m^4/s^2	
Process Contributions	Lead, 0.0025 µg/m^2	
	SO_2, 1.30 µg/m^2	Annual Mean
	13.94 µg/m^2	99.9th percentile of 1 hour averages in a year

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APPENDIX 7 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 meteorological 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.

APPENDIX 8 (ADDENDUM)

Comparison of Modelled and Monitored Data, East Midlands Airport