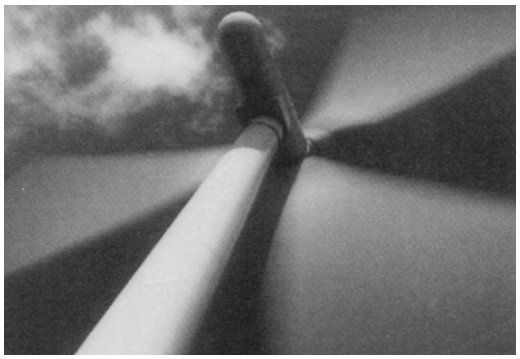
City of NOTTINGHAM

Air Quality Review and Assessment:



Second and Third Stage Report



September 2001





Air Quality Review and Assessment: Second and Third Stage Report

September 2001

Director of Development and Environmental Services

Acknowledgements

Nottingham City Council wishes to acknowledge the co-operation of the following organisations and bodies who contributed information that enabled the Second and Third Stage review and assessment to be undertaken;

Ashfield District Council

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Bassetlaw District Council

Gedling Borough Council

Mansfield District Council

Newark and Sherwood District Council

Nottingham City Council: Transportation Section

Rushcliffe Borough Council

Nottinghamshire County Council

Cambridge Environmental Research Consultants (CERC)

Atmospheric Research and Information Centre (ARIC)

National Environment and Technology Centre (NETCEN)

Department of the Environment, Transport and the Regions (DETR)

University of Western England (UWE)

This report was compiled and produced by Nottingham City Council's Development and Environmental Services Department: Pollution Control Section - September 2001.

Glossary

AQ	Air Quality
AQMS	Air Quality Mobile Station
ARIC	Atmospheric Research and Information Centre
AURN	Automatic Urban and Rural Network
CERC	Cambridge Environmental Research Consultants Ltd
CO	Carbon Monoxide
DEFRA	Department of the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
EPAQS	Expert Panel on Air Quality Standards
Exceedance	A period of time where the concentration of a pollutant is greater than, or equal to, the appropriate air quality standard
LSO	Local Site Operator
MW	Megawatt -1 million watts
NAQS	National Air Quality Strategy
NEI	National Emissions Inventory
NETCEN	National Environmental Technology Centre
ngs	Nanogrammes - one thousand millionth of a gramme
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
Percentile	A value that is the rank at a particular point in a collection of data. For instance, a 98th percentile of values for a year is the value that 98% of all the data in the year fall below, or equal.
PM_{10}	Particulate matter 10 microns(millionths of a metre) or less in diameter also called particles
ppb / ppm	Parts per billion / million - the concentration of a pollutant in air in terms of volume ratio

Glossary

Running mean	The mean or series of means calculated for overlapping time periods . For instance , an 8 hour running mean is calculated every hour and averages the values for the previous eight hours. There are therefore 24 possible 8-hour means in a day (calculated from hourly data)
SO_2	Sulphur dioxide
μgs	Microgrammes - one millionth of a gramme
μgsm^{-3} or μgm^{-3}	Microgrammes per cubic metre. A measure of concentration in terms of mass per unit volume
VOC	Volatile organic compounds e.g. benzene

Executive Summary

Air Quality Review and Assessment
Second and Third Stage Report - September 2001

The Government announced its Air Quality Strategy on the 12th March 1997 giving local authorities until the 31st December 1999 to carry out a progressively intensive three-stage review and assessment of air quality.

Review and assessment has to be implemented in accordance with Government guidance comparing local air quality with objectives specified in the Air Quality (England) Regulations 2000, which have to be achieved by the years 2003-5 for the pollutants of concern which are:-

Benzene	1, 3 Butadiene
Carbon monoxide	Lead
Nitrogen dioxide	PM_{10} (Particles)
Sulphur dioxide	Ozone

All local authorities have undertaken a First Stage review and assessment to identify all potential sources of pollution including:-

- industrial processes likely to emit substantial quantities of pollutants of concern;
- other significant pollutant sources;
- roads which exceed prescribed levels of use or congestion.

Where it has been determined that an Air Quality Objective (AQO) will not be achieved, Local Authorities must designate, by order, Air Quality Management Areas (AQMAs) and formulate and publish corresponding Air Quality Action Plans (AQAPs). The AQAP must specify what actions a Local Authority intends to take 'in pursuit of the air quality objectives'.

Nottingham City Council's First and Second Stage review and assessment (published April 2000) concluded that:-

i. The Air Quality Objectives set for benzene, 1,3 butadiene, lead, and carbon monoxide will be achieved by the prescribed dates, and
ii. a Second Stage and Third Stage review and assessment was required for particles and nitrogen dioxide, and
iii. a Third Stage review and assessment was required for sulphur dioxide.

The review and assessment time scale was reviewed by the Government in December 1999 and extended until 31st December 2000. The additional data and consequent modelling required, further delayed the completion of Nottingham City Council's review and assessment.

Executive Summary

The Air Quality Regulations and relevant guidance have been revised since Nottingham City Council undertook its Stage One and Stage Two review and assessment. Nottingham City's Stage Two and Stage Three review and assessment was carried out in accordance with the revised regulations and guidance. The Air Quality (England) Regulations 2000 are detailed below:-

Air Quality Objectives

Pollutant	Objective	measured as	Date to be achieved
Benzene	16.25 μgm^{-3} (5 ppb)	running annual mean	31/12/2003
1,3 Butadiene	2.25 μgm^{-3} (1 ppb)	running annual mean	31/12/2003
Carbon Monoxide	11.6 μgm^{-3} (10 ppm)	running 8 hour mean	31/12/2003
Lead	0.5 μgm^{-3}	annual mean	31/12/2004
	0.25 μgm^{-3}	annual mean	31/12/2008
Nitrogen Dioxide	200 μgm^{-3} (105 ppb)	1 hour mean not to be exceeded more than 18 times a year	31/12/2005
	40 μgm^{-3}	annual mean	31/12/2005
PM_{10}	50 μgm^{-3}	24 hour mean not to be exceeded more than 35 times a year	31/12/2004
	40 μgm^{-3}	annual mean	31/12/2004
Sulphur Dioxide	350 μgm^{-3} (132 ppb)	1 hour mean not to be exceeded more than 24 times a year	31/12/2004
	125 μgm^{-3} (47 ppb)	24 hour mean not to be exceeded more than 3 times a year	31/12/2004
	266 μgm^{-3} (100 ppb)	15 minute mean not to be exceeded more than 35 times a year	31/12/2005

Executive Summary

The Second and Third Stage review and assessment determined that a number of areas were likely to experience exceedances of the Air Quality Objectives and that Air Quality Management Areas are required.

Particles (PM_{10})

The Second and Third Stage review and assessment determined that the air quality objectives for particles were unlikely to be exceeded in 2004 and beyond.

Nitrogen Dioxide (NO_2)

The Second and Third Stage review and assessment determined that the air quality objective for nitrogen dioxide of 40 μgm-3 annual average was likely to be exceeded in a number of locations in 2005.

Sulphur Dioxide (SO_2)

The guidance requires large combustion plant (5 Megawatts+) to be considered. The identification of a combustion plant exceeding 5 Megawatts therefore required a Third Stage review and assessment. Results from this review and assessment indicate that no significant increases in sulphur dioxide are likely. However, it was likely that the Air Quality Objectives, in the vicinity of the combustion plant is currently being exceeded and will continue to be exceeded in 2005.

Areas of Exceedance of Air Quality Objectives

The areas are shown on the maps overleaf - figures 9 and 10 overleaf.

Air Quality Management Areas

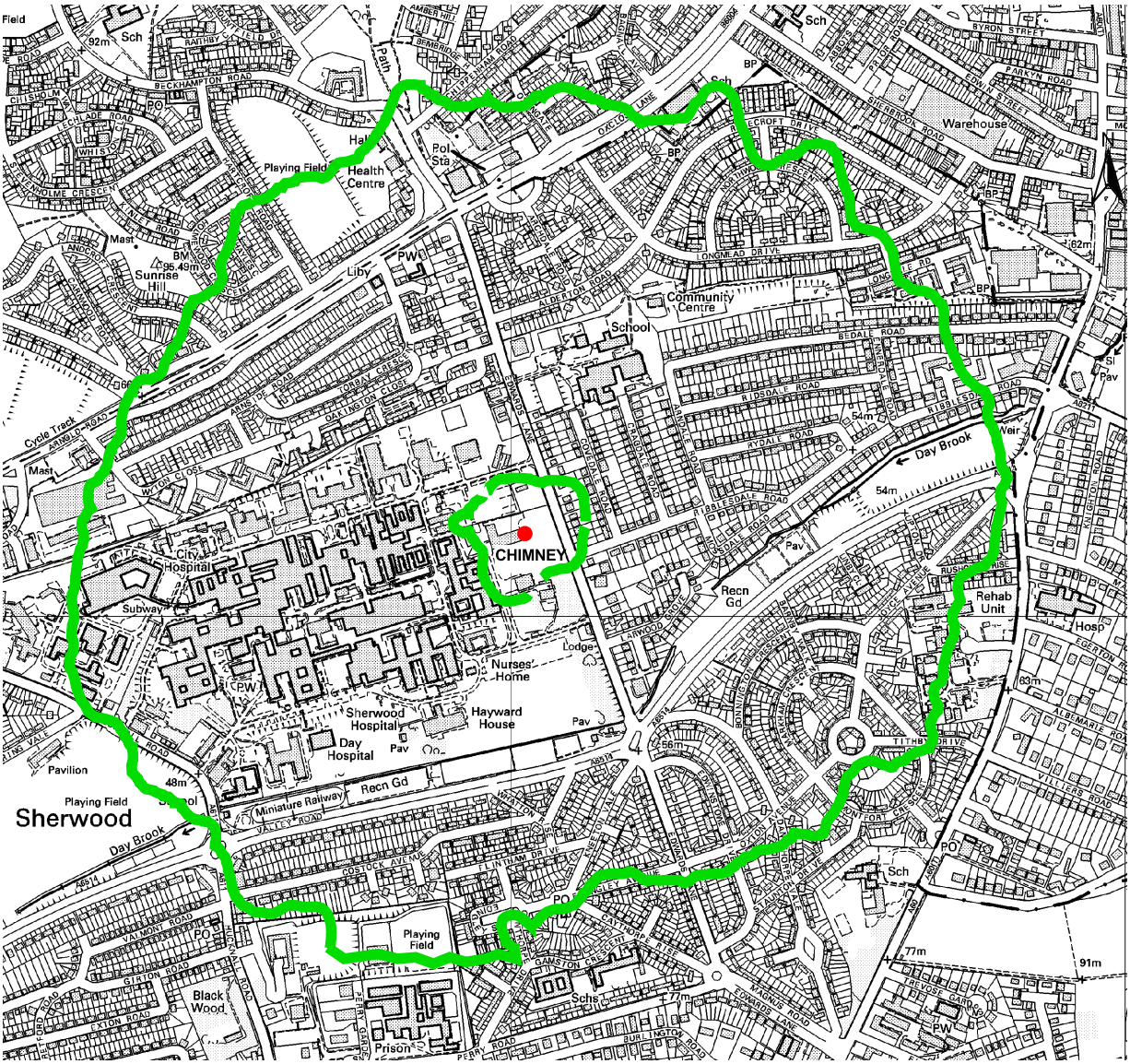
The proposed areas are shown on the maps overleaf - figures 11, 12a and 12b.

Consultation

Wide consultation about the Second and Third Stage review and assessment and the need to designate Air Quality Management Areas took place and included the following:-

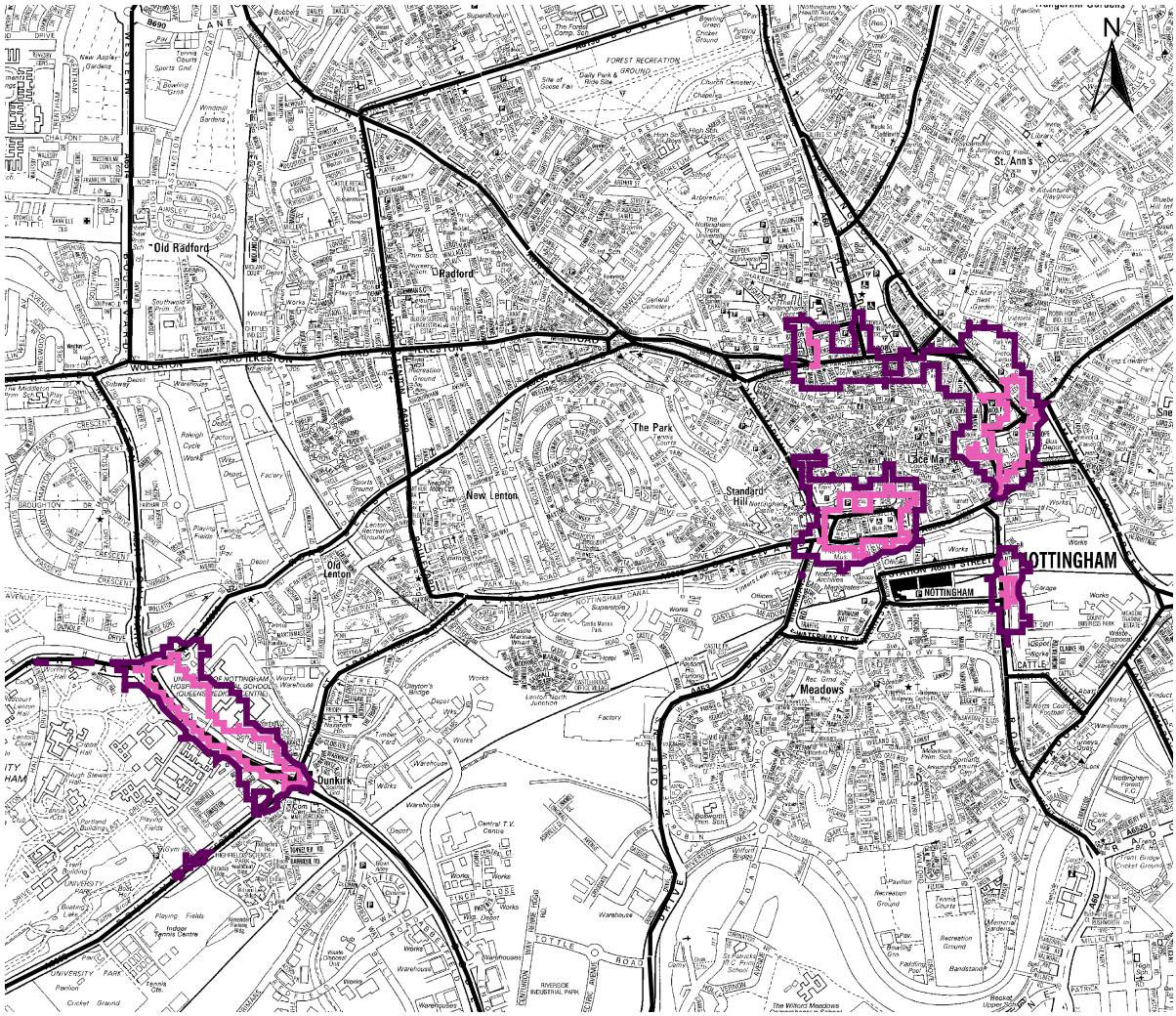
The Secretary of State;
The Environment Agency;
The Highways Authority;
all neighbouring local authorities;
Nottinghamshire County Council;
other relevant public bodies;
local business representative bodies;
other bodies as considered appropriate;
community groups;
environmental groups;
Local Government Office.

Figure 9
Area of exceedance of Sulphur Dioxide Air Quality Objectives



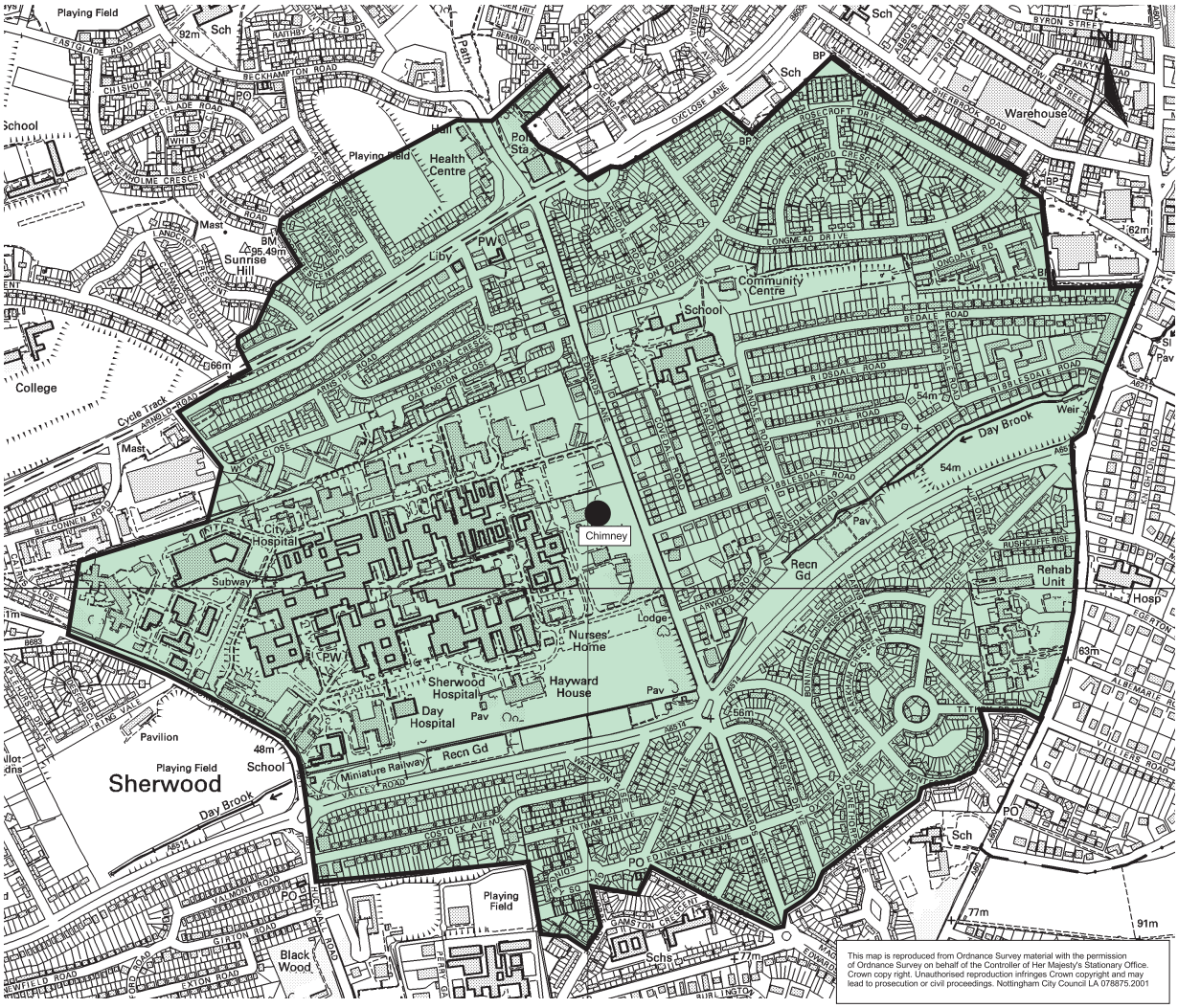
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Figure 10
Area of Exceedance of Nitrogen Dioxide Annual Mean Air Quality Objective



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Figure 11
Proposed Air Quality Management Area for Sulphur Dioxide

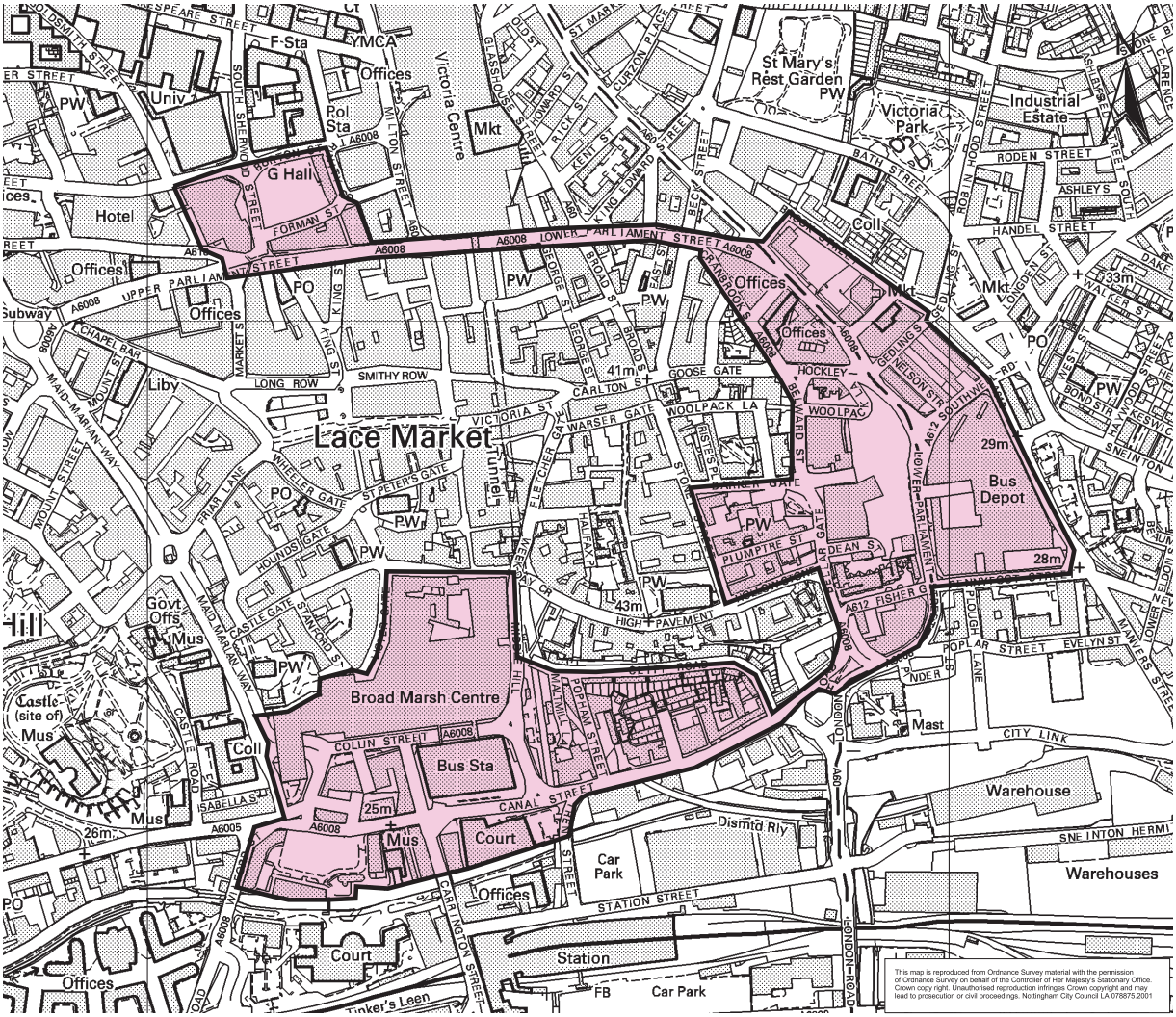


500 0 500 Metres

Area of Proposed Air Quality Management Area

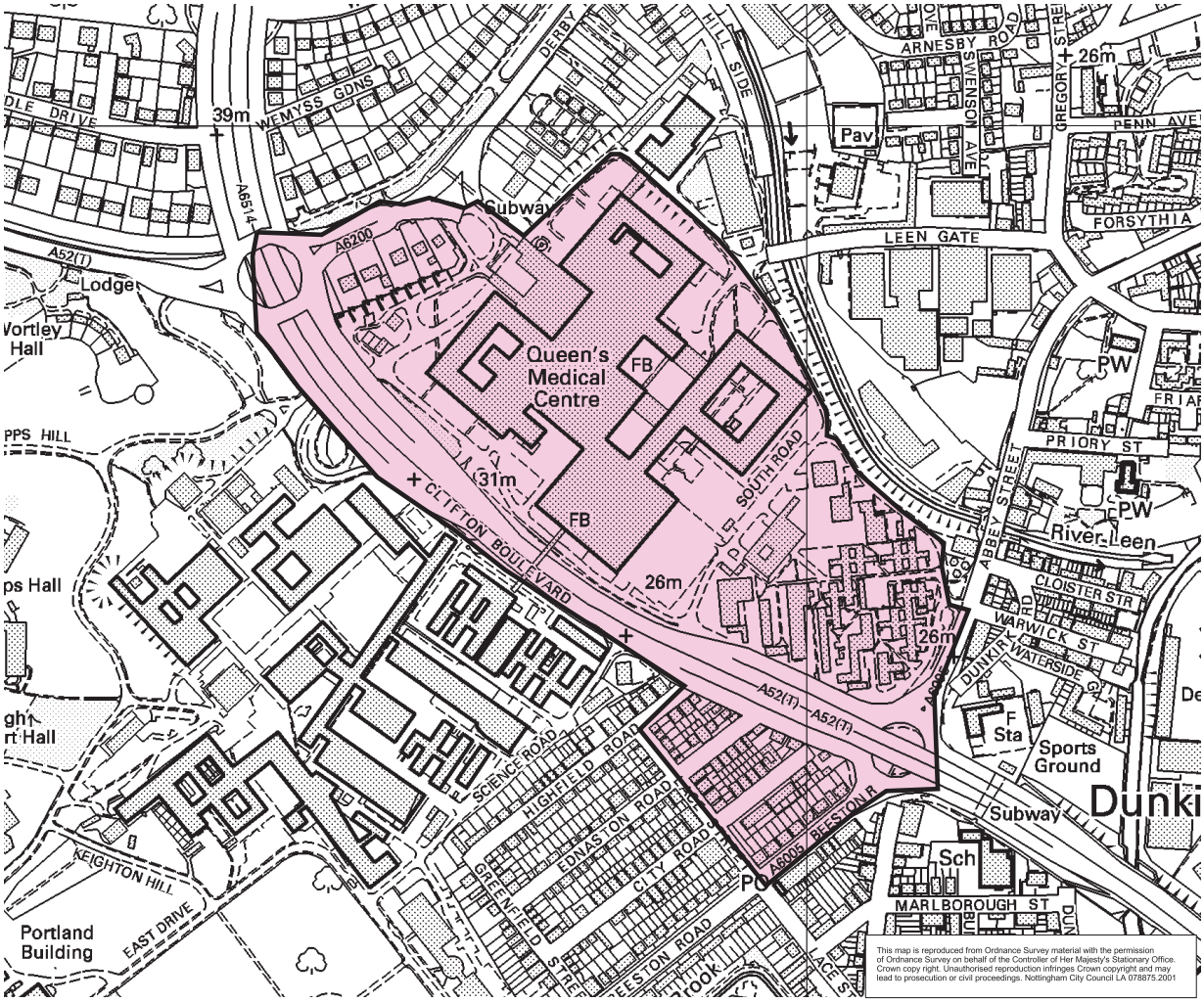
Figure 12a

Proposed Air Quality Management Area for Nitrogen Dioxide - City Centre



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Figure 12b
Proposed Air Quality Management Area for Nitrogen Dioxide - Dunkirk



400 0 400 Metres

Area of Proposed Air Quality Management Area

Executive Summary

The UK National Air Quality Strategy will have significant implications for future planning and transportation issues. It is a major factor influencing the well being and quality of life for the whole population. This work and the results of consultation with stakeholders, residents and business, will provide the basis for the assessment of the benefits and viability of future initiatives to improve our air quality.

This is a summary of the findings of the Second Stage and Third Stage review and assessment. The full document may be viewed at the main receptions of:-

- Development and Environmental Services, Lawrence House, Talbot Street.
- Development and Environmental Services, 2nd Floor, Exchange Buildings North, Smithy Row
- The Central Library, Angel Row
- All Nottingham City District Libraries
- All local Housing Management Offices

Following consultation any relevant comments and amendments have been incorporated prior to recommendation to the Strategic Board and subsequent publication of the Second and Third Stage review and assessment report.

Within four months of completing and publishing its Second and Third Stage review and assessment Nottingham City Council will proceed to designate Air Quality Management Areas for sulphur dioxide and nitrogen dioxide.

Nottingham City is required to prepare an Air Quality Action Plan for each AQMA and consult upon the draft AQMA action plan within 9-12 months of designation of an AQMA. The Air Quality Action Plan should be in place within 12-18 months following designation of an AQMA.

Nottingham City welcomes all observations, comments and suggestions on the Second and Third Stage review and assessment document. These should be addressed to : -

Mr J Bonham
Pollution Control Service Manager
Development and Environmental Services Department
Lawrence House
Talbot Street
Nottingham NG1 5NT

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TECHNICAL ANNEXE

1 Introduction

The increasing concerns of society about the quality of the air that we breathe resulted in political response and the enactment of The Environment Act 1995 - Part IV of which introduced the concept of Local Air Quality Management.

Under Section 82 of this Act Local Authorities are required to review the air quality in their area and assess whether the Air Quality Standards and Objectives will be achieved by the prescribed date for each pollutant of concern.

The review and assessment process has three stages, each with increasing depth of investigation, designed to ensure only those pollutants which will or are likely to exceed the air quality objectives are assessed in the next stage. The reasons for proceeding to each subsequent stage of the review and assessment must be clearly demonstrated, supported and in accordance with Government guidance.

The Act led to the publication of The National Air Quality Strategy (NAQS) in 1997 which proposed a number of air quality standards and objectives for seven substances, to be achieved by the year 2005.

The Air Quality Regulations 1997 formalized the air quality objectives, which had to be met by 2005. These have been replaced by The Air Quality (England) Regulations 2000 and the revised objectives are detailed in Table 1 page 5. The objectives in these regulations have been used for this Second and Third Stage review and assessment.

Where it has been determined that an Air Quality Objective will not be achieved, by the specified date, Section 83 of the Environment Act 1995 requires Local Authorities to designate by order Air Quality Management Areas (AQMAs) and formulate and publish corresponding Air Quality Action Plans (AQAPs). The AQAP must specify what actions a Local Authority intends to take 'in pursuit of the air quality objectives', including a timetable for implementing the plan.

Nottingham City Council undertook a review and assessment of the 'pollutants of concern' during 1999 and published its First Stage and Second Stage review and assessment in April 2000. This concluded that concentrations of nitrogen dioxide (NO_2) and particles (PM_{10}) were likely to lead to exceedances of the 1997 Air Quality Objectives. It was therefore proposed to bypass the Second Stage review and assessment and proceed to a Third Stage review and assessment, for these pollutants.

The LAQM.TG4(98) for sulphur dioxide required 'small' combustion plant (>5 Megawatts thermal) to be considered. When the First and Second Stage reviews and assessments were conducted one such combustion plant had not been identified and was not therefore included in the process. The consultation process identified a site with combustion plant exceeding 5 Megawatts and a Third Stage review and assessment was therefore undertaken.

In December 1999 the DETR published its consultation draft LAQM.TG4(00) Review and Assessment: Pollutant Specific Guidance. The guidance was more detailed than LAQM.TG4(98) and introduced changes to the methodology for determining the likely exceedance of air quality objectives for all pollutants of concern, particularly NO_2 and PM_{10} . The guidance was published in its final form in March and May 2000. The review and assessment detailed in this document was therefore undertaken in light of the revised guidance.

2 Purpose and focus

The purpose of this report is to: -

i. review current air quality in the Nottingham City area,
ii. detail the Second Stage and Third Stage review and assessment of nitrogen dioxide and particles, and the Third Stage review and assessment of sulphur dioxide, undertaken by the City of Nottingham (hereinafter termed Nottingham City Council or the Local Authority) and,
iii. identify the need for Air Quality Management Areas.

The review and assessment process was undertaken in accordance with LAQM.TG4 (00) 'Review and Assessment: pollutant specific guidance' published by the Department of the Environment, Transport and the Regions (DETR) para 1.17.

For objectives with short averaging times (e.g. the hourly objective for nitrogen dioxide, 15 minute objective for sulphur dioxide) the review and assessment was focused on 'any non-occupational, near ground level outdoor location' where people are likely to be for the period of exposure,

For objectives with longer averaging times (e.g. annual mean for nitrogen dioxide, 24 hour mean for PM_{10}), reviews and assessments were focused on the following near ground level outdoor locations:

- background locations
- roadside locations (i.e. sites close to the facade of a building) where there is housing and
- other areas where a person might reasonably be expected to be regularly exposed to outdoor air for a substantial part of the day (e.g. in the vicinity of housing, schools or hospitals, etc.), over the relevant averaging time of the objective.

The document 'Local Air Quality Management LAQM.G1(00)' states that '....Those authorities which have completed part of their review and assessment (e.g. Stages 1 and 2, but not Stage 3) before the introduction of the new Regulations will not need to redo the stages already carried out, but should shift the remaining parts of their review and assessment with immediate effect to the new objectives.'

Nottingham City Council has conducted the Stage Two and Stage Three review and assessment in accordance with LAQM.G1(00) and LAQM TG1 - 4(00), with reference to the Air Quality Objectives prescribed in The Air Quality Regulations 2000, which came into force on the 6th April 2000 (see Table 1 page 5).

LAQM.G1(00) requires an authority to 'carry out a third stage review and assessment where... ...the Second Stage review and assessment has revealed a significant risk of an air quality objective not being met for any pollutant of concern.' It also recommends that ' The authority should use validated dispersion models to predict current and future air quality.'

Furthermore, LAQM.TG1(00) requires 'a detailed and robust assessment of the potential impacts.' 'Potential impacts' has been interpreted as the likely concentration of an emission of a pollutant of concern from a significant point, line, area or combined source at a receptor where the air quality objectives should be applied. It requires 'that the assumptions within the review and assessment process are considered in depth, and the data which are collected or used are quality assured to a high standard. The authority will need to define both the magnitude and geographical extent of exceedances of the objective at this stage. It will also need to have confidence that its decision whether to designate an AQMA or not, is soundly based.'

Table 1

Air Quality Objectives

Pollutant	Objective	measured as	Date to be achieved
Benzene	16.25 μgm^{-3} (5 ppb)	running annual mean	31/12/2003
1,3 Butadiene	2.25 μgm^{-3} (1 ppb)	running annual mean	31/12/2003
Carbon Monoxide	11.6 mgm^{-3} (10 ppm)	running 8 hour mean	31/12/2003
Lead	0.5 μgm^{-3}	annual mean	31/12/2004
	0.25 μgm^{-3}	annual mean	31/12/2008
Nitrogen Dioxide	200 μgm^{-3} (105 ppb)	1 hour mean not to be exceeded more than 18 times a year	31/12/2005
	40 μgm^{-3}	annual mean	31/12/2005
PM_{10}	50 μgm^{-3}	24 hour mean not to be exceeded more than 35 times a year	31/12/2004
	40 μgm^{-3}	annual mean	31/12/2004
Sulphur Dioxide	350 μgm^{-3} (132 ppb)	1 hour mean not to be exceeded more than 24 times a year	31/12/2004
	125 μgm^{-3} (47 ppb)	24 hour mean not to be exceeded more than 3 times a year	31/12/2004
	266 μgm^{-3} (100 ppb)	15 minute mean not to be exceeded more than 35 times a year	31/12/2005

3 Current air quality

Nottingham City Council operates 1 automatic monitoring site, 11 Roadside Pollution Monitors, 4 NO_2 diffusion tubes and one semi automatic sulphur dioxide and smoke 8-port sampler. It provides Local Site Operators for the DETR AURN (Automatic Urban Rural Network) station, located in Clinton Street East (an urban centre). It also carries out its own monitoring at the mobile AQMS (Air Quality Monitoring Station) trailer, located in Sneinton Dale (an urban background). Their locations are shown in Appendix 1, together with the Ordnance Survey co-ordinates. See the technical annexe for information concerning their operation, calibration and other details.

Note. The Roadside Pollution Monitors although useful for determining trends, cannot be routinely calibrated and do not therefore fulfill the requirements of LAQM.TG1(00) 'Monitoring Air Quality'. The data acquired by them has therefore not been used in the Second and Third Stage review and assessment.

Monitored air quality from the continuous monitoring stations (AURN and AQMS) for 1999 and 2000 (provisional) compared with the Air Quality Objectives are detailed in Tables 2 and 3, pages 7 and 8.

These tables show that generally air quality objectives are being met. The annual mean for nitrogen dioxide, whilst being achieved in Sneinton, an urban background area, is being exceeded in the City Centre. Exceedances of the PM_{10}, 24-hour mean, and the sulphur dioxide 15-minute mean occur, however the relevant air quality objectives are being met.

Table 2

Current Air Quality - Monitored data compared with the Air Quality Objectives - AURN Clinton St, Urban Centre

AURN Clinton St East	Number of exceeds		Number of days with exceeds		Maximum value		Annual mean		% data Capture	
Pollutant and Objectives	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***
Particles, PM_{10} ug/m^3							25	24	97.1	98.3
Annual mean	Not Exceeded	Not Exceeded	n/a	n/a	n/a	n/a				
24 hour mean	9	5	9	5	60	113				
Nitrogen Dioxide ug/m^3							44	40	97.7	98.2
Annual Mean	Exceeded	Exceeded	n/a	n/a	n/a	n/a				
1 hour mean	0	0	0	0	132	168				
Sulphur Dioxide ug/m^3							13	17	81.1	96.4
15 minute mean	1	13	1	4	290	489				
1 hour mean	0	0	0	0	197	345				
24 hour mean	0	0	0	0	43	83				
Carbon Monoxide mg/m^3							0.6	0.45	97.1	98.2
8 hour running mean	0	0	0	0	3.4	5.8				
Ozone ug/m^3							33	29	98.1	98.4
8 hour running mean	53	26	7	4	156	138				

*based on provisional data n/a - not applicable

Table 3

Current Air Quality - Monitored data compared with the Air Quality Objectives - AQMS Sneinton Dale, Urban Background

AQMS Sneinton Dale	Number of exceeds		Number of days with exceeds		Maximum value		Annual mean		% data Capture	
Pollutant and Objectives	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***	**1999**	**2000***
Particles, PM_{10} ug/m^3							24	25	76.9	88.8
Annual mean	Not Exceeded	Not Exceeded	n/a	n/a	n/a	n/a				
24 hour mean	4	5	4	5	57	117				
Nitrogen Dioxide ug/m^3							36	36	73.7	88.8
Annual Mean	Not Exceeded	Not Exceeded	n/a	n/a	n/a	n/a				
1 hour mean	0	0	0	0	171	175				
Sulphur Dioxide ug/m^3							7	7	76.9	89.4
15 minute mean	6	21	2	7	435	514				
1 hour mean	0	0	0	0	237	405				
24 hour mean	0	0	0	0	41	71				
Carbon Monoxide mg/m^3							0.49	0.22	55.1	89.4
8 hour running mean	0	0	0	0	7.2	4.2				
Ozone ug/m^3							27	36	76.9	89.4
8 hour running mean	24	146	3	22	159	145				

*based on provisional data n/a - not applicable

4 Methodological approach to Second and Third Stage review and assessment

The original guidance LAQM.TG4(98) detailed a number of parameters which determined the need to proceed to a Second or Third Stage review and assessment (See First and Second Stage review & assessment document). These were replaced in LAQM.TG4(00). This latest guidance requires Local Authorities to '...immediately shift the focus of the remaining parts of the review and assessment to the new objectives.' The changes to the objectives for NO_2 and particles (PM_{10}) and LAQM.TG4(00), which introduced a further screening methodology, made a Second Stage review and assessment for NO_2 and PM_{10} appropriate in order to determine the need to proceed to a Third Stage review and assessment.

The guidance LAQM.TG4(00) advises that a Second Stage review and assessment 'can largely be based upon the application of simple screening methods, for example the Design Manual for Roads and Bridges (DMRB) model for roads, and the Environment Agency's Guidance for Estimating the Air Quality Impact of Stationary Sources for industrial processes. Wherever possible, local measurements should be taken into account to refine the estimates of both existing and future air quality.'

It also goes on to state 'How many and which areas, if any, local authorities select for Second Stage assessment will be up to them, but....this is meant to be a **precautionary approach**. If an authority meets an air quality objective in an area where the highest pollutant concentrations are likely, and there is no significant risk that it will not continue to meet it, it can be confident that it will not need an AQMA. If, however, this process indicates that, in any relevant area, the authority is not meeting an air quality objective, or the objective might be exceeded in future the authority should go to the Third Stage.

Two models have been used for the Second Stage review and assessment process.

Design Manual for Roads and Bridges (DMRB) 1999 + 2000 supplement.

DMRB is a screening tool for predicting the effect on air pollution caused by vehicle emissions. This model was used to estimate pollutant concentrations at chosen receptor points. Information on road traffic composition, volume and speed; the distance of receptors from the centre of the carriageway with their distances from the kerbside and background pollutant concentrations was required. See Appendix 3.

The spreadsheet available from www.stanger.co.uk/airqual/modelhlp/ was used. Nottingham City had identified a number of assessment areas where it was considered that road traffic and industry may lead to an exceedance of the annual mean objectives for NO_2 and PM_{10}.

Only some of the assessment areas were likely to have an exceedance caused solely by road traffic, however, it was considered prudent to undertake a screening exercise using DMRB for all the assessment areas.

Atmospheric Dispersion Modelling System (ADMS-Urban) v1.53,
(Cambridge Environmental Research Consultants (CERC)).

ADMS-Urban is an advanced dispersion model. Information can be input on traffic composition, flows and speeds; industrial, domestic and road traffic sources, background monitoring data and meteorology. The model can be used for predicting concentrations for single point sources or for complex urban areas. The output can be displayed as contour plots.

For the screening aspect of this review and assessment, ADMS-Urban was used in a similar way to DMRB i.e. the annual mean concentration from traffic alone was determined and added to the background pollutant concentrations. Road traffic data as described in the Emissions Inventory section of the technical annexe was used.

Monitored data, together with modelled concentrations from ADMS and predicted concentrations from DMRB were used for this stage because:-

1. Monitoring can assist in demonstrating whether there is a significant risk of an Air Quality Objective being exceeded in a relevant location,
2. Monitoring provides evidence of compliance with the Air Quality Objectives,
3. DMRB allows the prediction of pollutant concentrations at specific locations,
4. ADMS allows a large geographic area to be 'modelled' in a single program 'run', and thus allows a larger area to be assessed in a significantly shorter time scale. This model also allows concentrations at specific locations to be predicted.

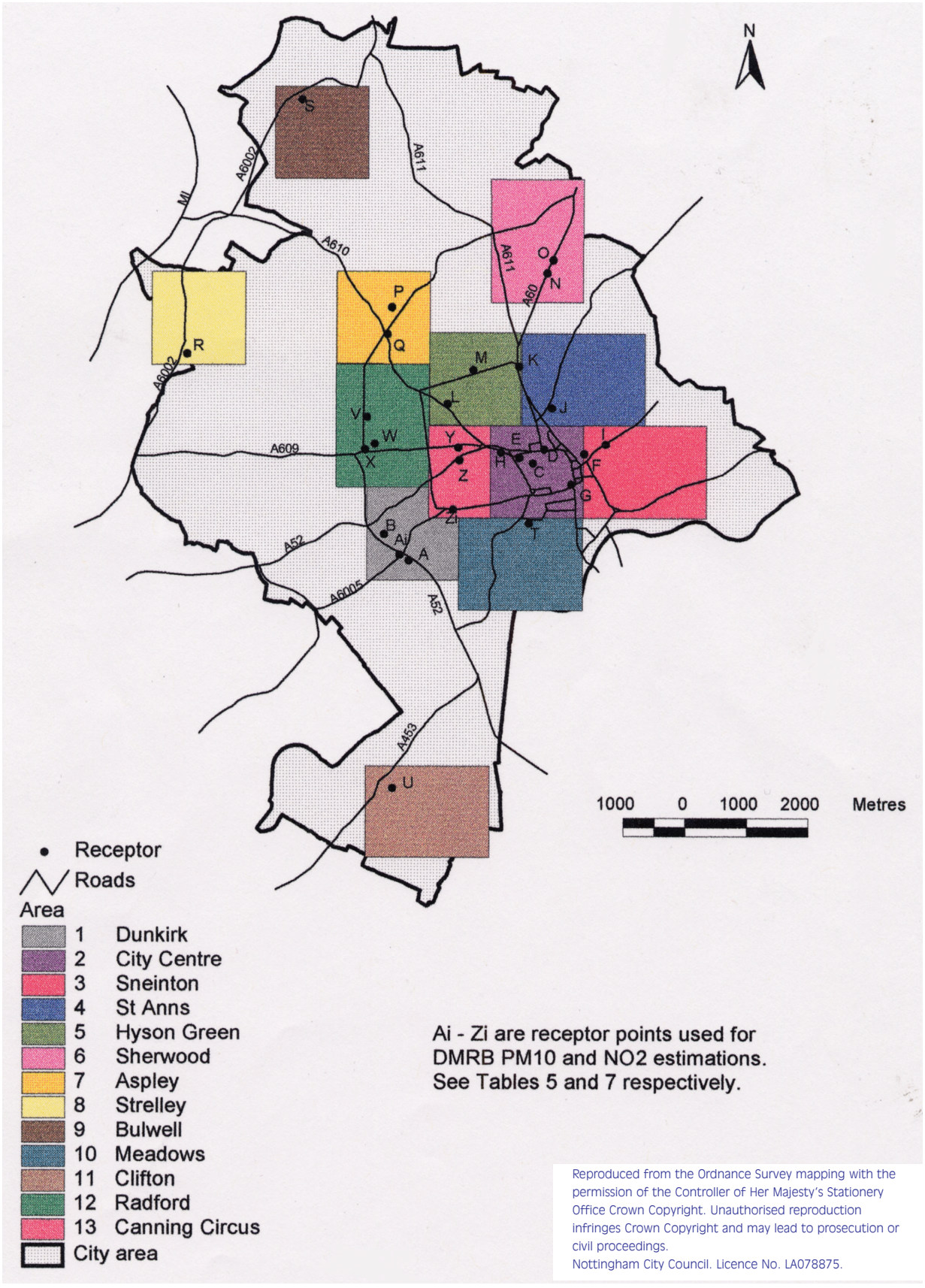
By using local measurement data, ADMS and DMRB, Nottingham City considered 13 geographically large areas in detail (between 9 and 12 km^2 each), whose characters encompassed some or all of the review and assessment criteria. Figure 1 page 11 defines these areas and the receptor points used for DMRB and ADMS.

For the third stage review and assessment , complex ADMS-Urban modelling was used for the final sulphur dioxide, PM_{10} and nitrogen dioxide 2004/5 predictions. The model calculates both annual means and percentiles that can be directly compared with the Air Quality Objectives. Road traffic information, area and industrial sources, meteorology as well as monitored background pollutant levels from an AURN rural site were included.

LAQM.TG4(00) recommends 'apparent under or over prediction may be taken into account... ...by means of an explicit adjustment to the predicted concentrations'. The model was found to underestimate concentrations and the adjusted predicted concentrations are reported herein. The unadjusted concentrations are shown in appendices 5 and 6a.

See the technical annexe for more information on these models, and the approach used for the advanced modelling and model validation.

Figure 1
Assessment areas and receptor locations



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4.1 Emissions Inventories prepared for Second and Third Stage review and assessment.

In order to predict the concentration of a pollutant at a given point in time it was necessary to have information detailing its release to, and transformation within, the atmosphere. This information came from an emission inventory that identified the sources of each pollutant.

Nottingham City has compiled a number of emissions inventories. Figure 2 (page 13) shows the locations of the sources.

4.2 Point Source Emission Data

Point sources, for example chimneys, usually serve boiler plant or large industrial processes. The information compiled for the inventory was calculated from data supplied by site operators using either: -

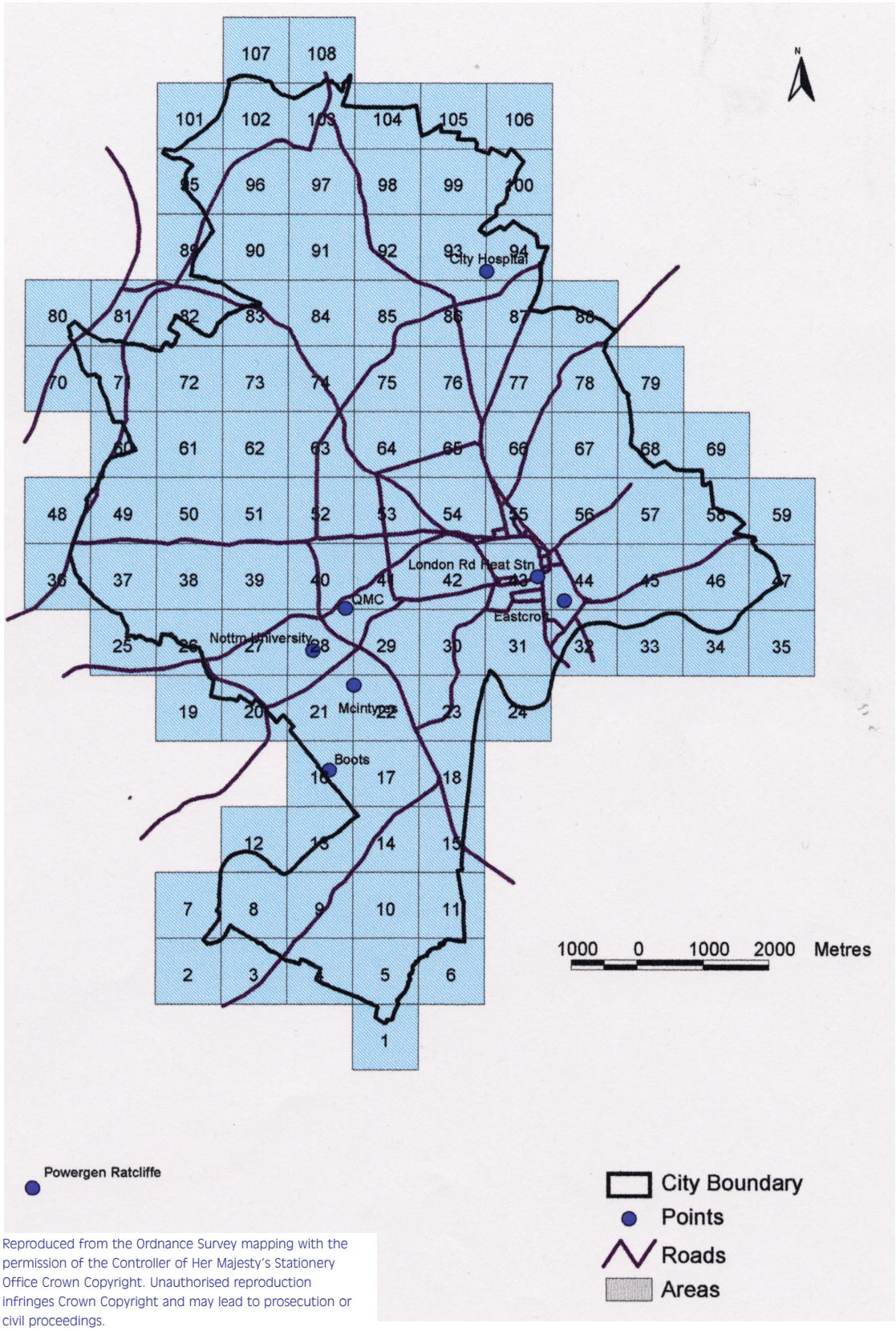
i. direct measurement of pollutant concentrations in the stack gases or
ii. estimate of pollutant emissions, based upon the type of fuel and consumption.

All point sources used are detailed in Appendix 2.

4.3 Area Source Emission Data (required for Third Stage)

For Third Stage detailed modelling purposes it is important to include sources that may contribute to a pollutant's concentration. Area source emission data for 'domestic' and 'other industrial sources' were therefore obtained and used in the model. These data were obtained from the National Emissions Inventory at http//www.aeat.co.uk/netcen/airqual/.

Figure 2
Positions of road, area and point sources included in the emissions inventory



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4.4 Line Source Emission Data

The term 'line source' is used for emissions from motor vehicles and trains. The First Stage review and assessment determined that rail traffic in the City of Nottingham was not likely to contribute to an exceedance of an air quality objective.

With respect to road traffic, Nottingham City does not currently have a traffic/transport model and traffic flows have been obtained from traffic counts. Vehicle speeds were either measured, where practicable, or estimated.

The majority of the information was gathered and supplied by Nottingham City Council's Transportation Section and Pollution Control Section.

4.5 Background Pollutant Concentrations

A pollutant's concentration at a given location and time is a combination of local emissions from point, line and area sources and those transported from distant sources. The emissions from distant sources contribute to the background concentration, i.e. the concentration of a pollutant that would be measured in the absence of local sources.

For the Second Stage screening/modelling exercise both DMRB and ADMS require background pollutant concentrations. LAQM.TG4(00) was followed and background concentrations were obtained from the NETCEN web site at www.aeat.co.uk/netcen/airqual.

Figures 3 and 4 (pages 16 and 17) show the background concentrations for particles and nitrogen oxides respectively.

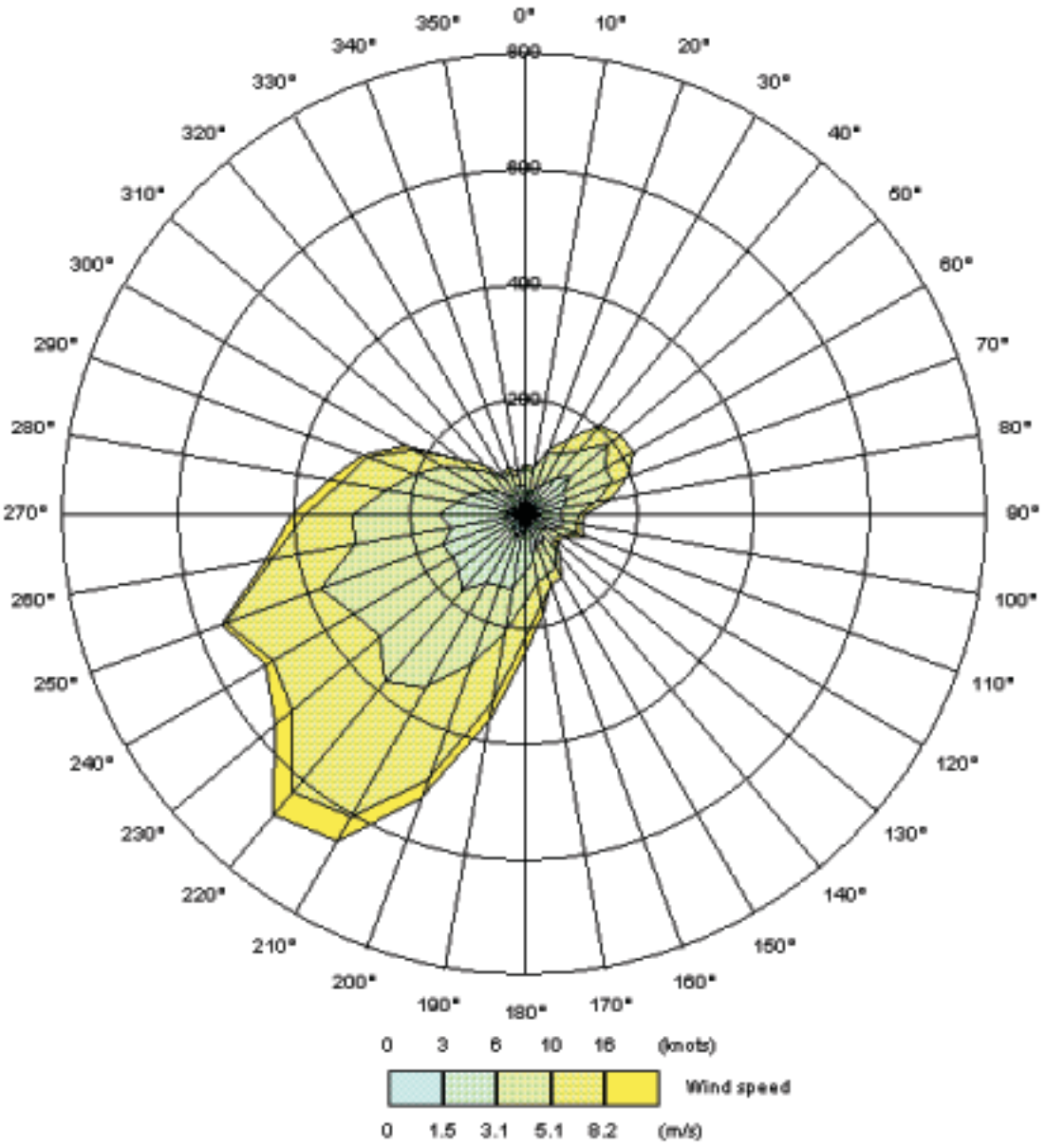
For the Third Stage complex modelling, the monitoring data from the AURN monitoring site at Rochester upon Medway (the most appropriate rural site that measured all the pollutants of concern) was used. The monitoring carried out by Nottingham City Council relates to the urban environment and may not be considered background.

4.6 Meteorology

ADMS Urban requires detailed meteorological information.

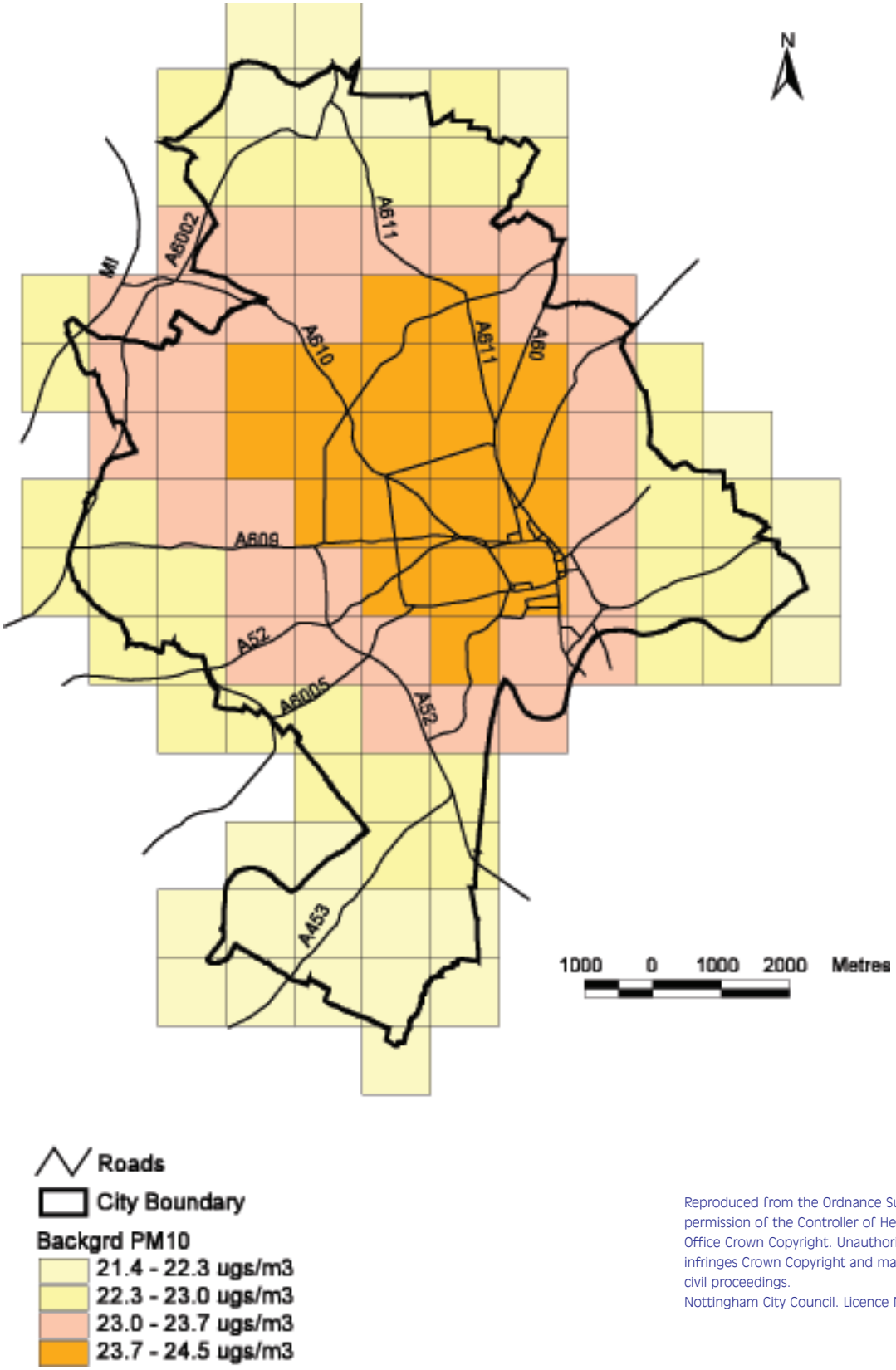
The Watnall station ceased measuring meteorological data with the required parameters in 1995. Special data sets, called Numerical Weather Prediction (NWP) data, have been compiled by the Meteorological Office for the Nottingham City area for 1998 and 1999. Figure 5 details the 1999 NWP data as a 'wind rose'. (See the technical annexe for further information.)

Figure 5
Nottingham Windrose 1999 (using numerical weather preduction data)



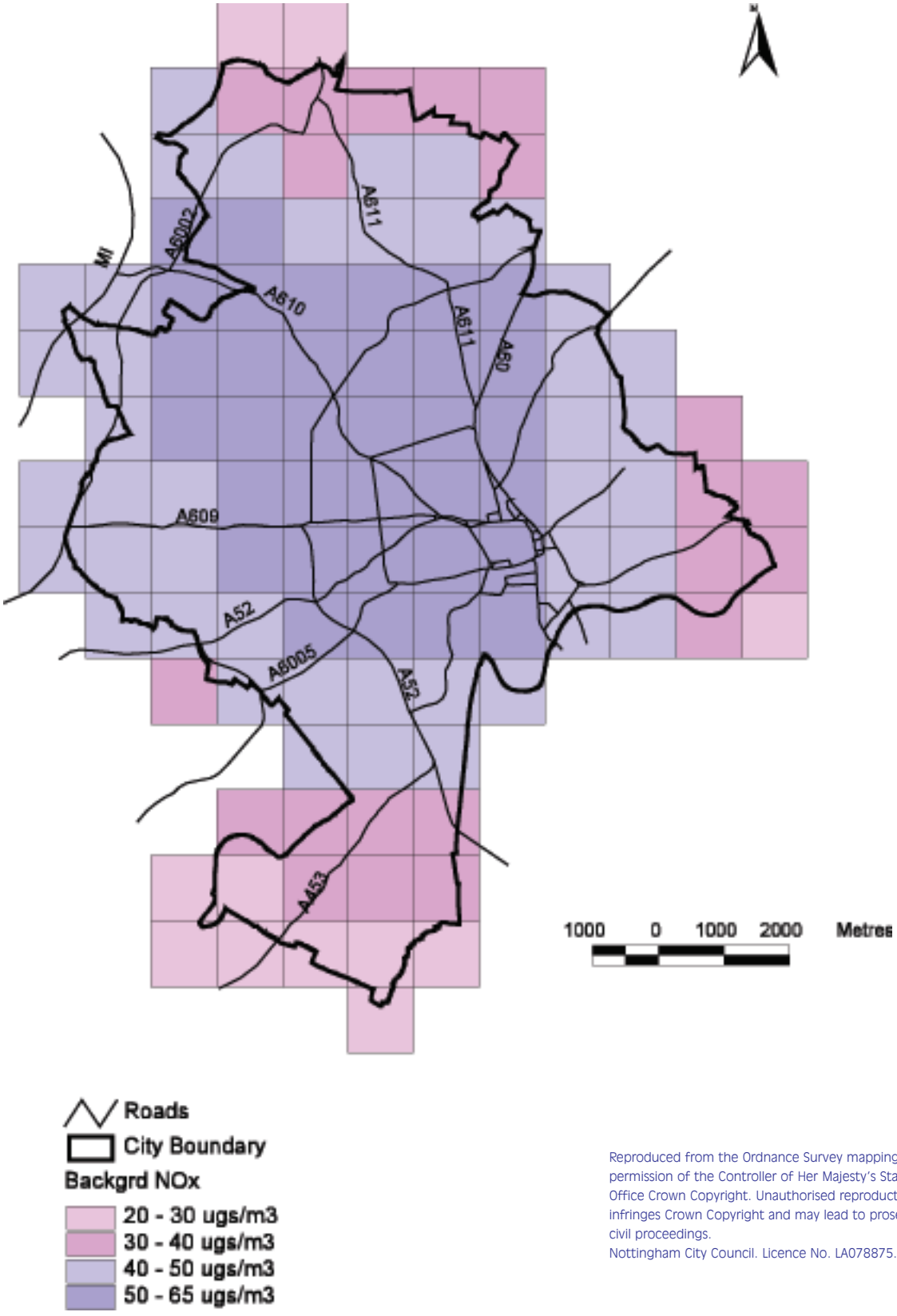
The wind rose shows the direction the wind was coming from and the associated wind speed. The numbers on the radial axis are the number of hours, each wind direction, occurred in the year.

Figure 3
Background PM_{10} Concentrations 2004



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Figure 4
Background Nitrogen Oxides Concentrations 2005



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5.0 Review & Assessment of Particles (PM_{10})

The review and assessment of particles (PM_{10}) was focussed on the following near ground level outdoor locations: -

- background locations
- roadside locations (i.e. sites close to the facade of a building) where there is housing, and
- other areas where a person might reasonably be expected to be regularly exposed to outdoor air for a substantial part of the day (e.g. in the vicinity of housing particularly gardens of residential property, schools or hospitals, etc.), over the relevant averaging time of the objective.

The contribution to ambient concentrations of particles from different sources will not remain uniform between the current monitoring year and 2004, and it is not therefore possible to simply extrapolate existing monitoring data to predict future levels. Suspended particulate matter comprises primary, secondary and coarse components. Only the 'primary' component is of significance in terms of local emissions. The 'secondary' and 'coarse' components can therefore be removed and added back in once the future predictions from local sources have been performed.

The guidance contained within LAQM.TG4(00) May 2000 states 'If the estimated annual mean background concentration in 2004 exceeds 28ug m-3, gravimetric,...' local authorities should proceed to a Third Stage review and assessment.

A screening exercise, to determine areas where the annual mean PM_{10} and 90th percentile concentrations might be exceeded was carried out using both DMRB and ADMS.

5.1 Monitoring results

Table 4

Particles, PM_{10} monitoring data from the ambient monitoring stations - 1997 to 2000.

	Annual Mean ugs/m^3	24hr Mean Number of Daily Exceeds	90th percentile ugs/m^3	Data Capture %
1997				
AURN	30	31	52	96.7
AQMS Dunkirk	34	49	62	92.8
1998				
AURN	27	21	47	98.3
1999				
AURN	25	9	40	97.1
AQMS Sneinton Dale	24	4	37	76.9
2000				
AURN*	24	5	35	98.3
AQMS* Sneinton Dale	25	5	36	88.8

*Provisional data AQMS was sited at different locations in 1998

It can be seen from the four years of monitoring data that the annual mean air quality objective has been met at all monitoring sites. Whilst exceedances of the 24-hour mean have occurred at the urban centre (Clinton Street East) and urban background (Sneinton) sites the air quality objective has been achieved.

In 1997 the AQMS was located approximately 15 metres from the Dunkirk fly-over and may be considered a kerbside/roadside site. There were 49 exceedances of the 24-hour mean.

5.2 Background PM_{10} concentrations

The guidance recommends the use of actual measurement data wherever these are available. The 2004 predicted annual mean background PM_{10} at Sneinton was calculated as 22.01 μgm^{-3} using the 1999 annual mean and the methodology in Box 8.5 LAQM.TG4(00). The corresponding value from the Internet maps was 23.2 μgm^{-3}. Estimated background PM_{10} concentrations vary across the City (Figure 3 page 16) and as actual data are not available for each of the screened/modelled areas the Internet background PM_{10} concentrations were used. These are specified as 1 km^2 grid and because each of the screened/modelled areas exceeded 1 km^2 an averaged background PM_{10} concentration for each assessment area was used. These are shown in Appendix 4.

5.3 Domestic Solid fuel use

The impact of domestic solid fuel was evaluated using the method recommended in LAQM.TG4(00). Annual mean black smoke for 1998-1999, 1999-2000 were 9 and 7 μgm^{-3} respectively and it was determined there was no need to proceed further.

5.4 Road Traffic

LAQM.TG4(00) requires the annual mean PM_{10} concentration to be estimated for 2004 at relevant locations close to those sections of the road network identified from the First Stage review and assessment as being of potential concern. It allows predictions to be made using DMRB, or any other appropriate screening model.

For each relevant location it was necessary to calculate the total annual mean concentration arising from the 'primary component'. Where it is predicted to be greater than 28 μgm^{-3} there is a risk of the objective being exceeded and a requirement to proceed to the Third Stage review and assessment.

5.5 Part A and Part B prescribed processes

There is one Part A process that lies in an area where the annual mean concentration of particles from primary sources is likely to exceed 28μgm^3.

5.6 Combined Source Impacts

A combined source impact was considered. Although not lying immediately adjacent to a major road, a Part A process was identified and included in the Stage Three modelling.

5.7 Uncontrolled and Fugitive Dust Emissions

There are no identified sources of uncontrolled or fugitive dust emissions in, or adjacent to the City of Nottingham (see First and Second Stage review and assessment). This did not therefore require further consideration.

5.8 Results

DMRB was used to predict concentrations at specific sensitive locations. ADMS screening was used to ensure a reasonable coverage of the City. Where ADMS receptor concentrations approached 28 μgm^{-3} DMRB calculation was also undertaken as a precautionary approach. The results of the DMRB calculations are shown in Table 5 (page 22).

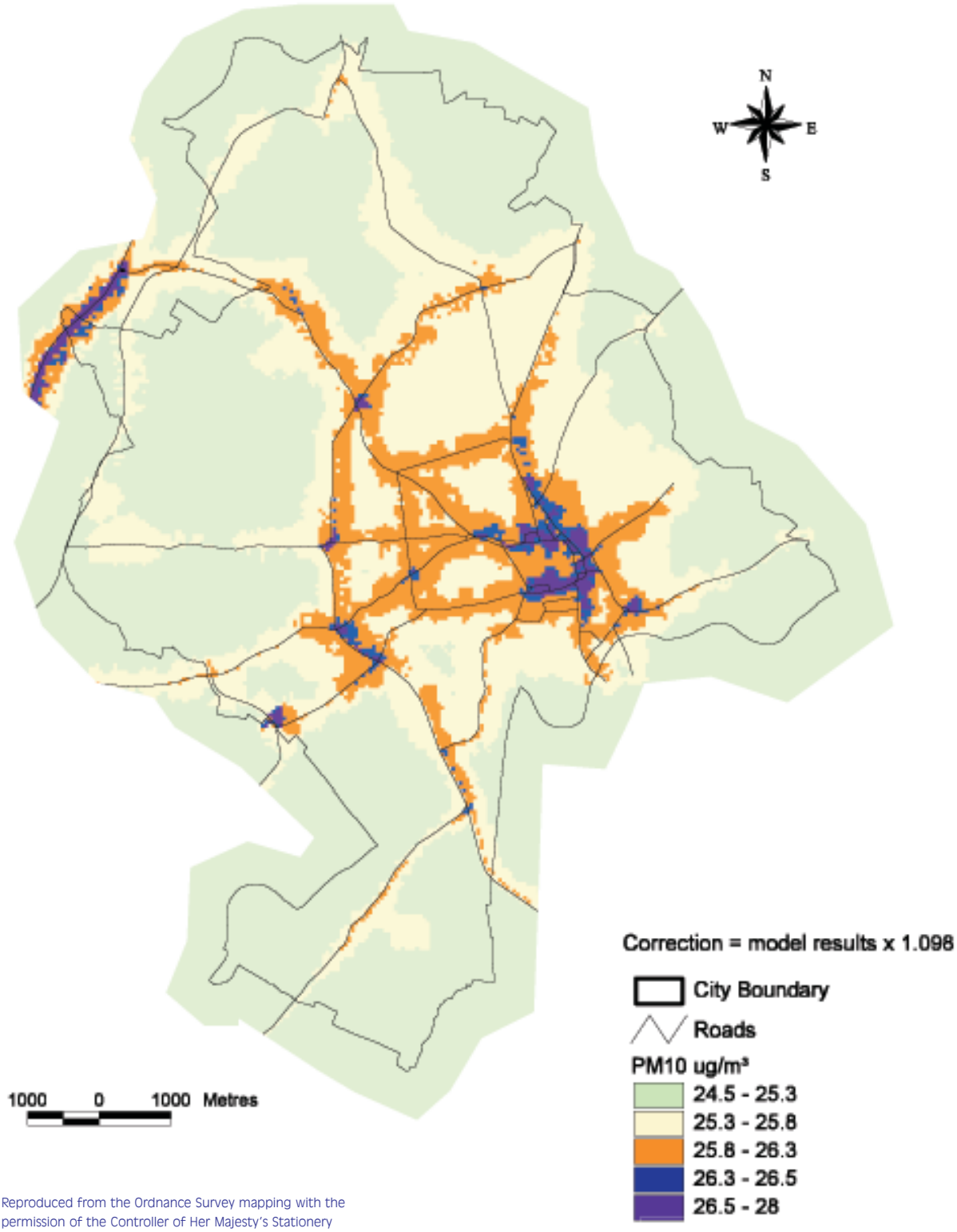
The screening exercise identified a number of road junctions where exceedances may occur. Road traffic surveys were undertaken to provide more detailed information about vehicle speeds and included in the City wide advanced modelling. The results are shown in Figure 6 (page 23) from which it is predicted that there will be no exceedances of the annual mean air quality objective in 2004.

The complex modelling predicts that the 90th percentile (which approximates to 35 exceedances of the 24-hour mean) is 46 μgm^{-3}, and therefore the 24-hour mean AQ Objective is unlikely to be exceeded.

Table 5 DMRB predicted PM_{10} concentrations for 2004 at various receptors

Area	Receptor ID	Receptor Type	DMRB PM_{10} ugs/m^3
1	Ai	Garden	27.8
	A	School	26.4
	B	Hospital	25.2
2	C	Market Square	24.3
	D	Victoria Centre	27.3
	E	Chapel Bar	25
	F	Market	24.4
	G	Garden	28.8
	H	School	26.4
3	I	School	24.5
4	J	School	24.6
5	K	Garden	27.3
	L	School	27.4
	M	School	24.9
6	N	Street	26.2
	O	Street	26.2
7	P	School	24.4
	Q	Garden	28.2
8	R	School	23.3
9	S	Playing Field	23.1
10	T	Nursery	24.1
11	U	School	22.3
12	V	School	27.8
	W	School	24.4
	X	Garden	29.7
13	Y	School	25.3
	Z	Garden	25.4
	Zi	Street	26.4

Figure 6
2004 Predicted Annual Mean Particle, PM_{10} Concentrations
(model correction applied)



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5.9 Conclusion

The monitoring results for PM_{10} for 1998 to 2000 show that in the City Centre and Sneinton the Air Quality Objectives are being met.

The screening exercise and detailed modelling determined that it was highly unlikely that locations in the City area would experience an exceedance of the Air Quality Objectives in 2004 and beyond. It is not necessary to declare any Air Quality Management Areas.

6 Review and Assessment of Nitrogen dioxide (NO_2)

The Second Stage review and assessment was undertaken according to the revised guidance contained in LAQM.TG4(00) and was focused on the following near ground level outdoor locations: -

- background locations, where members of the public might be regularly exposed,
- building facades of residential properties, schools, hospitals,libraries
- gardens of residential properties,
- kerbside locations (e.g. pavements of busy shopping streets) and
- any outdoor location to which the public might reasonably expected to have access.

The guidance contained within LAQM.TG4(00) May 2000 states the Second Stage review and assessment 'can largely be based on the application of simple screening modelling methods' and 'Wherever possible, local authorities are encouraged to use local measurements to refine the estimates of ... ... air quality.'

6.1 Monitoring Results

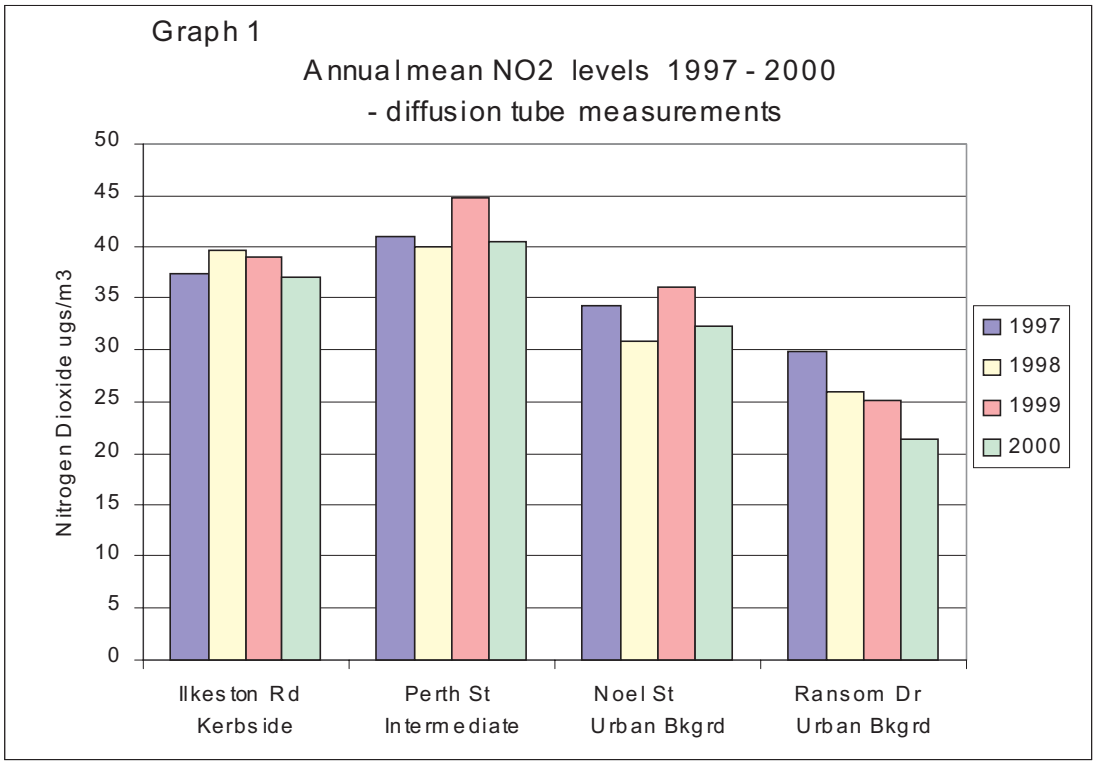
Table 6 Nitrogen dioxide, NO_2 monitoring data from the ambient monitoring stations 1997 to 2000.

	Annual Mean ugs/m^3	1 hr Mean Number of Exceeds	99.8th percentile ugs/m^3	Data Capture %
1997				
AURN	49	0	128	58.4
AQMS Dunkirk	40	0	139	93.5
1998				
AURN	47	0	117	93.8
1999				
AURN	44	0	92	97.7
AQMS Sneinton Dale	36	0	135	73.7
2000				
AURN*	40	0	103	98.2
AQMS* Sneinton Dale	36	0	134	88.8

*Provisional data AQMS was sited at different two locations in 1998.

For the four years from 1997 to 2000 the annual mean air quality objective for NO_2 at Clinton Street East (urban centre) was exceeded. For the 2 years for 1999 to 2000 the annual mean air quality objective for NO_2 at Sneinton (urban background) was not exceeded. An exceedance of the annual mean air quality objective occurred at the kerbside/roadside site at Dunkirk.

There have been no monitored exceedances of the 1-hour objective at any of the sites throughout the four-year period.



The Perth Street site is located approximately 200 metres north of the AURN station and shows similar concentrations to the AURN station.

It can be seen that neither the roadside site nor the urban background sites concentrations exceed the annual mean air quality objective.

There appears to be little 'year on year' variation at the sites except Ransom Drive where the trend is a gradual reduction.

6.2 Background NO_2 concentrations

For the DMRB screening exercise the estimated annual mean background NOx concentrations for 2005 were obtained from the Internet address: www.aeat.co.uk/netcen/airqual. See Figure 4 (page 17).

Following consultation with the former DETR the background concentrations for 2005 were predicted using DETR's guidance. The calculated reduction in background concentrations were then used in the 2005 Third Stage advanced dispersion modelling. See Technical Annexe for details of the calculations.

6.3 Road traffic

For the review and assessment of the annual mean objective, predictions were carried out for relevant roadside locations. The spreadsheet available from www.stanger.co.uk/airqual/modelhlp/ was used to determine the NOx contribution from road traffic. This uses the methodology recommended in LAQM.TG4(00). The spreadsheet also estimates the annual mean NO_2 concentrations for 2005.

6.4 Industrial sources

Sources identified as relevant to the Second and Third Stage review and assessment, are detailed in Appendix 2. These sources lie in close proximity to receptors where the annual mean concentration of NO_2 is calculated as likely to exceed 40 μgm^{-3}.

6.5 Combined Source Impacts

Combined source impacts were considered in the Third Stage modelling.

6.6 Results

DMRB was used to predict concentrations at specific sensitive locations/receptors where people are likely to be exposed for the period of the objective. The results are detailed in Table 7 (page 29).

ADMS screening was used to ensure a reasonable coverage of the City. Where ADMS receptor concentrations approached 40 μgm^{-3} DMRB calculation was also undertaken as a precautionary approach. The screening exercise identified a number of areas that required more detailed vehicle speed information. This was incorporated into the Third Stage complex modelling.

The Second and Third Stage complex modelling submitted for consultation covered the whole city area and indicated likely exceedances over a large area (Appendix 6b) of the City centre, ring road and major junctions when compared with the detailed modelling reported herein.

The complex modelling undertaken in light of the former DETR's comments focused on a smaller area encompassing the outer ring roads and main junctions, on the basis that the predicted reduction in background pollution levels in 2005 would reduce the area of likely exceedance. It had already been determined that there were no sensitive locations in areas of likely exceedance outside the area shown in Fig 7 (page 30).

It was determined from the complex modelling that the 99.8th percentile, which approximately corresponds to 18 exceedances of 1-hour mean objective of 200 μgm^{-3}, is unlikely to be exceeded and that the annual mean objective was likely to be exceeded in some areas.

Table 7 DMRB predicted NO_2 and NOx concentrations for 2005 at various receptors

Area	Receptor ID	Receptor Type	DMRB NO_2 ugs/m^3	DMRB NOx ugs/m^3
1	Ai	Garden	63.5	157.1
	A	School	54.8	127.3
	B	Hospital	44.4	97.7
2	C	Market Square	32.2	63.2
	D	Victoria Centre	50.8	131.0
	E	Chapel Bar	37.2	76.8
	F	Market	33.1	65.5
	G	Garden	65.9	170.9
	H	School	44.9	117.1
3	I	School	39.0	79.5
4	J	School	34.4	69.1
5	K	Garden	49.8	126.5
	L	School	48.1	132.7
	M	School	35.6	72.4
6	N	Street	42.0	104.2
	O	Street	44.6	105.2
7	P	School	27.5	50.6
	Q	Garden	57.1	145.6
8	R	School	27.9	52.0
9	S	Playing Field	26.3	47.8
10	T	Nursery	33.6	66.9
11	U	School	22.0	37.8
12	V	School	33.2	65.7
	W	School	34.3	68.7
	X	Garden	75.7	201.9
13	Y	School	39.3	85.2
	Z	Garden	40.8	83.1
	Zi	Street	43.2	93.5

Figure 7
2005 Predicted Annual Mean Nitrogen Dioxide concentrations
(model correction applied)



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6.7 Conclusion

In the City Centre, both the AURN and diffusion tube data show that, for 1997 to 2000, the annual mean NO_2 air quality objective has been exceeded. At the AQMS Sneinton and the remaining diffusion tube sites the annual mean NO_2 AQ Objective has been and is being met.

During the last four years there has not been a monitored exceedance of the 1-hour mean NO_2 AQ Objective. The screening exercise and complex modelling predicted that no locations in the City area would experience an exceedance of the 1-hour mean NO_2 AQO in 2005 and beyond.

Complex modelling predicted a likely exceedance of the NO_2 annual mean Air Quality Objective in the City Centre area and along part of the A52 between Derby Road and Abbey Road/Dunkirk junctions (Fig 7, page 30).

Therefore Air Quality Management Areas are required.

7 Third Stage review and assessment of sulphur dioxide (SO_2)

Following the Stage One and Stage Two consultation a single combustion plant was identified and evaluated as likely to cause an exceedance of the air quality objective for SO_2.

Monitoring is carried out in the City Centre and Sneinton. These sites are too remote from the identified source to provide relevant monitoring results.

See technical annexe for parameters used in the ADMS advanced modelling exercise.

7.1 Results

The Air Quality Objectives can be represented as the following percentile values:-

The 15-minute mean of no more than 35 exceedances of concentration of 266 μgm^{-3} equates to the 99.9th percentile. Figure 8a (page 33).

The 1-hour mean of no more than 24 exceedances of concentration of 350 μgm^{-3} equates to the 99.7th percentile. Figure 8b (page 34).

The 24-hour mean of no more than 3 exceedances of concentration of 125 μgm^{-3} equates to the 99.2th percentile. Figure 8c (page 35).

ADMS modelling predicts exceedances of the objectives for the 15-minute, 1-hour and 24-hour means in the vicinity of the City Hospital.

The Air Quality Objectives are health based and are averaged over short time periods. Short lived meteorological conditions can trap pollutants and bring them down to ground level, for example a temperature inversion resulting from a combination of low wind speeds and a cloudless sky. The modelling results in Figures 8a, 8b, and 8c show the predicted concentrations and geographical extent when these infrequent weather conditions occur.

Note:
Exceptional meteorological conditions may occasionally give rise to short lived elevated concentrations of SO_2 which may not be attributable to local sources. This occurred on the 2nd September 1998 and is the subject of a report by the Environment Agency.

7.2 Conclusion

An Air Quality Management Area is required in the vicinity of the City Hospital.

Figure 8a
2005 Predicted maximum 15min Mean (99.9%ile) Sulphur Dioxide Concentrations

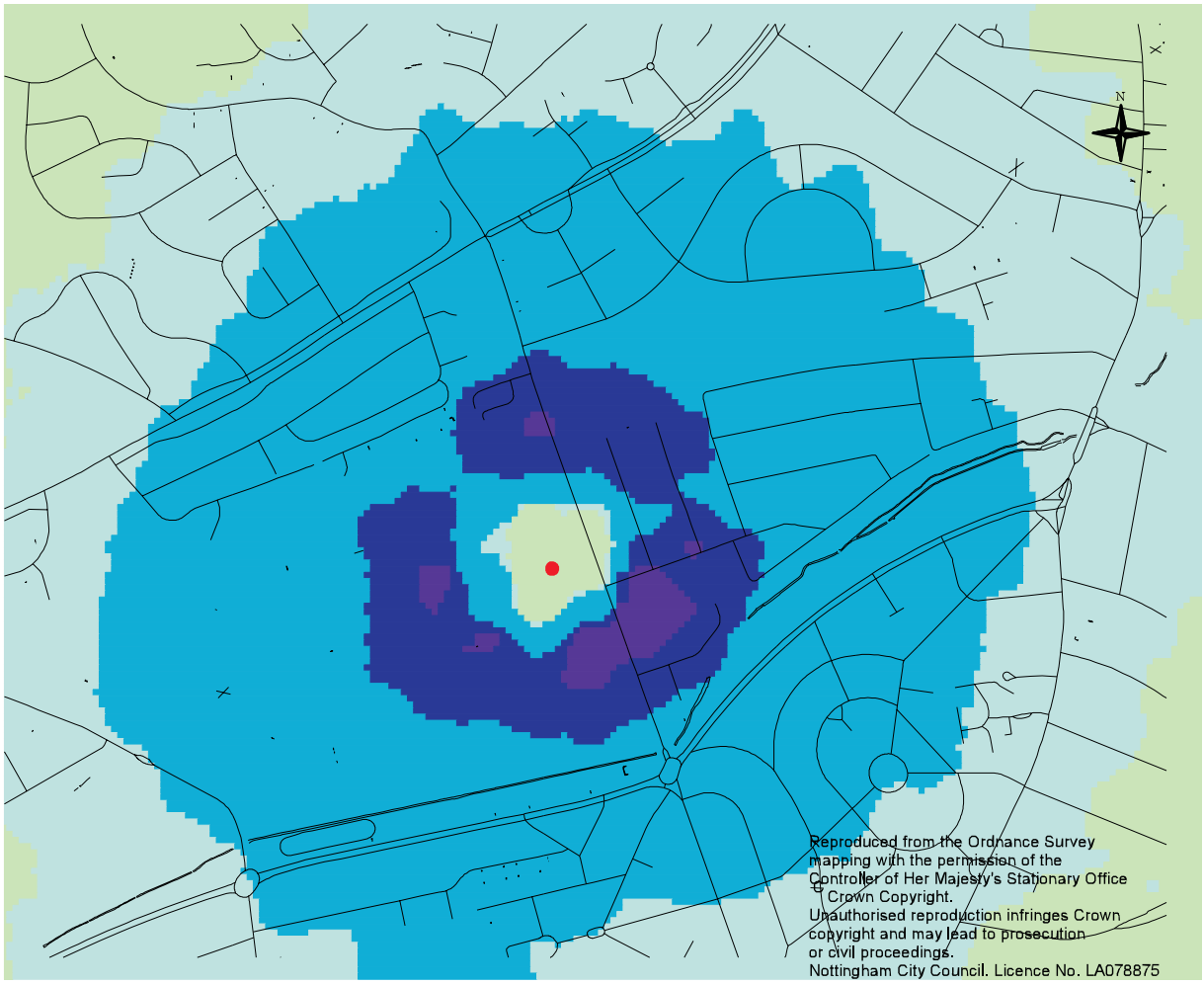
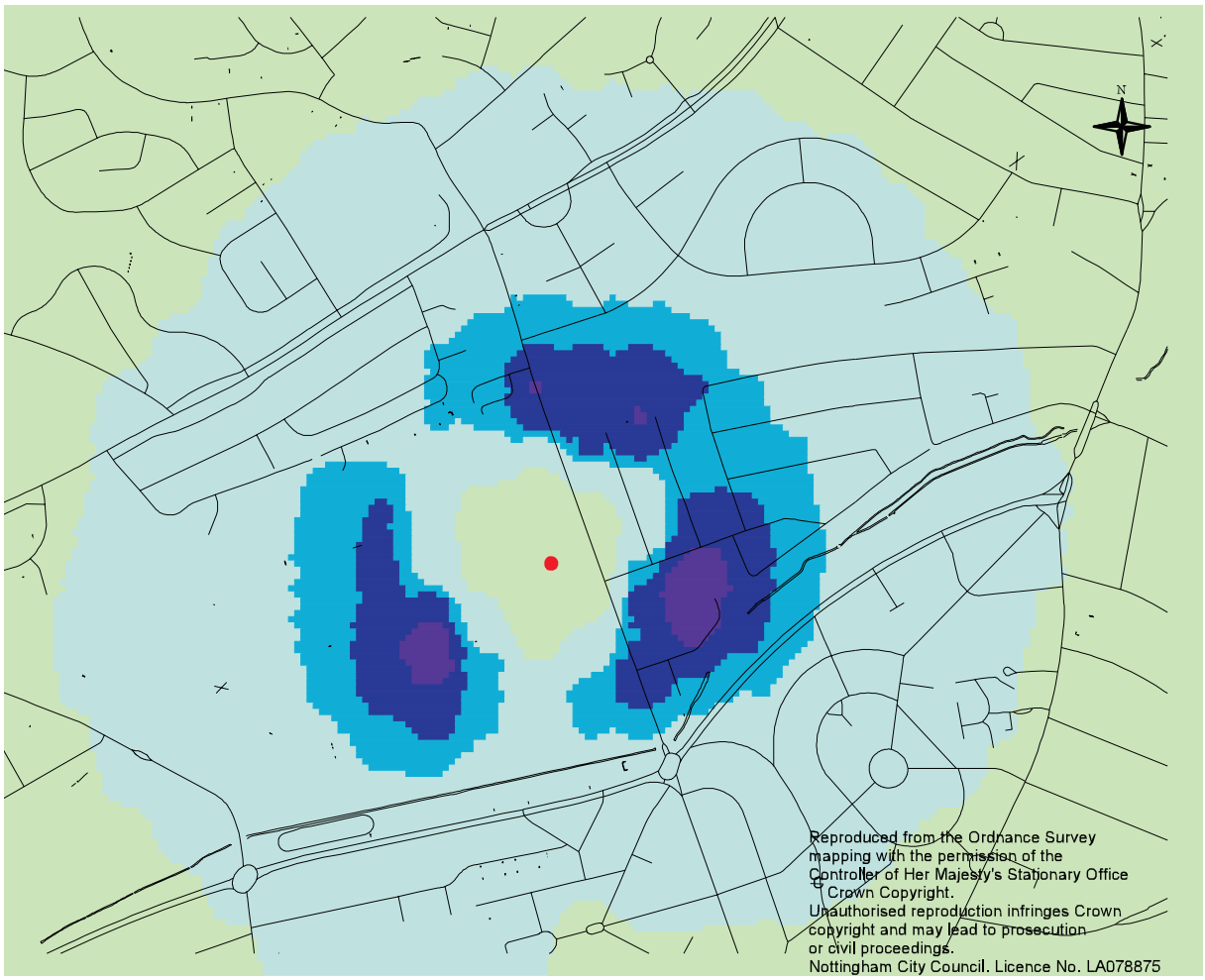


Figure 8b
2004 Predicted maximum 1 hr Mean (99.7%ile) Sulphur Dioxide Concentrations

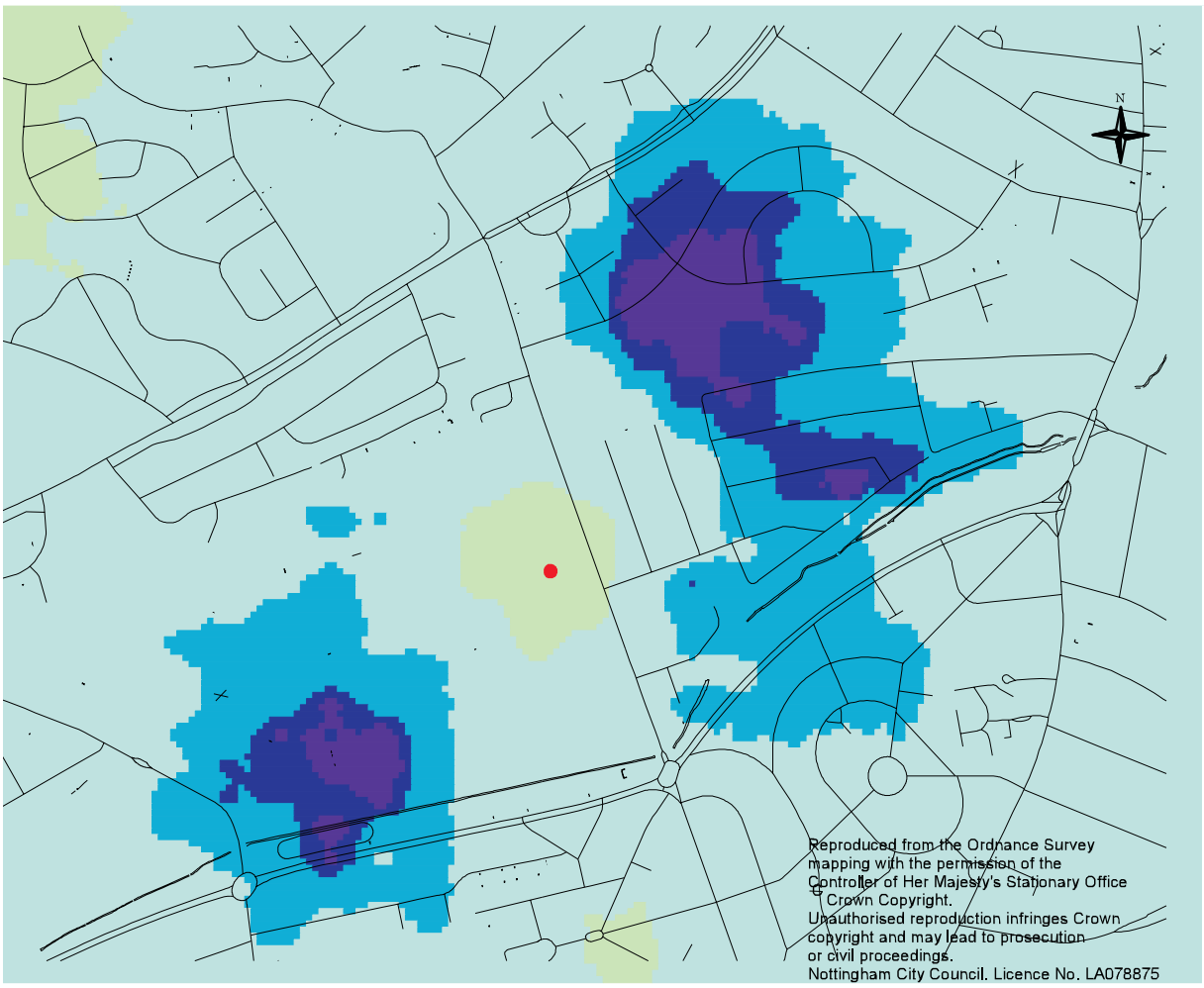


500 0 500 Metres

Chimney
Centre roads

SO2 99.7%ile ug/m³
0.2 - 200
200 - 350
350 - 400 exceeds AQO
400 - 450 exceeds AQO
450 - 500 exceeds AQO

Figure 8c
2004 Predicted maximum 24 hr Mean (99.2%ile) Sulphur Dioxide Concentrations



8.0 Air Quality Review and Assessment Process: Summary

The City of Nottingham's Three Stage review and assessment of air quality determined the following:-

8.1 Benzene (C_6H_6)

A single significant source was identified, which may give rise to fugitive emissions. Monitoring undertaken by Gedling City Council during 1998 in the vicinity of the source measured an average annual concentration of 2.3 μgm^{-3} (0.71 ppb). The air quality objective for benzene is 16.25 μgm^{-3} (5 ppb). No increases in fugitive emissions from this single significant source are predicted. It is therefore unlikely that the air quality objective for benzene will be exceeded.

8.2 1,3 Butadiene (C_4H_8)

Road transport emissions were the only source of 1,3 butadiene identified by the First Stage review and assessment. Existing national policies are expected to deliver the prescribed air quality objective for 1,3 Butadiene.

It is therefore unlikely that the air quality objective for 1,3 butadiene will be exceeded.

8.3 Lead (Pb)

No Part A, Part B processes, or other significant sources of lead were identified by the First Stage review and assessment process. Furthermore existing national policies are expected to deliver the prescribed air quality objective for lead. It is therefore unlikely that the air quality objective for lead will be exceeded.

8.4 Carbon monoxide (CO)

The review and assessment process identified traffic on a number of roads, and other significant sources of CO. However, monitored and predicted levels are significantly lower than the 2003 air quality objective of 11.6 mgm-3 (10ppb) expressed as the maximum 8-hour mean for both urban background sites and roadside locations.

There are no known proposed developments in or near Nottingham likely to significantly increase CO concentrations, nor are future predicted increases in traffic flow likely to significantly increase CO concentrations. It is therefore unlikely that the air quality objective for carbon monoxide will be exceeded.

8.5 Sulphur dioxide (SO_2)

The review and assessment process identified a single significant source of SO_2. Subsequent modelling predicts likely exceedances of the air quality objectives for the 15-minute, 1-hour and 24-hour means.

It is therefore proposed that an Air Quality Management Area be designated in the vicinity of the area highlighted in Figure 9 (page 38).

8.6 Particles (PM_{10})

The review and assessment process identified traffic on a number of roads and other significant sources. Predicted concentrations however, are lower than the 2004 air quality objectives of 50 μgm^{-3} 24-hour mean and the 40 μgm^{-3} annual mean and no further action for this pollutant is required.

8.7 Nitrogen dioxide (NO_2)

Complex modelling predicts that the air quality objective for the annual mean of 40 μgm^{-3} will be exceeded in a number of areas.

It is predicted that the air quality objective for the 1-hour mean of 200 μgm^{-3} will not be exceeded.

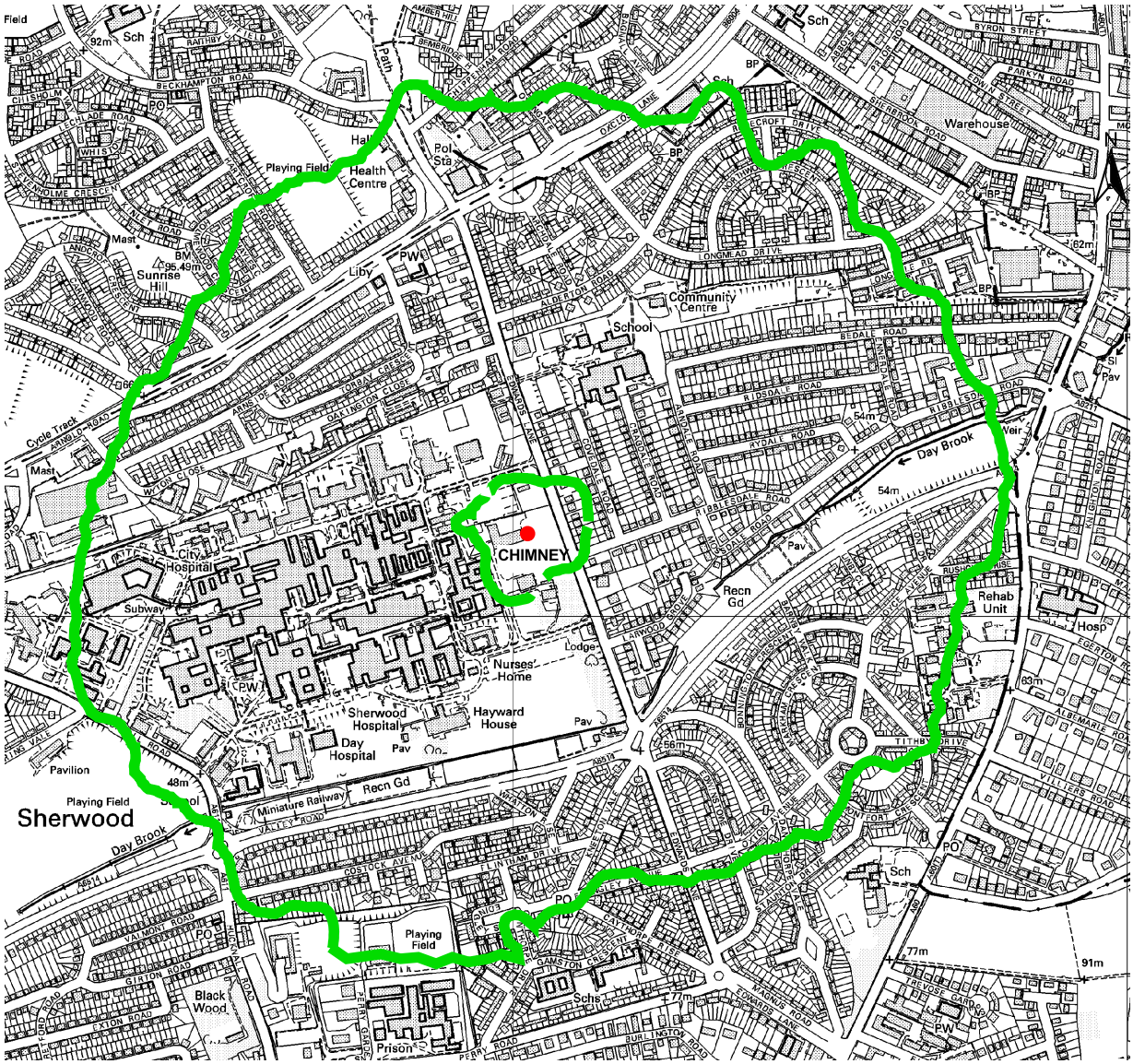
It is proposed that Air Quality Management Areas be designated in the vicinity of the areas shown in Figure 10 (page 39).

8.8 Conclusion

The review and assessment process concluded that it is not necessary to declare Air Quality Management Areas (AQMAs) for carbon monoxide (CO), lead (Pb), benzene (C_6H_6), 1,3 butadiene (C_4H_8), or particles (PM_{10}).

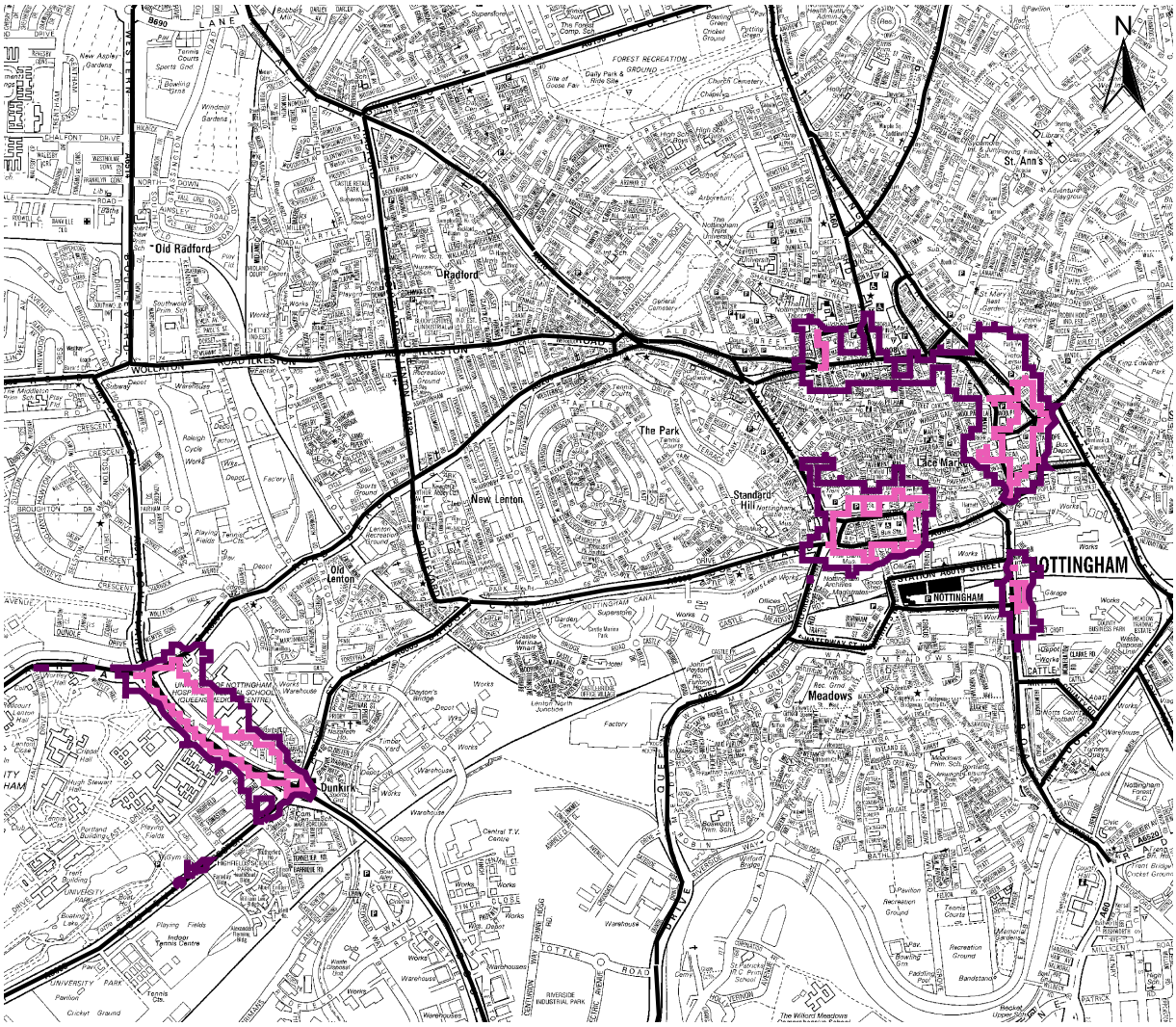
The process has identified that exceedances of the air quality objectives for nitrogen dioxide and sulphur dioxide are likely in 2004-5. It will therefore be necessary to designate Air Quality Management Areas for these two pollutants.

Figure 9
Area of exceedance of Sulphur Dioxide Air Quality Objectives



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Figure 10
Area of Exceedance of Nitrogen Dioxide Annual Mean Air Quality Objective



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9 Air Quality Management Area Proposals

Where, as the result of an air quality review, it appears any air quality standards or objectives are not being, or are not likely to be achieved within the relevant period local authorities are required by The Environment Act 1995 to designate AQMAs. Thus Nottingham City is required to designate AQMAs for sulphur dioxide and nitrogen dioxide.

The Air Quality (England) Regulations 2000 require the achievement or likely achievement of air quality objectives to be determined by reference to the quality of air at locations that are situated outside buildings AND where members of the public are regularly present.

Furthermore LAQM.G1 advises that 'Authorities may benefit from aligning AQMAs with existing physical or administrative boundaries... Where they choose to do this... ...the proposed AQMA should cover a greater, not a smaller, area than that suggested by the empirical data'

There are, therefore, slight differences between the areas of predicted exceedance (for sulphur dioxide and nitrogen dioxide) and the proposed Air Quality Management Areas. The boundary of each proposed AQMA uses clear/easily-described features to define and describe its perimeter. Those areas where exceedances are predicted but where members of the public are not regularly present have not been included in AQMAs.

9.1 Sulphur Dioxide

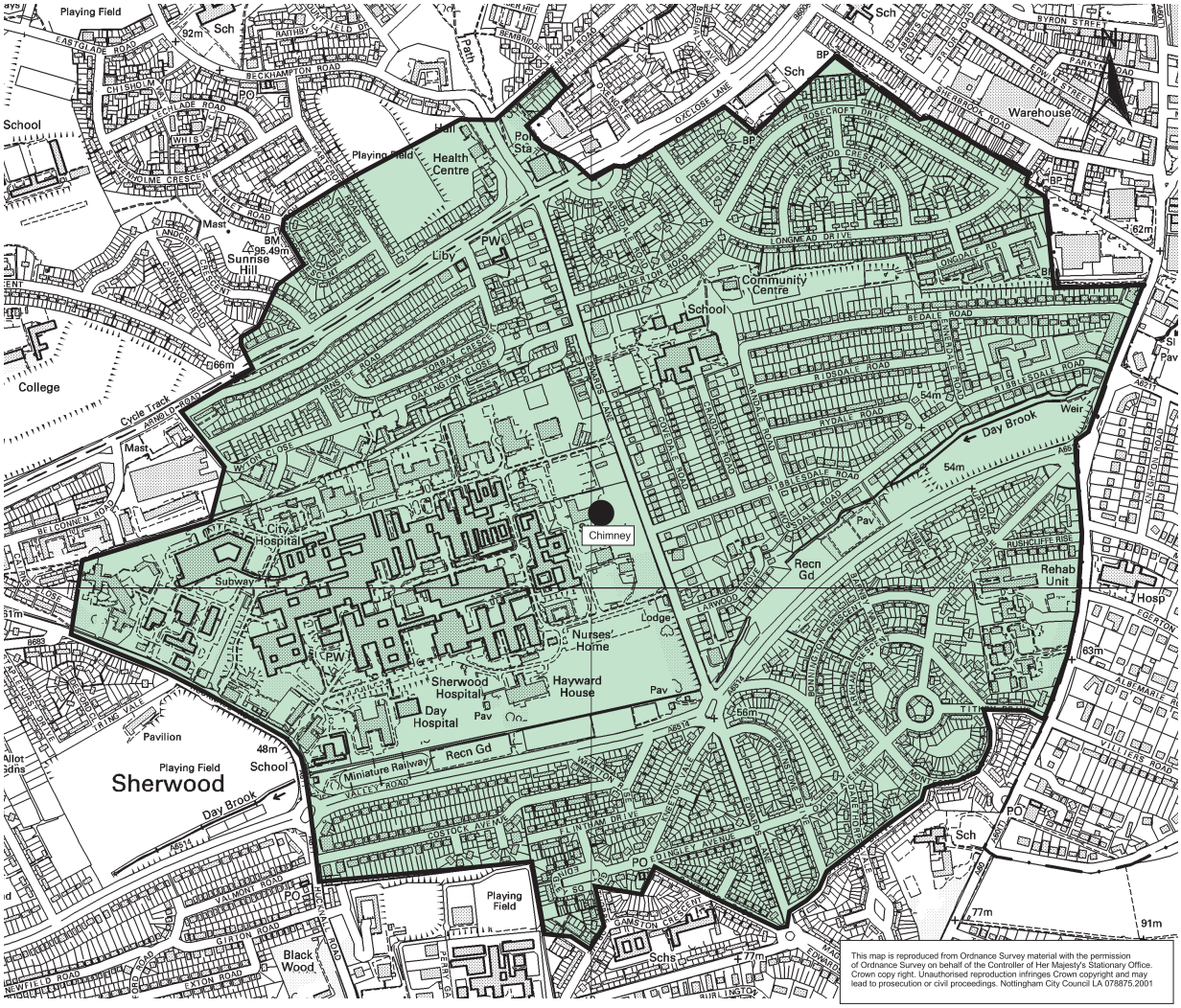
The review and assessment predicts that the Air Quality Objectives for 2004/5 are unlikely to be met in the vicinity of the City Hospital. The predicted area of exceedance extends into Gedling Borough Council's administrative area. This area cannot be included within an AQMA designated by the Nottingham City Council and has been referred to Gedling Borough Council for information and attention.

Figure 11 (page 41) details the proposed AQMA for sulphur dioxide.

9.2 Nitrogen Dioxide

The review and assessment predicts that the annual mean objective of 40 μgm^{-3} is unlikely to be met in 2005. Figures 12a & 12b detail the proposed AQMAs (pages 42 and 43).

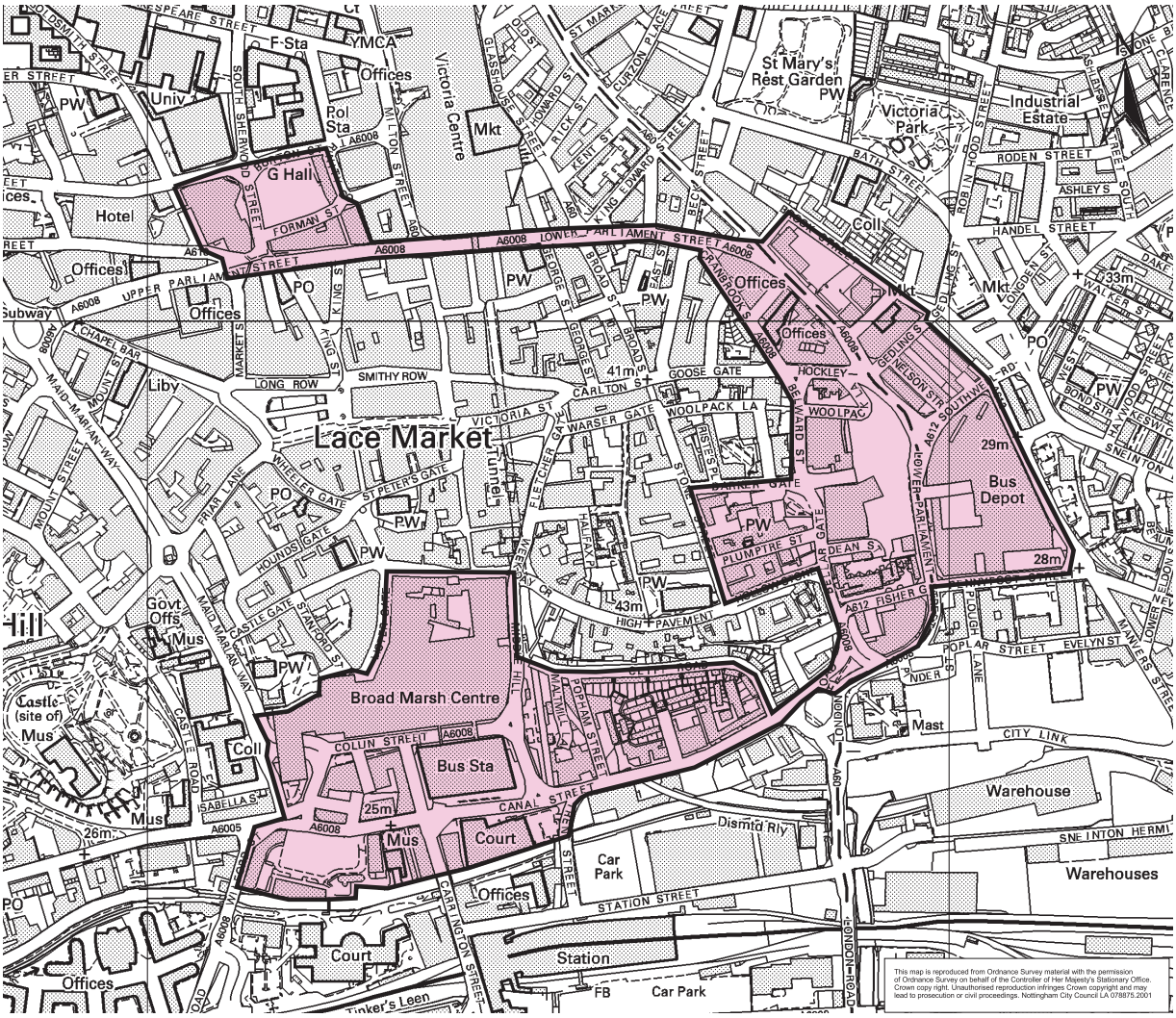
Figure 11
Proposed Air Quality Management Area for Sulphur Dioxide



500 0 500 Metres

Area of Proposed Air Quality Management Area

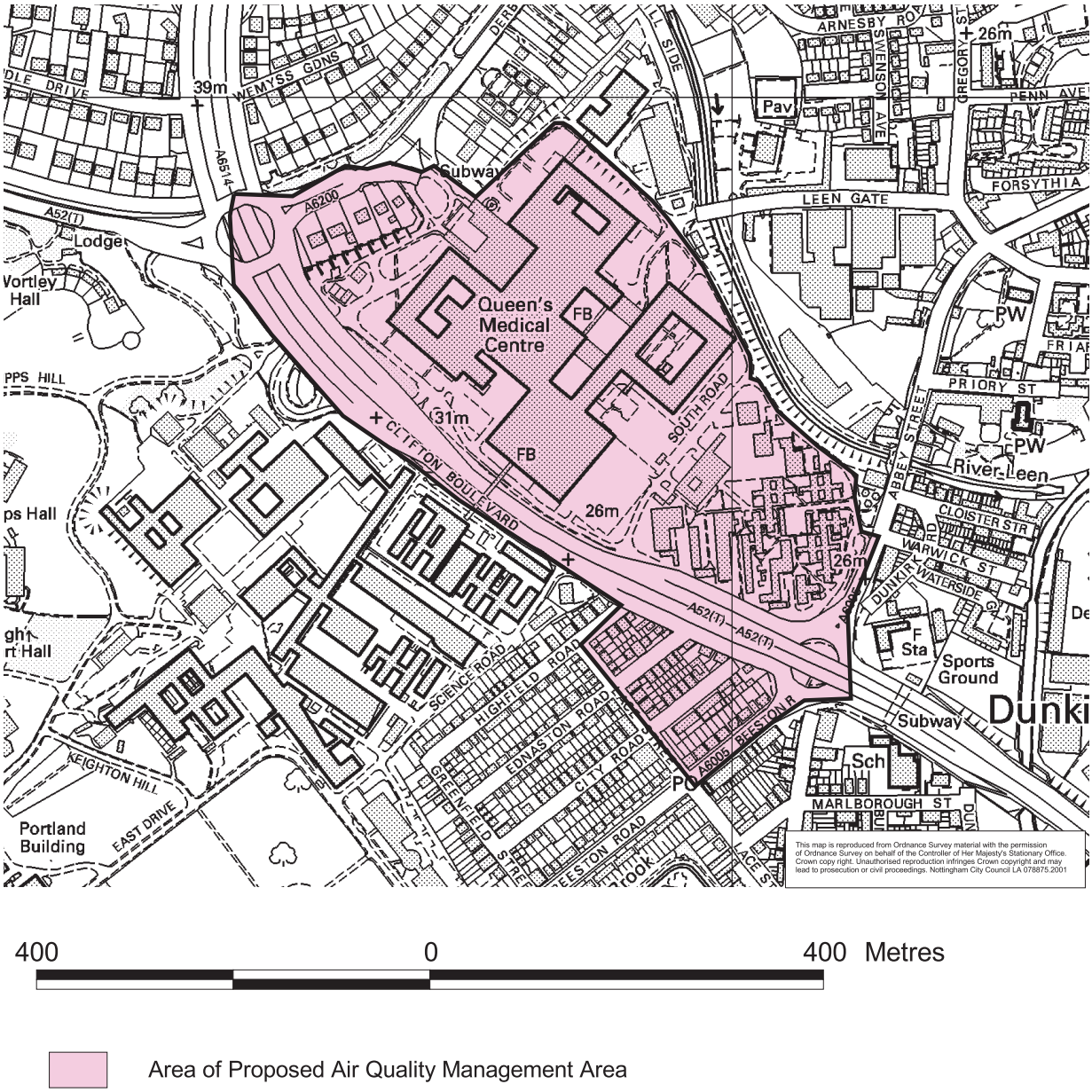
Figure 12a
Proposed Air Quality Management Area for Nitrogen Dioxide - City Centre



500 0 500 Metres

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Figure 12b
Proposed Air Quality Management Area for Nitrogen Dioxide - Dunkirk



400 0 400 Metres

Area of Proposed Air Quality Management Area

10 What happens next

Consultation on the draft Second and Third Stage review and assessment was undertaken during May/June 2001. Only the response from the former DETR required an amendment to the Second and Third Stage review and assessment. Further work was undertaken and the amendments to the draft report were submitted to DEFRA who confirmed its acceptance of the findings on the 17 September 2001.

The Environment, Planning and Transportation Strategic Board approved this amended Second and Third Stage review and assessment report on the 18th October 2001.

Having determined that the air quality objectives for two pollutants of concern are not likely to be met by the relevant dates, Nottingham City Council is required **within four months** of completing and publishing its Second and Third Stage review and assessment, to designate **by order** Air Quality Management Areas.

Accordingly the deadline for declaring the three air quality management areas is the 18th February 2002. Orders designating the AQMAs will be published in the Nottingham Evening Post.

Within twelve months of the date of the Order(s), Nottingham City Council is also required to undertake a further assessment of, and report on, air quality in each AQMA. The Council must also prepare a written 'action plan' for implementation by the Council in pursuit of the achievement of the air quality objectives in the designated AQMAs.

Nottingham City Council aims to consult on its draft Air Quality Action Plan(s) within 9 to 12 months of designation of the Orders (18th February 2003 at the latest). Nottingham City Council aims to publish the AQAP(s) within 12-18 months of designation of the Orders (18th August 2003 at the latest) in compliance with the Government's guidance and deadlines.

Nottingham City Council is also required to undertake a second round of reviews and assessments of all pollutants of concern by December 2003.

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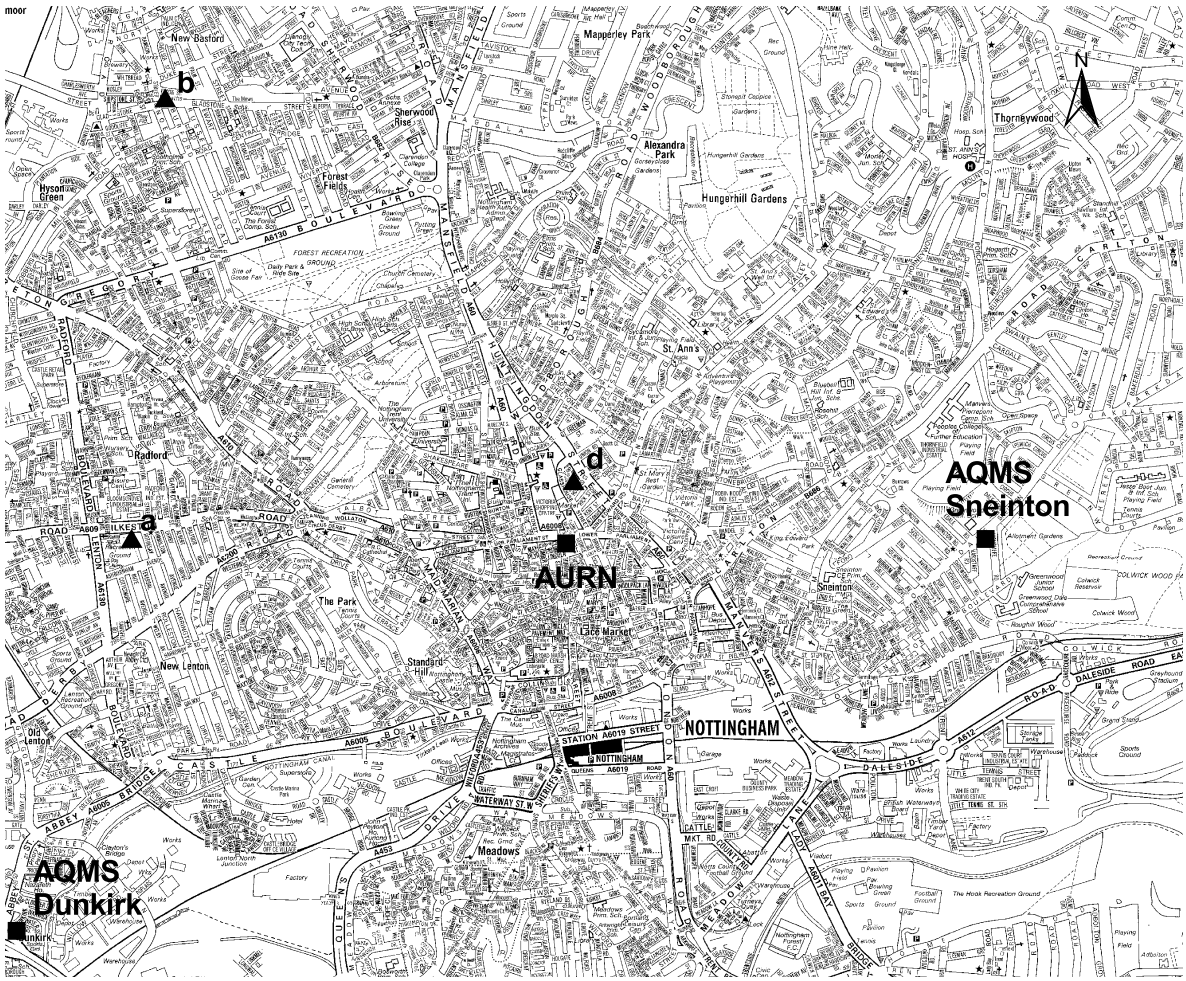
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Appendix 1

Monitoring Site Locations



Ambient Air Quality Monitoring Stations

AURN Clinton St East (1996 to present)	SK574 400
AQMS Sneinton (1998 to present)	SK592 401
AQMS Dunkirk (1996 - 1998)	SK552 385

Nitrogen Dioxide, NO2 Diffusion Tubes

a Ilkeston Rd, Radford	SK556 401
b Noel St, Basford	SK557 419
c Perth St, City Centre	SK574 403
d Ransom Rd, Mapperley	SK582 424

Smoke/SO2 sampler also located at c

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Appendix 2

Emissions Inventory - Industrial/Commercial Point Sources

Operator	Process	OS Co-ordinates
Boots the Chemist Plc (2)	Combined Heat and Power (gas fired)	454800 336600
J Mcintyre (Aluminium) Ltd (2)	Non ferrous foundry	455010 337790
University of Nottingham (2)	Combined Heat and Power (gas fired)	454050 338750
Queens Medical Centre (1)	Combined Heat and Power (gas fired)	454750 338800
Enviroenergy Ltd (Dalkia) (1) Heat station	Combined Heat and Power (gas fired)	457830 339440
Yorkshire Environmental Ltd (1) Eastcroft	Municipal Waste Incineration	458205 339124
Powergen Ratcliffe on Soar (1)	Power Generation FGD	450150 330200
Nottingham City Hospital (1)	Boiler plant (coal fired)	457015 344126

Appendix 3

Road input data used for DMRB PM_{10}, NO_2 and NOx calculations

Area	Receptor		Receptor distance from centre of road metres	Receptor distance from kerbside metres	Link Number
	ID	Type			
1	Ai	Garden	48.5 29.9	21.7 20.7	50 322
	A	School	44.1 112.2	14.1 101.2	50 322
	B	Hospital	66.6 151	41.4 138.1	49 416
2	C	Market Square	229 192.1 191.1	213.9 184.3 180.8	354 355 356
	D	Victoria Centre	31.7 15	24.6 5.9	357 360
	E	Chapel Bar	100.5 61.5	87.9 52	354 355
	F	Market	159.3 159.1	154.4 151.9	336 338
	G	Garden	43 28	19 17.8	341 345
	H	School	11	4.6	419
3	I	School	25.3	19.6	537
4	J	School	213.1 231.7 22.4	208.4 222.6 17.5	120 121 533
5	K	Garden	18.5	10	118
	L	School	12.5 18.3	4.5 4.0	185 186
	M	School	58	50	410
6	N	Street	8.1	2.5	115
	O	Street	13	7.3	114
7	P	School	134.5 212	121.6 206	427 182
	Q	Garden	30.6 42	14 14.1	183 427
8	R	School	142.2	131	312
9	S	Playing Field	125	117	309
10	T	Nursery	163.1 56.9	143.5 44.6	153 385
11	U	School	177.5 147.5	161.5 143	145 146
12	V	School	21.5	12.5	430
	W	School	140.7 148.2	133.9 136.1	171 430
	X	Garden	32.2 37.6	18.6 27.3	430 171
13	Y	School	12.4	6.6	173
	Z	Garden	22.4	16.2	418
	Zi	Street	21	15	418

Appendix 4

Estimated average background PM10, NO_2 and NOx concentrations (from Internet maps)

Area	PM_{10} ugs/m^3	NOx ugs/m^3	NO_2 ugs/m^3
Year	2004	2005	2005
1 Dunkirk	23.7	54.55	30.45
2 City Centre	24.23	60.93	32.68
3 Sneinton	23.2	46.33	27.56
4 St Anns	23.8	54.7	30.5
5 Hyson Green	24.43	63.8	33.65
6 Sherwood	24	56.45	31.0
7 Aspley	24.15	44.52	32.48
8 Strelley	23.2	49.48	28.68
9 Bulwell	22.98	45.25	27.23
10 Meadows	23.6	52.9	29.9
11 Clifton	21.98	29.98	21.9
12 Radford	24.07	59.3	32.12
13 Lenton	24.3	62.15	33.1

Appendix 5

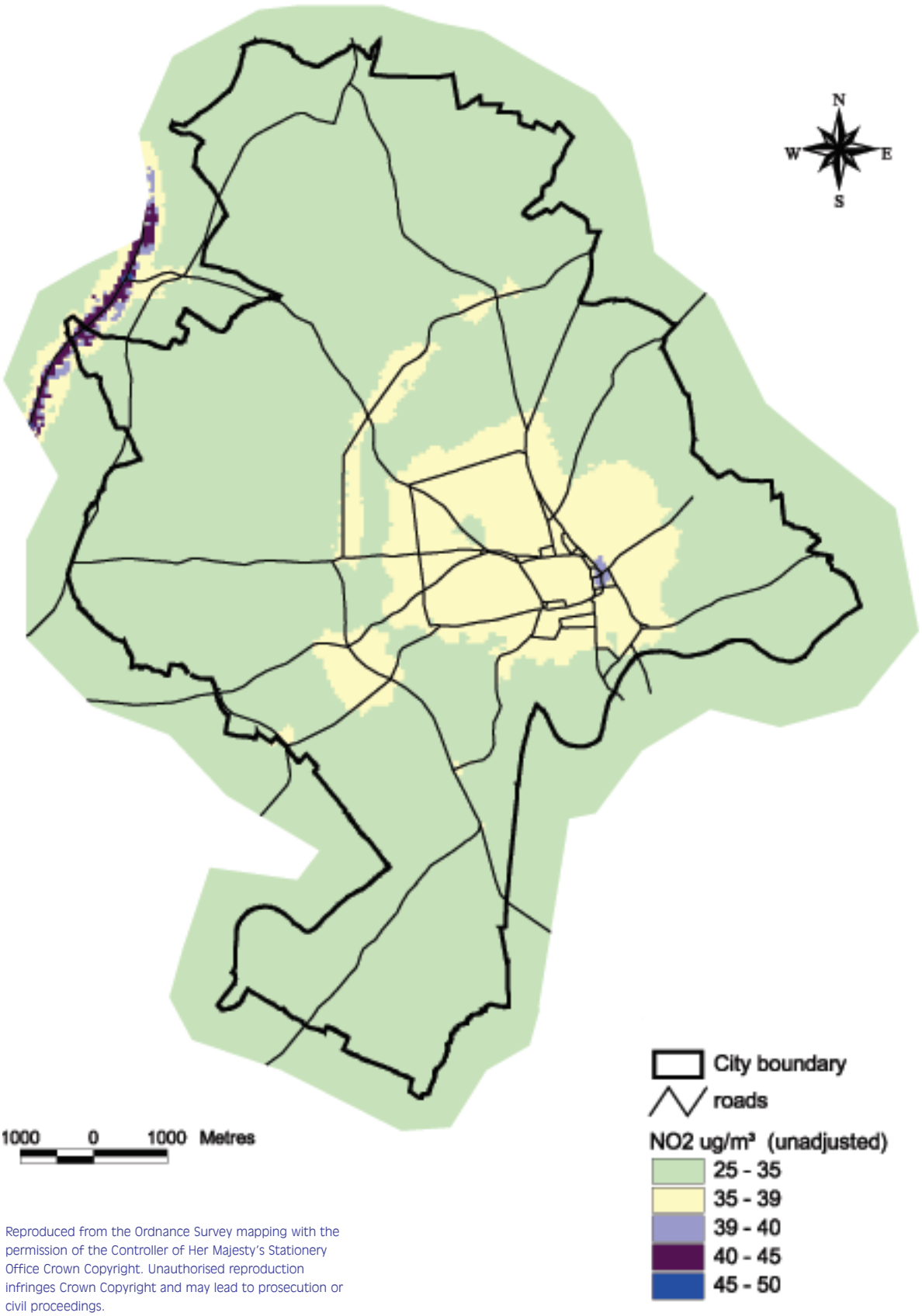
Unadjusted 2004 Predicted Annual Mean Particle, PM_{10} Concentrations



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Appendix 6a

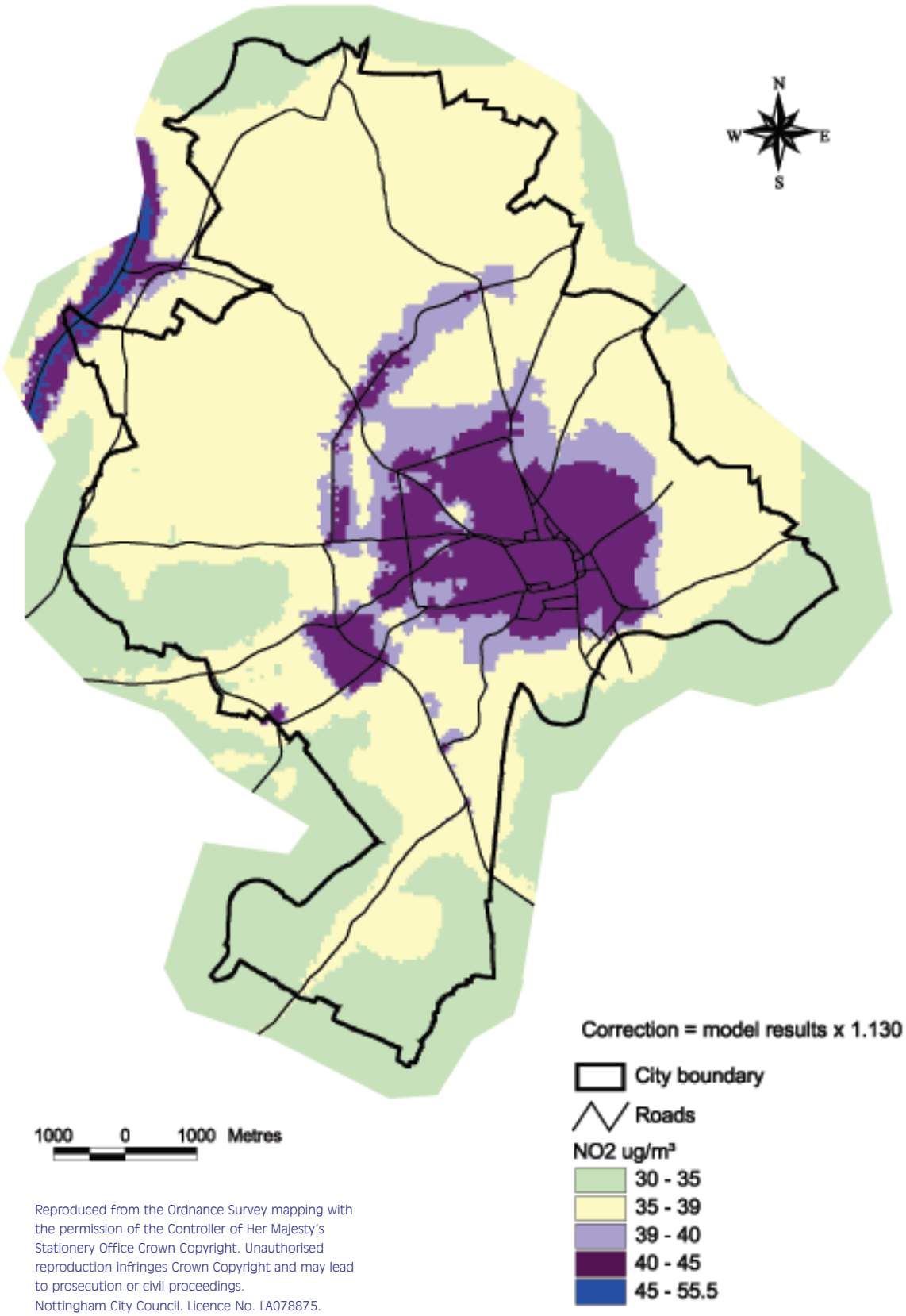
Unadjusted 2005 Predicted Annual Mean Nitrogen Dioxide Concentrations



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Appendix 6b

2005 Predicted Annual Mean Nitrogen Dioxide Concentrations
(No reduction in background pollutant concentrations)
(model correction applied)



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Technical Annexe

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Introduction

This annexe gives additional information about Nottingham City Council's approach to the Second and Third Stage review and assessment of nitrogen dioxide, sulphur dioxide, and particles. It details the pollution monitoring undertaken, information obtained, model parameters, methodology adopted and uncertainties considered in undertaking modelling predictions for the three pollutants. It consists of the following sections:

- Monitoring including description of analysers, data collection and processing, quality assurance and quality control,
- Emissions Inventory: point, line and area sources,
- Background pollutant concentrations,
- Meteorology: choice of data and wind roses,
- Modelling: Inputs, outputs and validation.

Uncertainty in monitoring and the modelling process

It must be borne in mind that pollution monitoring and the modelling process have 'uncertainty' and carry a degree of error. Such uncertainty can never be eliminated but should be acknowledged. Uncertainty occurs throughout the process and may be: -

i. Measured data uncertainty
   This is reflected by the precision and accuracy of a monitoring system,
ii. Model uncertainty
   The model algorithms are mathematical approximations to the way the atmosphere behaves (e.g. chemistry, dispersion),
   The parameters used in the model set-up (e.g. surface roughness) are mathematical constants used to represent a physical characteristic.
iii. Input data uncertainty
   Emissions - either monitored with their inherent error or derived and thus statistical errors.
   Background concentrations - either monitored or derived from surrogate data thus statistical errors.
   Meteorological data.
   Source geometry.
iv. Natural variability.

Models give results that follow trends in measurements but show two types of error - systematic and random. Systematic errors may occur but can be accounted for through model validation. Random errors lead to scatter in dispersion modelling results.

Monitoring

Nottingham City Council operates 2 automatic monitoring sites. It provides Local Site Operators for the DETR AURN (Automatic Urban Rural Network) station and carries out its own monitoring at the mobile AQMS (Air Quality Monitoring Station) trailer. Their locations are detailed in Appendix 1 (main report) together with their OS co-ordinates. The locations of the monitoring equipment were determined by a number of factors particularly the sites' relation to sources, and security.

The AURN station is located in a central urban site surrounded by retail outlets and business premises and in close proximity to roads. The monitoring equipment is in a self-contained, air-conditioned housing located in a pedestrianised area. The nearest road is located 30 metres from the site and is a major through route within the city centre. Traffic flow is approximately 24,250 vehicles per day. The manifold inlet is approximately 3.5 metres high.

The AQMS station is a mobile unit and was located at Dunkirk Fire Station during the period 1997-1998. The Dunkirk site was a suburban mixed industrial/commercial/residential area of the City adjacent to the A52. The AQMS has been located at Sneinton Police Station since 1998. The Sneinton site is a suburban residential area to the east of the City Centre. The AQMS is located approximately 1.75 km east of the AURN station, on Sneinton Dale. The self contained, air -conditioned trailer is 40 metres from the road. The sampling inlet is approximately 3.5 metres high.

Both the AURN and AQMS have analysers that measure the following pollutants: - sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particles (PM_{10}), ozone (O_3), carbon monoxide (CO), nitric oxide (NO) and nitrogen oxides (NOx).

Pollutant: Particles

Description of equipment

The TEOM (Tapered Element Oscillating Microbalance) analyser consists of a sample inlet head attached to the sensor unit, a control unit containing the mass flow controllers and system software and a carbon vane pump. The total flow of 16.67 litres per minute through the sampling head is divided using a flow splitter to give 2 litres per minute through the filter cartridge and an auxiliary flow of 14.67 litres per minute.

The unit measures the frequency of oscillation of a tapered element, onto which particulate matter is deposited. The concentration of particulate material is calculated from the changes in frequency of oscillation and the flow rate of sampled air. The mass concentration is given at the reference condition of 20^{o}C and 1 atmosphere.

Pollutant species measured

The main emphasis in ambient particulate monitoring is to determine the concentration of total particulates in the respirable and thoracic size ranges, since they have the greatest significance in relation to health. The sampling head has a maximum collection efficiency for particles with an aerodynamic size distribution of less than 10 microns called the PM_{10} fraction.

The TEOM system determines particulate concentration by continuously calculating the weight of particles deposited on a filter.

The Air Quality Objective for PM_{10} is quoted as a gravimetric measurement and reflects the European standard for determination of PM_{10}. The UK AURN network uses the TEOM technique to determine PM_{10} concentrations and has been found to underestimate PM_{10} concentrations when compared with the gravimetric technique. LAQM.TG4(00) advises 'It is considered that TEOM data can be used... ...provided that the adjustment factor of 1.3 is applied'. The adjusted concentration is quoted as 'gravimetric equivalent'.

Pollutant concentrations and averaging times

The TEOM monitoring equipment measures PM_{10} concentration continuously. However the data measured by the analysers are retained by the data loggers as 5-minute raw voltage averages.The concentrations are recorded as μgm-3.

Monitoring period

The AURN station has been operational since October 1996. The site has a high level of data capture of 97.6% during 1997, 98.1% during 1998, 97.1% during 1999 and 98.3% in 2000.

The AQMS unit was commissioned in 1996 at the Dunkirk site and remained there until June 1998, providing approximately 93% data capture during the period 1997 to 1998. It was then relocated to Sneinton police station where at the time of this report, it was operational, providing approximately 80% data capture during the period 1998-2000.

Information collected

Information from the AQMS is collected daily as 15 minute monitoring periods. The DETR AURN measurements are downloaded periodically to the NETCEN web site in the form of hourly averages.

Estimation of accuracy and precision of results

Accuracy is defined as 'the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value' (from ISO 6879).

Precision is defined as 'the closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions' (from ISO 6879).

The automatic monitoring of particles uses an indirect measurement and subsequent calculation to determine the concentration of particles. The documentation supplied with the equipment does not quote its accuracy.

As with other sensitive air quality analysers, the overall precision of TEOM PM_{10} measurements will depend on both the short-term instrument noise and longer baseline drift. An estimate of this precision can be determined by calculating the difference in concentrations measured by two TEOM analysers operating side-by-side. The California Clean Air Board (CARB) has undertaken this test and calculated as a standard deviation of $\pm$ 2 μgm^{-3} for hourly average PM_{10} measurements. Working from this figure, a corresponding uncertainty in the instantaneous chart recorder output would be a peak-to-peak variation of 60 μgm^{-3}. Ratified hourly average PM_{10} data are quoted with the precision of $\pm$ 2 standard deviations i.e. $\pm$ 5 μgm^{-3}. The precision targets for PM_{10} analysis is quoted as being $\pm$ 4 μgm^{-3}.

Quality control, maintenance, calibration

At both the AURN and AQMS the site operators change the filter unit and clean the TEOM head every 4 weeks in accordance with the manufacturer's operating manual. The auxiliary flow cartridge is replaced once every 6 months as part of the service and maintenance procedure.

Data processing techniques

The DETR AURN station's data logger is interrogated on an hourly basis by Stanger Central Management and Co-ordination Unit (CMCU). The data logger records information for all the analysers operating at the site including the PM_{10} analyser. The data obtained is validated by CMCU and passed to the Data Dissemination Unit (DDU) who disseminates the information via air quality bulletins. Information from the AURN station is reported as an hourly averaged concentrations.

The City's AQMS data logger is interrogated on a daily basis by the Siemens Environmental Measurement Database v2.63 (EMD) program. This collects the data as 15 minute averages. The fluctuations in concentrations of the pollutant are subsequently averaged by EMD and displayed as hourly averages. No other data processing techniques are applied.

Pollutant: Nitrogen Dioxide

Description of equipment

The nitrogen oxides monitoring equipment located in the AQMS and DETR AURN stations use a technique called chemiluminescence. Nitric oxide (NO) in the sample air stream reacts with ozone (O_3) in an evacuated chamber to produce 'activated' nitrogen dioxide (NO_2). The intensity of chemiluminescent radiation produced is measured using a photomultiplier tube. The ambient air sample is divided into two streams; in one, ambient NO_2 is reduced to NO using a molybdenum catalyst before reaction. Separate measurements are made of total oxides of nitrogen, NOx (=NO+NO_2) and NO. The ambient NO_2 concentration is calculated from the difference (NO_2=NOx - NO).

Roadside Pollution Monitors (RPM)

The City operates nine RPMs. Data from the RPMs has been omitted from this stage of the review and assessment because they cannot be calibrated and overall data capture was low.

Pollutant species measured

The chemiluminesence analysers determine NO_2 concentrations indirectly from the chemiluminescent emission of light by NO.

Pollutant concentrations and averaging times

The chemiluminesence analysers measure NO and NOx, and determine NO_2 concentrations in ppb, over the range 2 to 1000 ppb and average the concentrations over a 15-minute period.

Monitoring period

The AURN station has been operational since October 1996. The site has a high level of data capture, 97.6% during 1997 and 98.1% during 1998.

The AQMS was commissioned in 1996 at the Dunkirk site and remained there until June 1998, providing approximately 94% data capture during the period 1997-1998. It was then relocated to Sneinton police station where it is still operational at the time of this report, providing approximately 80% data capture during 1999.

Information collected

Information from the AQMS is collected daily as 15 minute monitoring periods.

The DETR AURN measurements are downloaded periodically to the NETCEN web site in the form of hourly averages.

Estimation of accuracy and precision of results

Accuracy is defined as 'the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value' (from ISO 6879).

Precision is defined as 'the closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions' (from ISO 6879).

The chemiluminescent analysers have a quoted accuracy of + or - 2 % and a precision of + or - 1% of upper range limit (10 ppb).

Quality control, maintenance, calibration

The DETR AURN analyser is subject to a bi-monthly calibration. The calibration is undertaken by suitably trained local site operators (LSOs) and conducted in accordance with the Local Site Operators manual. The equipment is serviced bi-annually. The site is also audited by NETCEN on a six monthly basis to ensure the equipment is performing correctly.

The AQMS analyser is subject to bi-monthly calibrations. The calibrations are undertaken by officers trained as LSOs and are conducted in accordance with the manufacturers' operating manuals. The equipment is serviced six monthly by the equipment supplier or sooner if necessary.

Calibration gas traceability

Span or calibration gases used in the DETR AURN is supplied by BOC who have demonstrated compliance with relevant quality control procedures in the preparation of gas mixtures and certified by National Physics Laboratory, NPL.

Span or calibration gases used in the AQMS are supplied by Messer UK Ltd. Each cylinder is supplied with a certificate of analysis.

Data processing techniques

The NOx analysers measuring cycle takes just a few minutes. The fluctuations in concentration are converted to an output voltage and sent to an Odessa data logger. The logger records the voltage variations over time and calculates and stores the 15-minute averages.

The DETR AURN station's data logger is interrogated on an hourly basis by Stanger Central Management and Co-ordination Unit (CMCU). The data logger records information from all the analysers operating at the site. The data obtained is validated by CMCU and passed to the Data Dissemination Unit (DDU) who compiles and disseminates the information via air quality bulletins. Information from the DETR AURN station is reported as hourly averaged concentrations.

The City's AQMS data logger is interrogated on a daily basis by the Siemens Environmental Measurement Database (EMD) v2.63 program. The software scales the collected data with reference to calibration data entered following fortnightly calibrations. The fluctuations in concentrations of the pollutant are subsequently averaged by EMD and displayed as 15 minute or hourly averaged data. No other data processing techniques are applied.

The data is reported as annual average levels for each site in Tables 2 and 3, AURN and AQMS respectively in the main report.

Non automatic monitoring: NO_2 passive diffusion tubes

Passive diffusion tubes are located at four sites in the City, see Appendix 1, main report for their locations.

A diffusion tube consists of a plastic tube approximately 1cm in diameter and 7 cm in length that is fixed in an appropriate location for a period of four weeks. During sampling, one end is open and the other closed. The closed end of the tube holds stainless steel mesh discs, coated with an NO_2 absorbent: triethanolamine (TEA). The tubes are returned to the supply laboratory for analysis and the results supplied as a concentration of NO_2 in both ppb and μgm^{-3}.

Nottingham City Council's NO_2 diffusion tubes are supplied and analysed by Casella GMSS Ltd. Tubes are prepared using a solution of 10% TEA in de-ionised water. The laboratory participates in two QA/QC monitoring systems to demonstrate satisfactory performance:

- The WASP (Workplace Analysis Scheme for Proficiency) programme to ensure uniformity in data throughout the year.
- Annual Field Intercomparison with other laboratories to enable assessment of bias and precision.

WASP

This involves monthly analysis of doped tubes, allowing assessment of overall uniformity of data throughout the year. Performance scores are assigned to the reported analysis results, on the basis of their difference from the known concentration of the analyte and the actual standard deviations.

Results are classified as follows:

Good < 2 Standard deviations from true concentration

Warning 2-3 Standard deviations from true concentration

Action > 3 Standard deviations from true concentration

Each participating laboratory's results are analysed by AEA Technology and combined to give an annual relative standard deviation. If this value is greater than +25% then the laboratory's performance for the year in the WASP scheme will be deemed unsatisfactory. Only laboratories that remain in the WASP scheme are used for analysing tubes from the national NO_2 diffusion tube non-automatic network.

Annual Field Intercomparison

Each participating laboratory is asked to provide six diffusion tubes for exposure, plus one travel blank. The tubes are exposed at a suitable location for a period of around one month, before being returned to the laboratories for analysis. The exposure site will be co-located with a chemiluminescent analyser. Laboratories are expected to perform within +25% of the reference concentration (usually that obtained by the chemiluminescent analyser).

In 2000 AEA Technology performed such a comparison on all laboratories involved in the NO_2 diffusion tube network. However, due to a technical difficulty, only 70% of information from the chemiluminescent analyser was available therefore the reference value was calculated based on the mean value of all diffusion tubes.

Casella GMSS Ltd performed within required performance objectives for this comparison:

% Bias relative to automatic analyser 2000	-0.5
Standard deviation 2000	4.56
% Bias relative to average diffusion tube conc. 2000	-16.0
% Bias relative to automatic analyser 1999	17.0

Pollutant: Sulphur Dioxide

Monitoring equipment - automatic and location

Nottingham City currently operates 1 semi-automatic smoke and SO_2 sampler, its own SO_2 analyser located within the Air Quality Mobile Station (AQMS), and provides local site operators for the DETR AURN station. The locations of the equipment are detailed in Appendix 1 (main report), together with their OS co-ordinates.

However, only results from the AURN and AQMS are reported in the main body text as these can be compared directly with the air quality objectives.

Studies by the Power Generators (National Power and PowerGen) during their Joint Environmental Programme (JEP) show that under certain meteorological conditions and at a distance from the source, the plume from a point source will be detected at ground level more frequently, but will usually be highly diluted.

The JEP study's main conclusions were that: -

1. '..individual power stations make only a small contribution to annual mean sulphur dioxide concentrations, of the order of a few ppb at most.
2. 'The contributions of individual power stations to annual mean sulphur dioxide concentrations are hard to detect above the background..'
3. 'The distance to the point of maximum impact on annual mean concentrations depends on station size and chimney height...Typically, the distance to the point of maximum impact will be between about 5 and 15 km from the power station.'

(Laxen, D. 1996)

However, the three 'northern' sources are approximately 40 km away and the west south westerly source is approximately 15 km, from Nottingham City, thus annual mean concentrations monitored at the automatic sites in the City area will be dominated by SO_2 emitted from local sources.

Description of equipment

The automatic monitoring equipment located in the AQMS and AURN uses a technique called Ultra Violet Fluorescence, (UVF). Ambient air is drawn into the analyser and exposed to ultra violet light. The SO_2 molecules absorb the energy of this light and the molecules' electrons move to an 'excited' state. The 'excitation energy' is rapidly lost again as the electrons fall back to their stable 'unexcited' state by emitting light radiation. This light is detected by a photo-multiplier tube, which generates an output voltage proportional to the concentration of SO_2 in the air sample. A permeable membrane 'kicker' is used to remove other gases, which also fluoresce, and thus interfere with the detection of SO_2 molecules.

Pollutant species measured

The UV fluorescence technique measures the amount of fluorescence of SO_2 within a chamber of known volume, thus allowing the direct determination of the concentration of SO_2.

Pollutant concentrations and averaging times

The automatic UV fluorescence monitoring units measure sulphur dioxide concentrations in parts per billion (ppb), and are averaged by the instrument over a 15-minute period.

Monitoring period

The AURN station has been operational since October 1996.

The site has a high level of data capture of 97.6% during 1997, and 98.1% during 1998.

The AQMS unit was commissioned in 1996 at the Dunkirk site and remained there until June 1998, providing approximately 80% data capture during the period 1997 to 1998. It was then relocated to Sneinton police station where at the time of publication of this report, it was operational, providing approximately 80% data capture during the period 1998-1999.

Information collected

Information from the AQMS is collected daily as 15 minute monitoring periods. The DETR AURN measurements are downloaded periodically to the NETCEN web site in the form of hourly and 15 minute averages.

Estimation of accuracy and precision of results

Accuracy is defined as 'the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value' (from ISO 6879).

Precision is defined as 'the closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions' (from ISO 6879).

The UV fluorescence systems have a quoted accuracy of + or - 10 % and a precision of + or - 1.2 ppb.

Quality control, maintenance, calibration

The DETR AURN SO_2 monitor is subject to fortnightly calibration. The calibration is undertaken by suitably trained LSOs and conducted in accordance with the Local Site Operator's manual. The equipment is serviced twice per year. The site is also audited by NETCEN on a six-monthly basis to ensure the equipment is performing correctly.

The AQMS SO_2 monitor is subject to a bi-monthly calibration. The calibrations are undertaken by officers trained as LSOs for the DETR AURN and are conducted in accordance with the manufacturer's operating manual. The equipment automatically performs overnight zero and span checks. The equipment is serviced six monthly by the equipment supplier.

Calibration gas traceability

Span or calibration gases used in the DETR AURN are supplied by BOC who have demonstrated compliance with relevant quality control procedures in the preparation of gas mixtures and certified by National Physical Laboratory, NPL.

Span or calibration gases used in the AQMS are supplied by Messer UK Ltd. Each cylinder is supplied with a certificate of analysis.

Data processing techniques

The analysers measuring cycle takes just a few minutes. The fluctuations in concentration are converted to an output voltage and sent to an Odessa data logger. The logger records the voltage variations over time and calculates and records 15-minute averages.

The DETR AURN station's data logger is interrogated on an hourly basis by Stanger Central Management and Co-ordination Unit (CMCU).

The data logger records information from all the analysers operating at the site, including the sulphur dioxide analyser.

The data obtained is validated by CMCU and passed to the Data Dissemination Unit (DDU) who disseminates the information via air quality bulletins. Information from the DETR AURN station is reported as 15 minute and hourly averaged concentrations.

The AQMS's Odessa data logger is interrogated on a daily basis by the Siemens Environmental Measurement Database v2.63 program. The software scales the collected data with reference to calibration data entered following bi-monthly calibration. The fluctuations in concentrations of the pollutant are subsequently averaged by EMD and displayed as an hourly and fifteen minute averages.

Results

Tables 2 and 3 in the main report detail the results from AURN and the AQMS.

Emission Inventory

All models require certain information in order to predict a pollutant's concentration at some point in time or space. An emission inventory is a schedule or database of sources of air pollutants in a geographical area and includes information about the conditions of release of a pollutant.

The inventory characterises the type of emission, (such as point, line or area), its location or geographical extent, the pollutant or pollutants, temperature, exhaust velocity, stack dimensions (where applicable) etc.

The air quality in a geographical area is a combination of emissions from local sources e.g. roads, industry, domestic sources and the 'background' levels of a pollutant. The background concentration of a pollutant arises from natural sources e.g. wind entrained particles, or as a result of an emission of a pollutant some distance away that is transported by the wind to the geographical area of interest.

The compilation of a detailed emissions inventory of all sources in the Nottingham City area was impracticable. Information was obtained for a number of large point sources, and major roads. Emissions from the remaining sources - domestic, small commercial/businesses were obtained from the National Atmospheric Emissions Inventory (NAEI).

The Nottingham City emissions inventory used in ADMS Urban comprised:-

i. Point Sources
A database of emissions from industrial/commercial/processes considered to have significant emissions was compiled. It contained information about the physical and emission parameters of the process obtained either from the process operator or from information already held by Nottingham City Council.

ii. Area Sources
Obtained from the National Atmospheric Emissions Inventory (NAEI) using data for 'domestic' and 'other sources'.
The NAEI is a database of national emissions on a 1x1 kilometre square grid. It has been compiled from emissions information from major industry and derived from statistics for fuel usage and vehicle mileage see http://www.aeat.co.uk/netcen/airqual/naei/ for details on the methodology. It details emissions from 'roads', 'domestic', 'industry', and 'other' in tonnes per annum. In the case of area sources ADMS Urban uses emission rate units of grammes per second per square metre. The NAEI emissions data were therefore converted into appropriate units and dimensions.

iii. Line Sources

The inventory information was compiled from road data given by the Transportation Section of the Development and Environmental Services Department. They supplied 1997 annual average daily traffic (AADT) flows, and the number of heavy goods vehicles (HGVs) for each of the main road links in the City. Initially these were used as the basis for all traffic flows in the DMRB and ADMS modelling.

Following advice from the Transportation Section, 1999 traffic figures were calculated as a 1% reduction compared with 1997 and the traffic growth for future years was calculated as a 1% per year increase from 1999 onwards. This is in accordance with Nottingham City Council's road traffic reduction plan. The DETR guidance LAQM.TG2 (00) is clear that where a committed policy or infrastructure scheme regarding changes in traffic is available, the scheme should be used as first preference.

Average traffic speed information was not available for many of the links. For some main arterial routes and from traffic surveys, speeds were provided by the Transportation Section. Other speeds were found by a driving survey undertaken by the Pollution Control Section or by reasonable estimates from knowledge of the roads. Nottingham City has several major road junctions. The Transportation Section undertook specific surveys of vehicle speeds through Nuthall Rd/ Western Boulevard, Crown Island and Canal St/London Road junctions. Average speeds through these junctions were determined and used in ADMS modelling. Road widths were measured using a Geographical Information System (GIS).

The former DETR required the nitrogen dioxide predictions for 2005 to be re-modelled. Actual 1999 AADT traffic information became available and was used for 2005 traffic growth based on a 1% per year increase. These traffic figures were used for the subsequent 2005 nitrogen dioxide predictions.

Background Pollutants

A pollutant's concentration at a given location and time is a combination of local emissions from point, line and area sources, those transported from distant sources, and naturally occurring sources. The emissions from distant sources contribute to the background concentration, i.e. the concentration of a pollutant that would be measured in the absence of local sources. If local monitoring data representative of background pollution concentrations is not available it is necessary to use monitoring data from a site that is considered representative of background pollution concentrations. Rochester in south east England, classed by the DETR as a 'background' site, is one of a few such sites that measure nitrogen dioxide, particles and sulphur dioxide. Monitoring data for Rochester was therefore used for modelling predictions.

Particles PM_{10}

PM_{10} is one of the most difficult pollutants to map due to the range of sources of both primary and secondary particles that contribute to ambient concentrations. The sources include:

- primary particles from vehicles;
- primary particles from stationary combustion sources;
- primary particles from non-combustion sources such as quarrying, demolition and wind blown dust;
- secondary particles formed by chemical reactions.

Background PM_{10} concentrations

DMRB Screening

For DMRB screening, it was necessary to consider both the 2004 estimated background concentration (obtained from www.aeat.co.uk/netcen/airqual) together with the additional contribution of emissions from local sources such as road traffic and industry.

Advanced Modelling for 2004 predictions

LAQM.TG4(00) recommends the use of actual monitoring data wherever available. The City and Sneinton monitoring sites do not fit the criteria for 'local background' sites and the data gathered cannot therefore be used to determine the 2004 background PM_{10} concentrations. The AURN site at Rochester was considered most representative of a background site and the 1999 monitoring results were used in the 2004 modelling predictions. No adjustment was made to the 1999 background particulate concentrations because ADMS Urban considers background particulates concentrations to comprise secondary and coarse particles. With primary emissions arising from specific sources e.g. traffic emission and point sources.

Nitrogen Dioxide

The relationship between NOx and NO_2

The Air Quality Objectives refer to nitrogen dioxide whereas the emissions from most combustion sources are in the form of nitric oxide. As the nitric oxide travels downwind it is oxidised by ozone (O_3) to nitrogen dioxide (NO_2). The reaction depends upon the amount of ozone present and meteorological conditions (Fisher BE et al 1999).

Therefore to predict NO_2 concentrations it is necessary for any screening model or computer model to take into account this chemical reaction. A number of methods are available including:-

i. The use of a constant conversion factor,
ii. The use of surrogate statistics to represent NOx conversion to NO_2,
iii. The use of photochemical models.

DMRB screening model uses a method derived from the empirical relationships between annual mean NO_2 and NOx concentrations from an analysis of monitoring data at UK automatic monitoring sites. LAQM.TG4(00).

The ADMS Urban 1.53 computer model uses a 'Generic Reaction Set' (GRS). This is a 'Photochemical' model that makes direct predictions of NO_2 concentrations (Carruthers et al 1996, 1997).

Background nitrogen dioxide concentrations

DMRB Screening

For DMRB screening, it was necessary to consider both the 2005 estimated background concentration (obtained from www.aeat.co.uk/netcen/airqual) together with the additional contribution of emissions from local sources such as road traffic and industry.

Advanced Modelling for 2005 predictions

The AURN site at Rochester was considered a representative background site and the 1999 monitoring results were used in the 2005 modelling predictions. Initially no adjustment was made to the 1999 background concentrations of nitrogen dioxide, nitrogen oxides, nitric oxide and ozone, because of the complex interactions of nitrogen oxides and ozone.

However following consultation with the former DETR, the Dispersion Modelling and Stack Height Calculation Helpline was contacted. This is operated by Stanger Science and Environment. The advice given was that reduction factors for NOx and NO_2 concentrations can be derived in accordance with the LAQM.TG4 (00) Pollutant Specific Guidance methodology. No reduction factors are given for NO or ozone. The advice also suggested that there was some justification for using the same reduction factors for

hourly mean NOx, NO and NO_2 and that 1999 ozone concentrations should be used for the 2005 predictions. This latter approach was adopted. 2005 NOx, NO and NO_2 hourly background concentrations were calculated using LAQM.TG4 (00) Box 6.3 'Correction factors to estimate annual mean background NO_2 concentrations for future years'. The Rochester 1999 monitored hourly ozone values were used for the 2005 predictions.

Example Calculation

	Correction Factor to be applied
1999	0.90
2005	0.74

If 1999 measured NO_2 (or NOx or NO) = 26$\mu gs/m^3$

Then 2005 estimated NO_2 (or NOx or NO) = 26 x (0.74/0.90) = 21.4 $\mu gs/m^3$

Meteorology

Dispersion models enable the user to calculate the concentration of a substance at various distances from the point of emission. The concentration is determined as the amount of a substance in a given volume, usually 1 cubic metre, of air.

A number of factors have a direct bearing on the concentration of an emitted substance at a given point:-

i. The initial height of discharge/release
ii. The temperature and velocity of the release
iii. The wind speed and direction
iv. Atmospheric stability

The release height, velocity and temperature of an emission may be readily determined. See LAQM.TG3(00) for further information.

The weather varies from season to season, day to day and hour to hour. A dispersion model requires this time varying information to predict the concentration of a substance at a given location.

Even in the UK the meteorology experienced in one geographical area can be quite different to that in another relatively nearby location.

Thus for a dispersion model to accurately predict pollutant concentration over a given area meteorological data for the geographical area being modelled is required.

The closest meteorological site to Nottingham is Watnall. However in 1996 it ceased measuring all the meteorological parameters required by the dispersion modelling software ADMS Urban 1.53 used by Nottingham City.

It was therefore necessary to identify and if possible obtain suitable data from a meteorologically similar site.

Three similar sites were identified :-

i. Elmdon, near Birmingham
ii. Waddington in Lincolnshire and
iii. Wittering, near Peterborough

Data availability discounted Elmdon and comparison between Waddington, Wittering and Watnall wind speed and direction data identified Wittering meteorological data as most similar. Whilst liaising with The Met. Office to obtain Wittering meteorological data, the use of recently developed Numerical Weather Prediction (NWP) data was suggested. NWP data would be available for 1998 and 1999, but at the time the initial validation work was being undertaken NWP data was not available and therefore Wittering meteorological data was used.

Choice of modelling meteorological data.

NWP data is interpolated data specifically for the Nottingham area, reflecting local conditions. For the 2004/2005 modelling Nottingham 1999 NWP data was used because the wind rose was more similar to the Watnall 10 year statistical 1986-1995 wind rose then the Wittering wind roses for 1997-1999 (figures 1 and 2).

Figure 1: Wittering 1997, 1998 and 1999 Wind Roses

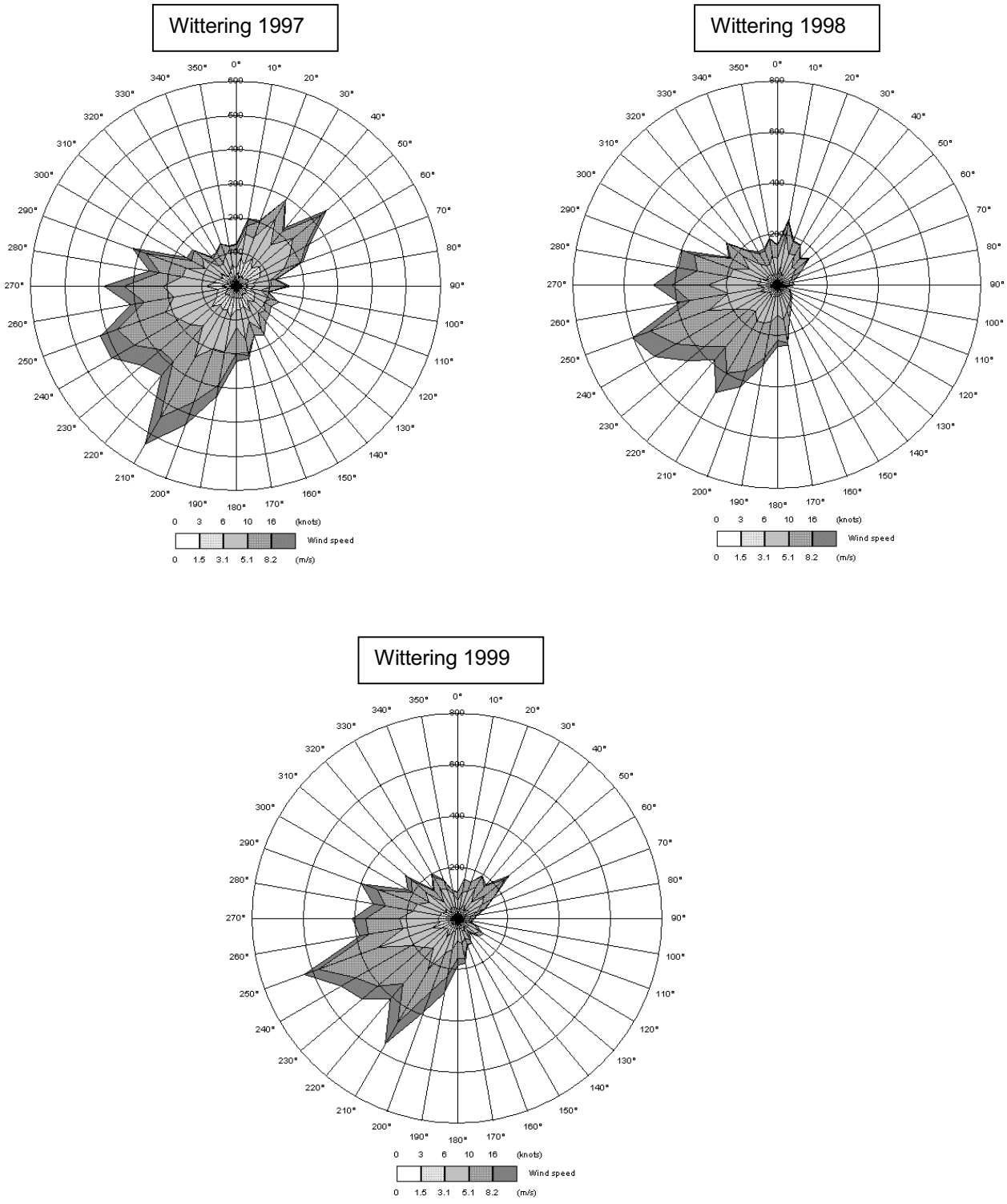
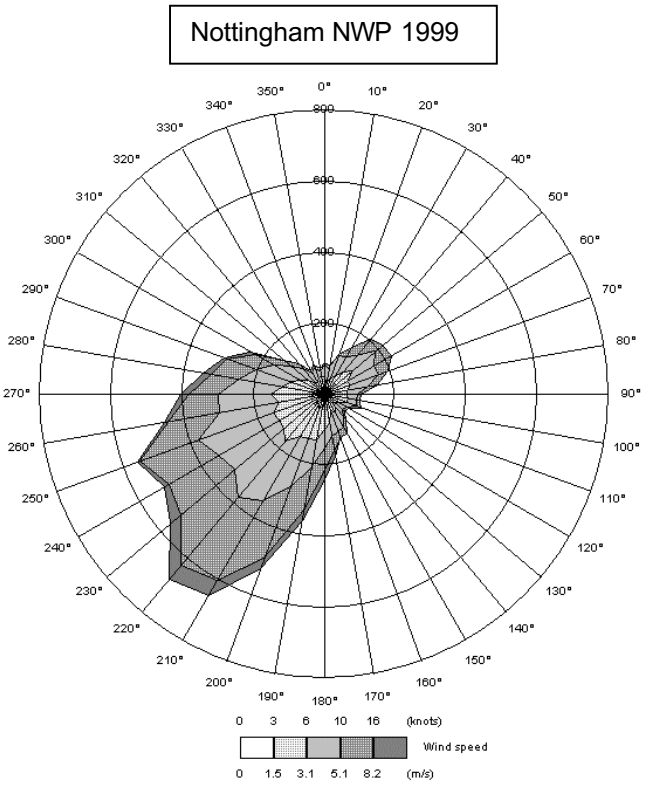
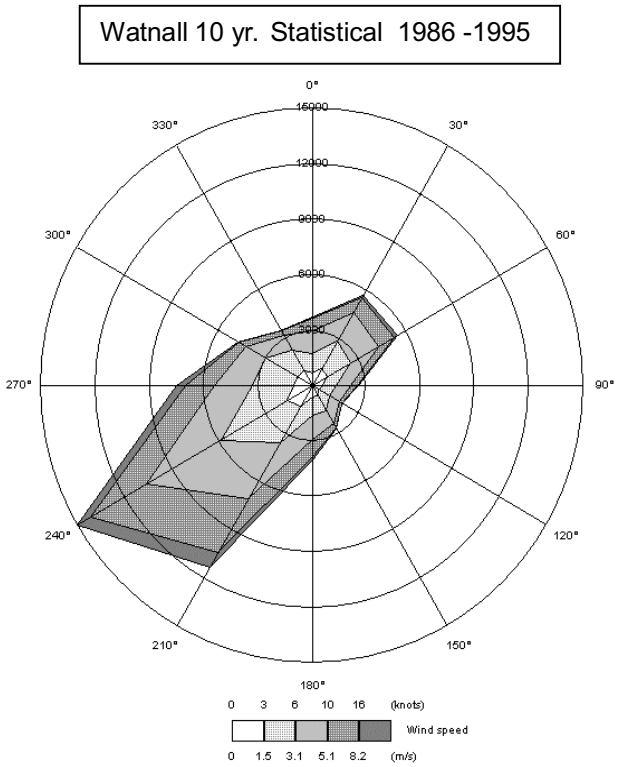


Figure 2: Nottingham NWP 1999 and Watnall 10 yr statistical 1986-1995





Comparisons between Nottingham 1998 and 1999 NWP and Wittering 1998 and 1999 meteorological data were undertaken and found to correlate well, with little difference between predicted concentrations and percentiles. Figures 3 and 4.

Figure 3

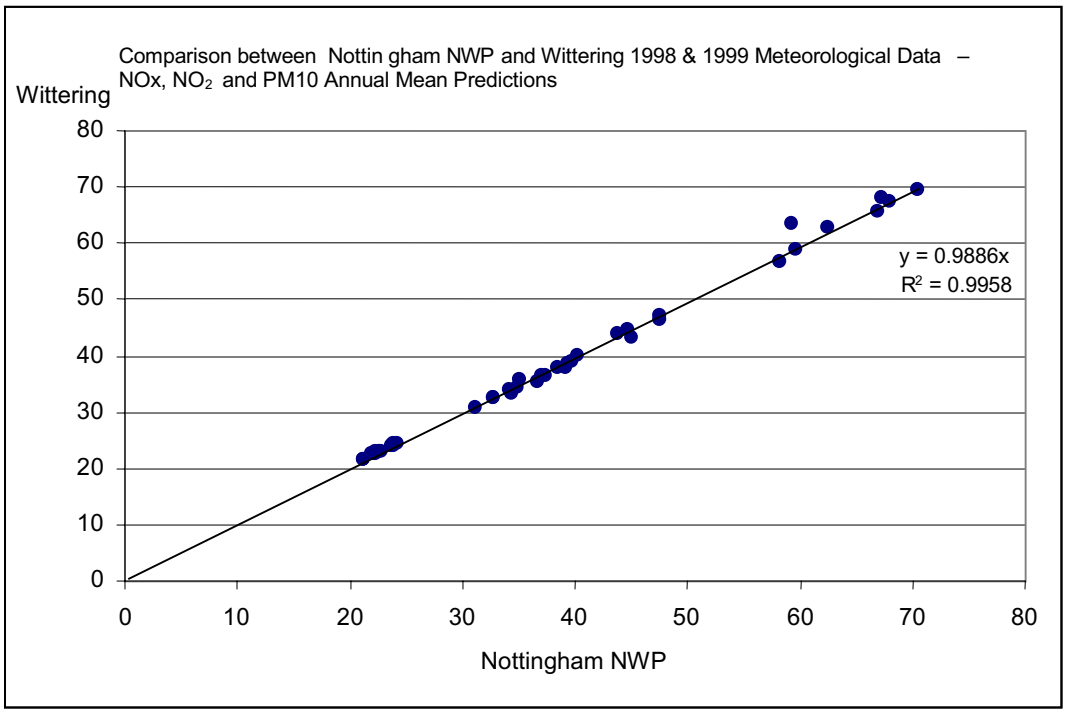
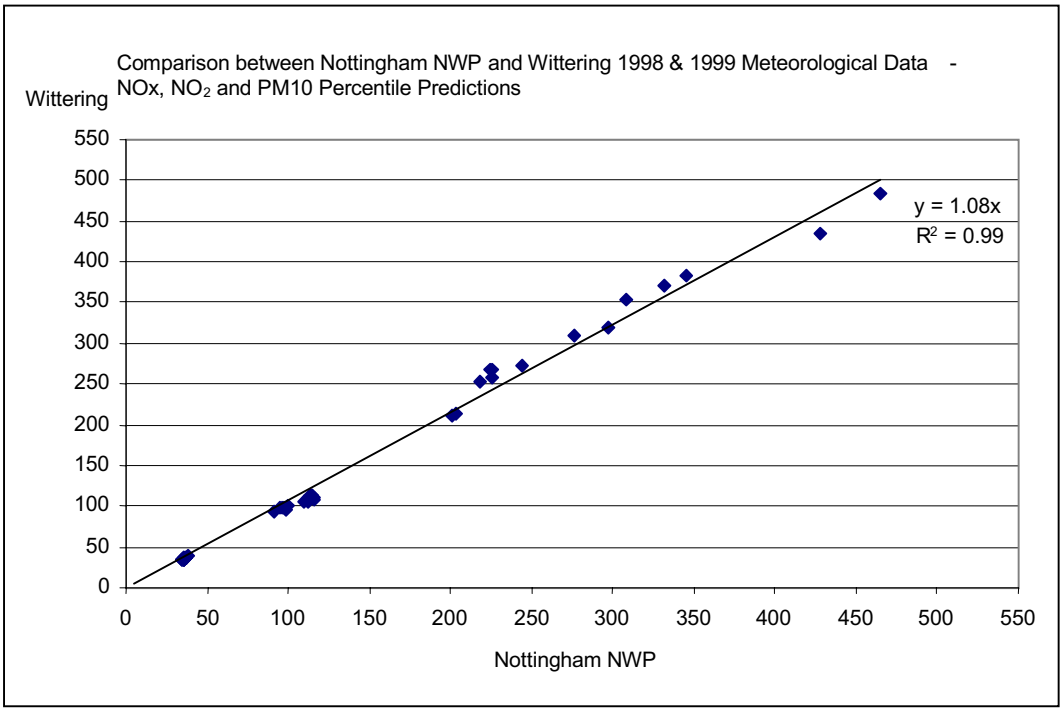


Figure 4



Information on modelling techniques and the use of meteorology is given in Atmospheric Dispersion Modelling: Guidelines on the justification of choice and use of models, and the communication of results 1995. Royal Meteorological Society.

Design Manual for Roads and Bridges, DMRB - Volume 11 Section 3 Model Description

DMRB assessment methodology is used for evaluating the air quality impacts of road projects. The methodology has been revised so that it can also be used in the review and assessment process, to determine the contribution of traffic activity to specific pollutants.

The method requires information on receptor to centre road distances, and for NO_2 prediction, the distance from the receptor to the kerbside and traffic information relating to vehicle speeds, flows and composition (i.e. % HGV). Fixed meteorological conditions are assumed i.e. low wind speed, neutral atmospheric conditions and wind direction evenly distributed around the compass. DMRB contains a database of vehicular emission factors for future years. The calculation method is based on tables and nomograms. A spreadsheet has been provided by Stanger (www.stanger.co.uk/airqual/modelhlp/) to enable DMRB pollutant concentration estimations.

The use of DMRB methodology for air quality assessment of road projects has been validated in a wide variety of conditions. In this review and assessment, DMRB has been used as a screening tool, not for final pollutant predictions, therefore no further validation has been carried out.

Advanced Dispersion Modelling System - ADMS Urban 1.53 Model Description

Nottingham City used ADMS Urban 1.53 by CERC to model and predict concentrations produced by emissions from a variety of sources, over a geographical area.

In order to model an emission, its dispersion, dilution and consequent concentration at a given location a model requires specific information - the input to the model. It performs complex calculations using this information to predict a concentration - the output of the model.

ADMS Urban 1.53 requires the following information: -

Meteorology

The wind direction, wind speed and degree of turbulence determines where an emission is directed, how quickly it travels and how much mixing with the ambient air occurs, i.e. its dispersion and dilution.

Wind speed and direction can be measured directly. The degree of turbulence is indirectly derived from cloud cover, the height of the mixing layer, the time of day, and the time of year. The data may be provided as: -

i. Hourly sequential, giving wind speed, direction, cloud cover, time of day, time of year, temperature and possibly precipitation or
ii. Statistical, data comprising wind speed, direction, surface sensible heat flux, boundary layer depth and precipitation.

Nottingham City used hourly sequential data from Wittering and Nottingham NWP.

Topographical information

Surface roughness

Buildings, hills and undulations cause friction and turbulence as the wind moves over land. Turbulence effects the dispersion of an emission. The amount of friction that topographical features cause is described by the parameter 'surface roughness'.

Surface roughness varies from 1.0 for Cities and woodlands, to 0.5 for parkland and open suburbia, to 0.02 for open grassland.

In ADMS Urban only one value may be chosen for the modelled area.

Nottingham City is characterised by low rise suburban housing, parks, fields and a relatively small 'high rise' core. A value of 0.5 was therefore used.

Emission sources

ADMS Urban can deal with four different types of emission sources, point, line, area and volume. The first three adequately describe emission sources that occur in Nottingham City.

Point Sources

The emission occurs from a specific point. A point source is usually a chimney, which for non-combustion processes may also be called a 'stack'.

Stack height (metres)

The stack height is the height of the point of emission above ground level.

Stack diameter (metres)

The stack diameter is the internal diameter of chimney. In a chimney with multiple flues the aggregated diameter is used.

Area Sources (square kilometres)

An area source is usually a large building or process with emissions occurring in a number of locations over the area. It may also be a large geographical area such as a housing estate where small emissions occur from a large number of point sources which are thus impracticable to model discreetly but collectively emit a significant quantity of a substance and can be included when defined as an area source.

Line Sources (metres or kilometres)

A line source is usually a road (or possibly a railway line). Where a large number of discrete moving point sources can be modelled as a continuous emission along the length of road considered. The model allows only one speed to be specified per line source. Therefore where it is known that vehicle speeds vary along a given road the road was divided into segments. The average speed was determined for each segment.

Physical parameters: Road width and road/segment length.

Traffic volume and average speed

Traffic speed affects the emission rate and composition of exhaust gases. Average speed data was obtained from Nottingham City transportation section, timed journeys or estimated.

Traffic type/mix and emission factors (grammes per kilometre)

Emissions vary between classes of vehicle e.g. heavy goods vehicles (HGVs) and cars and light goods (LGVs). The model uses the 1999 DMRB emission factors, which in turn are derived from the UK emissions factors database http://www.rsk.co.uk/ukefd/. The model only requires the vehicle split between LGV and HGV classes. For roads in Nottingham the vehicle split was obtained from the Development and Environmental Services Department Transportation Section.

Pollutant species

The model is pre-programmed with the characteristics of a number of common pollutants including sulphur dioxide, nitric oxide, nitrogen dioxide, particles PM_{10}. If the emission is not gaseous the model allows the user to specify the size of the particle emitted. Nottingham City only considered PM_{10}.

The background concentration of the pollutant

ADMS Urban models a pollutant source discreetly. To predict the pollutant's concentration it is necessary to add a pollutant's background concentration to the modelled concentration. Background concentrations from the AURN station sited at Rochester were used in model predictions.

Rate of emission

Each process emits pollutants at a given rate. The rate of emission can vary. In the case of sulphur dioxide from a coal fired combustion plant it depends upon the sulphur content of the coal and the rate at which the fuel is burned. For point sources this rate was obtained from data supplied by the plant operator. In the case of line sources and area sources, from data derived from the statistical analysis of national data sets.

Emission temperature

The temperature of an emission affects its thermal buoyancy. If an emission is 'hot' it acts like an extension to a chimney or stack increasing the effective height of discharge.

For point sources the emission temperature was obtained from data supplied by process operators.

For area sources it was considered to be the same as the ambient air temperature.

It is not a required input parameter for line sources.

Chemistry

Nitrogen dioxide arises from the chemical reaction between nitric oxide and ozone. ADMS Urban models the reaction using either the Derwent-Middleton (DM) correction or the Generic Reaction Set (GRS) (ADMS Urban 1.53 manual). Nitrogen dioxide modelling was undertaken using the GRS chemistry option.

Sulphur Dioxide Modelling Information

Modelling was carried out for the Nottingham City Hospital, a single point source with significant SO_2 emissions. It was based on a typical winter situation with two boilers running, one operating at 75% maximum continuous rating (MCR) and the other at 45% MCR. The following information was provided by the combustion plant operators:

Chimney height = 48.8 m
Chimney diameter = 1.22 m
Exit velocity = 13 m/s
Temperature = 200oC
PM_{10} emissions = 1.289 g/s
SO_2 emissions = 78.4g/s

Emission rates were calculated from the monitored data supplied.

The above data and 'domestic' and 'other' area emissions were used in the model run to predict 99.9th%ile, 99.7th%ile and 99.2th %ile sulphur dioxide concentrations arising from the point source for 2004-5.

Model Outputs

The model calculates pollutant concentrations in a defined study area. ADMS Urban was used in conjunction with ArcView for defining output grids for contour plots and specifying receptor points.

ArcView is a geographical information system, (GIS). It can be used to overlay a map with concentration data.

In addition to specifying an area of interest it is necessary to specify short term or long term averaging.

Short term averaging gives a concentration output for each line of meteorological data e.g. a concentration at each point for hour 1, hour 2, etc.

Long term averaging gives one output value at each location averaged over the whole of the input meteorological data set. Therefore the annual mean concentrations can be calculated. Percentiles of pollutant concentrations may be calculated in long-term mode.

Percentiles

ADMS allows several percentiles to be calculated during a single model run. The percentiles chosen were appropriate for the Air Quality Objective being modelled e.g. for SO_2 the 15-minute mean of no more than 35 exceedances of a concentration of 266 μgm^{-3} equates to the 99.9th percentile.

Model Validation

ADMS Urban v1.53 - Atmospheric Dispersion Modelling System.

The use of ADMS Urban enabled forecasts of pollutant concentrations for large areas of the city. In order to have confidence in the model predictions, validation work was undertaken. Validation involves comparison between modelled and measured concentrations at monitoring sites. Any data used in the model should be independent of the monitored concentrations that have been measured at the specific site. The process allows the identification of systematic errors such as whether the model consistently over or under predicts. The error can be quantified and predictions corrected. ADMS Urban has been validated by CERC (Carruthers et al 1996, 1997). However it was appropriate for Nottingham City Council to validate the model for local circumstances and use.

Long term modelling was used to predict annual means and percentiles for PM_{10} and NO_2 for comparison with monitored data. Short term modelling was used to look at the performance of the model by comparing monthly averages for the AURN and AQMS monitoring with model predictions.

Information and Data used

Validation modelling, for the years shown, was carried out where monitoring equipment was sited i.e.

AURN Clinton St East	1997,1998, 1999
AQMS Dunkirk	1997
AQMS Sneinton Dale	1999

The locations of the monitoring equipment are shown in Appendix 1 of the main report.

Model parameters

Surface Roughness = 0.5m
Minimum Monin-Obukov length = 30m
GRS chemistry
Background particulate file used
Meteorology
Meteorological data used were Nottingham NWP 1998 and 1999, Wittering 1997, 1998 and 1999

Background pollutants

Rochester AURN hourly averaged data for the respective year was used.

Emissions data

Road - Traffic flows were calculated for each year. The speeds for each link were kept the same for each year.

Point - The parameters and emissions supplied by the operators or reasonable assumed values were used and kept constant for each year.

Area - 'Domestic' and 'Other' emissions from the NAEI were used. The 1996 values were used for 1997, the 1998 values were used for 1998 and 1999. No corrections were made for the different years. The assumption was made that these particular categories were not likely to alter significantly.

See the monitoring, meteorology, modelling and emissions inventory sections of the technical annexe for details of the above.

Long Term Modelling - Annual means and percentiles

The PM_{10} and NO_2 annual means and percentiles for 1997 to 1999 were modelled. The comparison of monitored levels with the model results showed that there was bias in the model predictions and that the model under predicted results.

Particles, PM_{10}

Table 1 Annual Mean

PM_{10} ugs/m^3 Annual Mean	Monitored	Modelled	Percentage difference	Monitored/ modelled ratio
1 AURN 1997	30	30	0	1.000
2 AURN 1998	27	24	- 11.1	1.125
3 AURN 1999	25	23	- 8.0	1.087
4 AQMS Dunkirk 1997	34	30	- 11.8	1.133
5 AQMS Sneinton Dale 1999	24	21	- 12.5	1.143
Only years with monitored data capture rates greater than 75% are included in the average percentage difference and monitored/modelled ratio i.e.1,2,3,4,5				
Average			- 8.7	1.098

Table 2 90th Percentile

PM_{10} ugs/m^3 90th percentile of 24hr averages	Monitored	Modelled	Percentage difference	Monitored/ modelled ratio
1 AURN 1997	52	49	- 5.8	1.061
2 AURN 1998	47	38	- 19.1	1.237
3 AURN 1999	40	37	- 7.5	1.081
4 AQMS Dunkirk 1997	62	49	- 21.0	1.265
5 AQMS Sneinton Dale 1999	37	38	2.7	0.974
***Only years with* monitored data capture rates greater *than* 75% are included in *the average* percentage *difference* and monitored/modelled ratio i.e. 1,2,3,4,5**				
Average			- 10.1	1.124

Nitrogen Dioxide NO_2

Table 3 Annual mean

NO_2 ugs/m^3 Annual Mean	Monitored	Modelled	Percentage difference	Monitored/ modelled ratio
1 AURN 1997	49	41	- 16.3	1.195
2 AURN 1998	47	38	- 19.1	1.237
3 AURN 1999	44	39	- 9.1	1.128
4 AQMS Dunkirk 1997	40	39	- 2.5	1.026
5 AQMS Sneinton Dale 1999	36	34	- 5.6	1.059
***Only years with* monitored data capture rates greater *than* 75% are included in *the average* percentage *difference* and monitored/modelled ratio i.e. 2,3,4**				
Average			-10.2	1.130

Table 4 99.8th Percentile

NO_2 ugs/m^3 99.8th percentile of hourly averages	Monitored	Modelled	Percentage difference	Monitored/ modelled ratio
1 AURN 1997	128	137	-7.0	0.934
2 AURN 1998	117	112	- 4.3	1.045
3 AURN 1999	92	110	19.6	0.836
4 AQMS Dunkirk 1997	139	135	- 2.9	1.030
5 AQMS Sneinton Dale 1999	135	100	- 25.9	1.350
Only years with* monitored data capture rates greater *than* 75% are included in *the* average percentage *difference* and monitored/modelled ratio i.e. *2,3,4				
Average			4.1	0.970

These percentage differences are consistent with data published by CERC relating to Birmingham East and Birmingham Centre over the three year period, 1994 -1996.

"These studies show that the annual mean is generally (with a few exceptions) accurate to within 15% for NO_2 and PM_{10}, the 90th percentile of daily averages of PM_{10} (35 exceedances) is accurate to within 20% and the 99.8th percentile of hourly means of NO_2 (18 exceedances) is accurate to within 40%." (Carruthers et al 1996,1997).

Tables 1 to 4 above show that the model generally under predicts the values for PM_{10} and NO_2, for both the annual means and the 90th and 99.8th percentiles. Therefore correction factors were derived to apply to the model predictions for future years.

Correction factor = monitored concentrations divided by the modelled concentrations

e.g. AURN 1998 PM_{10} Annual mean
27 μgs/m^3 divided by 24 μgs/m^3 = 1.125

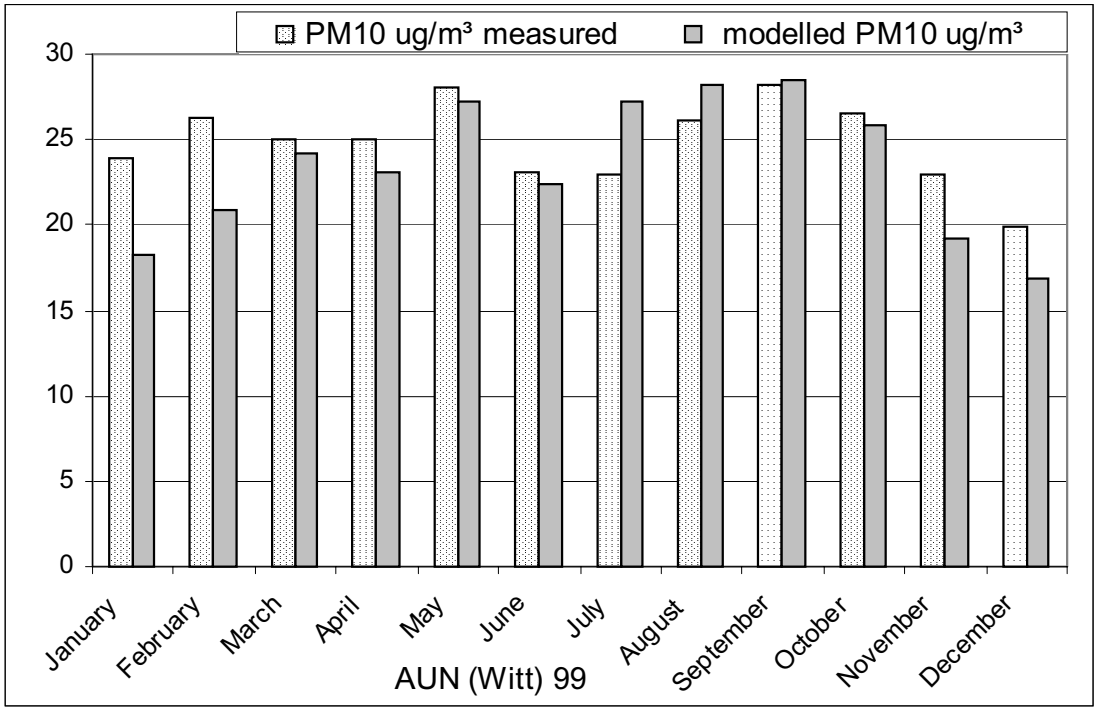
Modelled results were multiplied by the appropriate averaged correction factor for the pollutant concentration predictions for 2004 and 2005. For PM_{10} annual mean, the correction factor = 1.098 and for 90th percentile, factor = 1.124. For NO_2 annual mean, the correction factor = 1.130. The model results for NO_2 99.8th percentiles were not adjusted because the validation work showed that the model gave slightly higher results than the monitored levels and the correction factor was 0.97.

Short Term Modelling

Short term modelling results in a pollutant concentration value for each hour of a year. It cannot be used to predict percentiles but it does allow hours to be amalgamated for different time periods. Monthly averages for the AUN and AQMS 1997 to 1999 were calculated. The AURN measured and the corresponding modelled PM_{10} and NO_2 values for 1999 are shown in graphs 1 to 4. Both Wittering and Nottingham NWP meteorological data were used.

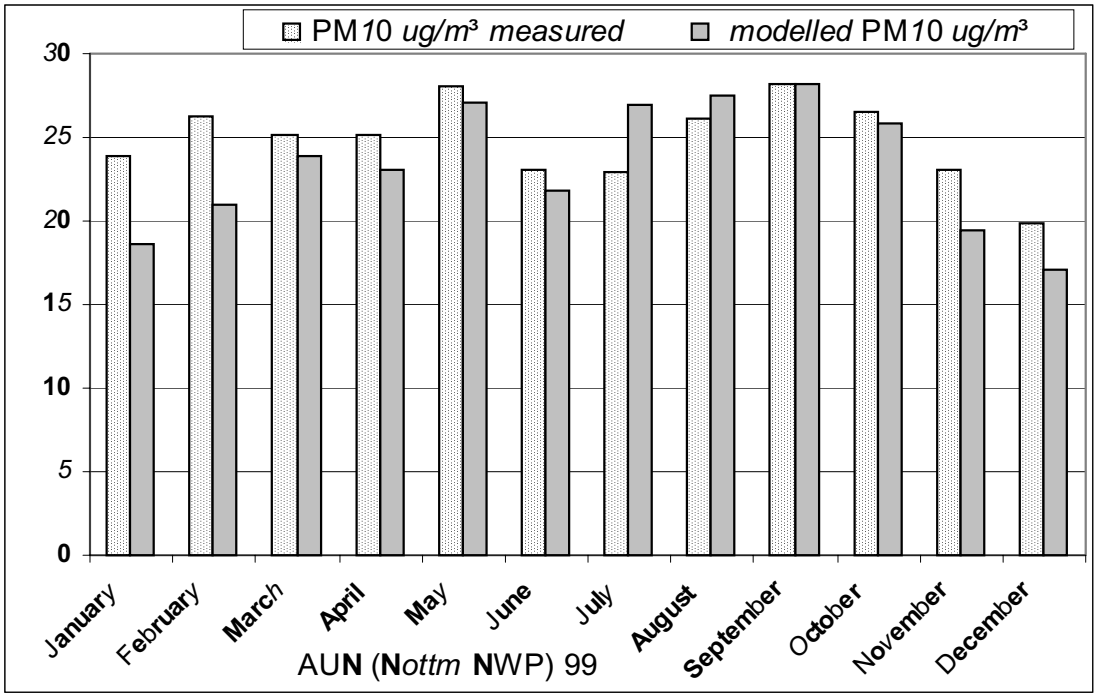
Graph 1

Particle,PM_{10} - comparison between monitored and modelled monthly concentrations using Wittering 1999 meteorological data



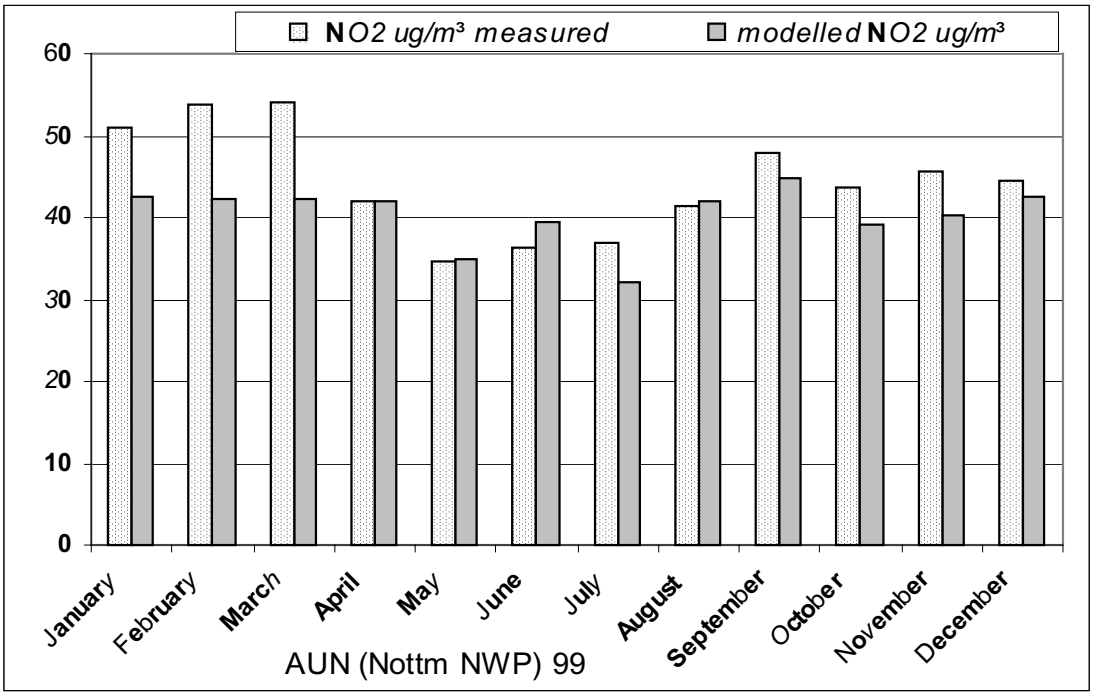
Graph 2

Particle, PM_{10} - comparison between monitored and modelled monthly concentrations using Nottingham NWP 1999 meteorological data.



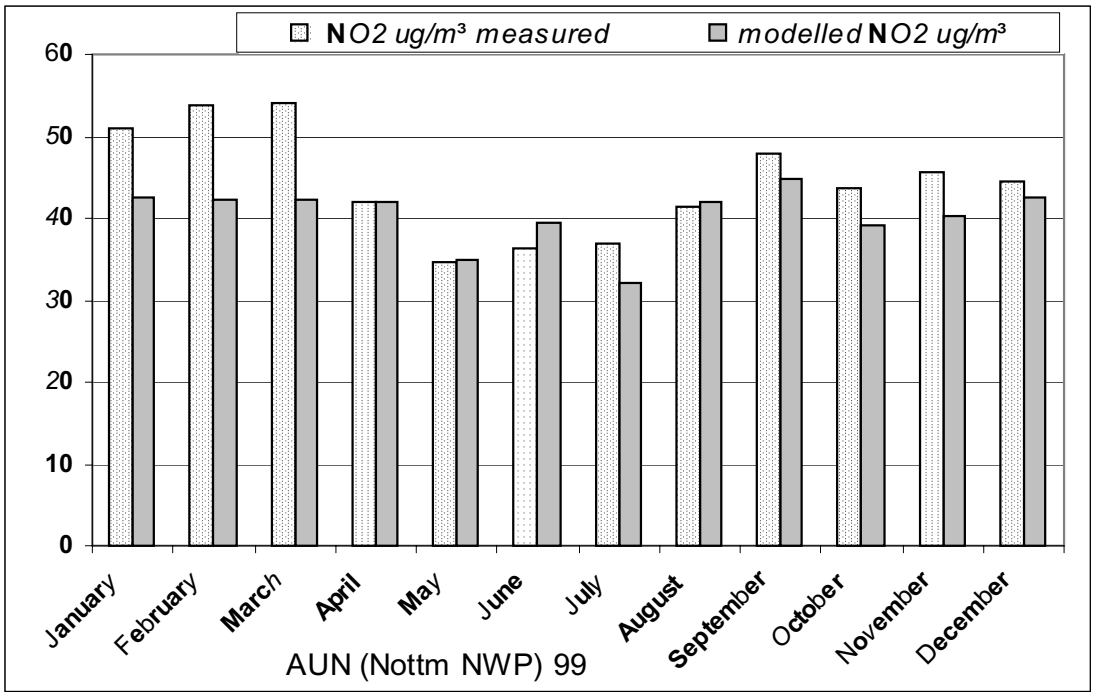
Graph 3

Nitrogen dioxide, NO_2 - comparison between monitored and modelled monthly concentrations using Wittering 1999 meteorological data



Graph 4

Nitrogen dioxide, NO_2 - comparison between monitored and modelled monthly concentrations using Nottingham NWP1999 meteorological data



The graphs show that for the AURN, most of the under prediction compared with monitored results, occurs in the Winter months. Results not shown, for the other years and for AQMS, are similar. There is little difference in the monthly averages between the two meteorological data sets used.

Sulphur dioxide (SO_2) has not been validated separately. Nottingham City relied upon the validation studies undertaken by CERC (Carruthers et al 1996, 1997).

The modelling validation exercise demonstrated that whilst the model under predicted PM_{10} and NO_2 concentrations this was within recognised acceptable limits. Multiplying factors can be used to correct for systematic error and it is appropriate to use the model for prediction of pollutant concentrations in the City of Nottingham.

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Policy Statement - **Atmospheric Dispersion Modelling : Guidelines on the justification of choice and use of models, and the communication of results.**

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