Report

Air Quality Review and Assessment - Detailed

A Report produced for St Albans City and District Council

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AEA Technology Environment
Culham
Abingdon
Oxfordshire
OX14 3DB
Telephone 0870 190 6529
Facsimile 0870 190 6607

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	Name	**Signature**	**Date**
Author	Jim McGinlay		
Reviewed by	Beth Conlan		
Approved by	Beth Conlan		

Executive Summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality which culminated in the Environment Act, 1995. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives[2] have been enacted through the Air Quality Regulations in 1997 and 2000 and the Air Quality (Amendment) Regulations 2002. The Environment Act 1995 requires Local Authorities to undertake an air quality review. In areas where the air quality objective is not anticipated to be met, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

The intention is that local authorities should only undertake a level of assessment that is proportionate to the risk of air quality objectives being exceeded. The first step in the second round of review and assessment is an Updating and Screening Assessment (USA), which is to be undertaken by all authorities. Where the USA has identified a risk that an air quality objective will be exceeded, the authority is required to undertake a detailed assessment.

In July 2003 St Albans City and District Council published their updating and screening assessment in which it was assessed that there was a risk of exceedance of the UK objectives for NO_2 in 2005 at 4 locations which had not previously been subject to a detailed assessment, nor had been declared air quality management areas. These areas were in the vicinity of:

- M1 Lyebury Lane, Redbourn
- Isolated property next to A4147, south of M1 junction 7 with the M10
- London Colney, north east of M25 Junction 22 London Colney
- Peahen Crossroads, central St Albans

The screening report also concluded that no significant changes had occurred at locations previously studied in St Albans' Stage 4 report, and therefore that the conclusions of this report still stood.

The present report therefore constitutes a Detailed Assessment for St Albans City and District Council. Only the impact of nitrogen dioxide emissions are considered in this report. This report investigates current and potential future nitrogen dioxide levels through an examination of the location and size of principal traffic emission sources, emissions modelling exercises and by reference to monitored air quality data.

Nitrogen Dioxide

In this rassessment modelling of NO_2 concentrations has been undertaken using the ADMS v3.1 model and the most recent set of emission factors for road vehicles. The model results have been adjusted in the light of automatic monitoring results to take account of model bias.

Following the previous round of Review and Assessment, St Albans City and District Council declared 2 AQMAs for nitrogen dioxide at the following areas adjacent to the M25:

- Colney Street; and
- Frogmore

The modelling results of this assessment have shown that there are two further areas where the probability of exceedance of the UK objective for annual average NO_2 is "probable" to "very likely":

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[1] Refers to standards recommended by the Expert Panel on Air Quality Standards. Recommended standards are set purely with regard to scientific and medical evidence on the effects of the particular pollutants on health, at levels at which risks to public health, including vulnerable groups, are very small or regarded as negligible.

[2] Refers to objectives in the Strategy for each of the eight pollutants. The objectives provide policy targets by outlining what should be achieved in the light of the air quality standards and other relevant factors and are expressed as a given ambient concentration to be achieved within a given timescale.

- Isolated property next to the A4147, between the M1 and M10 south of M1 junction 7
- Peahen crossroads, central St Albans

Further action is therefore necessary in these areas. The risk of exceedance of the objectives for NO_2 at the other two locations studied in this assessment was found to be at most "possible", and therefore it is recommended that no further action is necessary.

The results of the model validation, (which takes into account uncertainty based on model errors and year to year variability) suggests that only areas within the 40 $\mu g\ m^{-3}$ contour will "probably" (>50% probability) exceed and only areas within the 46 $\mu g\ m^{-3}$ contour are "likely" (>80% probability) to exceed the objective in 2005. It would be generally recommended that St Albans City and District Council only considered declaring an AQMA where the probability of exceedance in 2005 is greater than 50%.

Consideration has been given to the possibility of designating Air Quality Management Areas at the locations assessed. Factors to be taken into account include:

- the likelihood that the objective will be met;
- the likelihood that members of the public will be exposed over the relevant averaging time;

It is recommended that St Albans City and District Council consider declaring two further AQMAs for NO_2 at the following locations:

- Isolated property next to the A4147, between the M1 and M10 south of M1 junction 7
- Peahen crossroads, central St Albans

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Acronyms and definitions

AADTF	annual average daily traffic flow
ADMS	an atmospheric dispersion model
AQDD	Common Position on Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
CNS	central nervous system
d.f.	degrees of freedom
DEFRA	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
ERG	Environmental Research Group, Kings College, London
GIS	Geospatial Information System
kerbside	0 to 5 m from the kerb
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NETCEN	National Environmental Technology Centre
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NPL	National Physical Laboratory
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient
roadside	1 to 5 m from the kerb
SACDC	St Albans City and District Council
SD	standard deviation
TEMPRO	A piece of software produced by the DfT used to forecast traffic flow increases
UWE	University of West of England

Contents

1 Introduction

1.1 PURPOSE OF THE STUDY

Following the outcome of their updating and screening report of July 2003, St Albans City and District Council have commissioned **netcen** to undertake a Detailed Assessment for nitrogen dioxide around the following areas in the district:

- M1 Lyebury Lane, Redbourn
- Isolated property next to A4147, south of M1 junction 7 with the M10
- London Colney, north east of M25 Junction 22 London Colney
- Peahen Crossroads, central St Albans

The risk of an exceedance of the 2005 UK objective for annual mean NO_2 was predicted in the screening report as a result of either diffusion tube results, or from predictions of roadside NO_2 concentrations calculated using the latest version of the DMRB screening tool.

1.2 GENERAL APPROACH TAKEN

The approach taken in this study was to:

- Collect and interpret additional data to that already used in the screening assessment, in order to support the detailed assessment, including more detailed traffic flow data around the areas outlined above;
- Utilise the monitoring data from the Council's monitoring campaign to assess the ambient concentrations resulting from road traffic emissions, and to validate the output of the modelling studies;
- Model the concentrations of NO_2 around the selected roads, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations.

1.3 VERSION OF THE POLLUTANT SPECIFIC GUIDANCE USED IN THIS ASSESSMENT

This report has used the latest guidance in LAQM.TG(03), published in February 2003.

1.4 NUMBERING OF FIGURES AND TABLES

The numbering scheme is not sequential, and the figures and tables are numbered according to the chapter and section that they relate to.

1.5 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g\ m^{-3}$ (which is consistent with the presentation of the new AQS objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is a detailed Air Quality review for St Albans City and District Council for nitrogen dioxide. This chapter, Chapter 1 has summarised the need for the work and the approach to completing the study.

Chapter 2 of the report describes developments in the UK's Air Quality Strategy (AQS). In addition, it discusses when implementation of an AQMA is required.

Chapter 3 contains details of the information used to conduct the Detailed Assessment for St Albans City and District Council.

Chapter 4 introduces the latest standards and objectives for nitrogen dioxide and summarises the monitoring of NO_2 that has taken place in St Albans in the areas of concern.

Chapter 5 describes the results of the assessment and discusses whether the nitrogen dioxide objectives will be exceeded in St Albans in 2005. The results of the analysis are displayed in tabular form and as contour plots. It also presents the recommendations from the St Albans assessment.

1.7 GIS DATA USED

St Albans City and District Council provided the Ordnance Survey landline data for use in this project.

1.8 EXPLANATION OF THE MODELLING OUTPUT

The contour maps generated in the modelling for this report are an indication of the predicted pollutant concentrations around the area modelled. They are not lines of absolute values and should not be considered as such. Care should also be taken, in cases where contours join up as enclosed loops. This is common, for example along a section of road. The contours may appear to circle a section of the road, rather than extend all the way along it. This is due to the input area over which the model was run being only a section of the road in question. No assumptions of pollutant concentrations can be made on locations outside of the area being modelled.

2 The updated Air Quality Strategy

2.1 THE NEED FOR AN AIR QUALITY STRATEGY

The Government published its proposals for review of the National Air Quality Strategy in early 1999 (DETR, 1999). These proposals included revised objectives for many of the regulated pollutants. A key factor in the proposals to revise the objectives was the agreement in June 1998 at the European Union Environment Council of a Common Position on Air Quality Daughter Directives (AQDD).

Following consultation on the Review of the National Air Quality Strategy, the Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

The Environment Act (1995) provides the legal framework for requiring LA's to review air quality and for implementation of an AQMA. The main constituents of this Act are summarised in Table 2.1 below.

Table 2.1 Major elements of the Environment Act 1995

Part IV Air Quality	Commentary
Section 80	Obliges the Secretary of State (SoS) to publish a National Air Quality Strategy as soon as possible.
Section 81	Obliges the Environment Agency to take account of the strategy.
Section 82	Requires local authorities, any unitary or Borough, to review air quality and to assess whether the air quality standards and objectives are being achieved. Areas where standards fall short must be identified.
Section 83	Requires a local authority, for any area where air quality standards are not being met, to issue an order designating it an air quality management area (AQMA).
Section 84	Imposes duties on a local authority with respect to AQMAs. The local authority must carry out further assessments and draw up an action plan specifying the measures to be carried out and the timescale to bring air quality in the area back within limits.
Section 85	Gives reserve powers to cause assessments to be made in any area and to give instructions to a local authority to take specified actions. Authorities have a duty to comply with these instructions.
Section 86	Provides for the role of County Councils to make recommendations to a district on the carrying out of an air quality assessment and the preparation of an action plan.
Section 87	Provides the SoS with wide ranging powers to make regulations concerning air quality. These include standards and objectives, the conferring of powers and duties, the prohibition and restriction of certain activities or vehicles, the obtaining of information, the levying of fines and penalties, the hearing of appeals and other criteria. The regulations must be approved by affirmative resolution of both Houses of Parliament.
Section 88	Provides powers to make guidance which local authorities must have regard to.

2.2 OVERVIEW OF THE PRINCIPLES AND MAIN ELEMENTS OF THE NATIONAL AIR QUALITY STRATEGY

The main elements of the AQS can be summarised as follows:

- The use of a health effects based approach using national air quality standards and objectives.
- The use of policies by which the objectives can be achieved and which include the input of important factors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with target dates of 2003, 2004, 2005, 2008 and 2010 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the AQS will provide a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles which include:

- the provision of a statement of the Government's general aims regarding air quality;
- clear and measurable targets;
- a balance between local and national action and
- a transparent and flexible framework.

Co-operation and participation by different economic and governmental sectors is also encouraged within the context of existing and potential future international policy commitments.

2.2.1 National Air Quality Standards

At the centre of the AQS is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Most of the proposed standards have been based on the available information concerning the health effects resulting from different ambient concentrations of selected pollutants and are the consensus view of medical experts on the Expert Panel on Air Quality Standards (EPAQS). These standards and associated specific objectives to be achieved between 2003 and 2010 are shown in Table 2.2. The table shows the standards in ppb and $\mu g\ m^{-3}$ with the number of exceedances that are permitted (where applicable) and the equivalent percentile.

Specific objectives relate either to achieving the full standard or, where use has been made of a short averaging period, objectives are sometimes expressed in terms of percentile compliance. The use of percentiles means that a limited number of exceedances of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as November 5th. For example, if an objective is to be complied with at the 99.9th percentile, then 99.9% of measurements at each location must be at or below the level specified.

Table 2.2 Air Quality Objectives in the Air Quality Regulations (2000) and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management.

Pollutant	Concentration limits ($\mu g\ m^{-3}$)	Concentration limits (ppb)	Averaging period	Objective [number of permitted exceedances a year and equivalent percentile] ($\mu g\ m^{-3}$)	Objective date for objective
Benzene	16.25	5	**running annual** mean	**16.25**	by 31.12.2003
	5	1.5	**Annual mean**	**5**	by 31.12.2010
1,3-butadiene	2.25	1	**running annual** mean	**2.25**	by 31.12.2003
CO	10,000	8,600	**running 8-hour** mean	**10,000**	by 31.12.2003
Pb	0.5	-	**annual** mean	**0.5**	by 31.12.2004
	0.25	-	**annual** mean	**0.25**	by 31.12.2008
NO_2 (see note)	200	105	**1 hour** mean	**200** [maximum of 18 exceedances a year or equivalent to the 99.8th percentile]	by 31.12.2005
	40	21	**annual** mean	**40**	by 31.12.2005
PM_{10} gravimetric (see note)	50	-	**24-hour** mean	**50** [maximum of 35 exceedances a year or ~ equivalent to the 90th percentile]	by 31.12.2004
	40	-	**annual** mean	**40**	by 31.12.2004
SO_2	266	100	**15 minute** mean	**266** [maximum of 35 exceedances a year or equivalent to the 99.9th percentile]	by 31.12.2005
	350	132	**1 hour** mean	**350** [maximum of 24 exceedances a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour** mean	**125** [maximum of 3 exceedances a year or equivalent to the 99th percentile]	by 31.12.2004

Notes

1. Conversions of ppb and ppm to ($\mu g\ m^{-3}$) correct at 20°C and 1013 mb.
2. The objectives for nitrogen dioxide are provisional.

PM_{10} measured using the European gravimetric transfer standard or equivalent.

2.2.2 Relationship between the UK National Air Quality Standards and EU air quality Limit Values

As a member state of the EU, the UK must comply with EU Directives.

There are three EU ambient air quality directives that the UK has transposed in to UK law. These are:

- **96/62/EC** Council Directive of 27 September 1996 on ambient air quality assessment and management (the Ambient Air Framework Directive).
- **1999/30/EC** Council Directive of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, particulate matter and lead in ambient air (the First Daughter Directive).
- **2000/69/EC** Directive of the European Parliament and the Council of 16 Nov 2000 relating to limit values for benzene and carbon monoxide in ambient air (the Second Daughter Directive).

The first and second daughter directives contain air quality Limit Values for the pollutants that are listed in the directives. The United Kingdom (i.e. Great Britain and Northern Ireland) must comply with these Limit Values. The UK air quality strategy should allow the UK to comply with the EU Air Quality Daughter Directives, but the UK air quality strategy also includes some stricter national objectives for some pollutants, for example, the 15-minute sulphur dioxide objective.

The Government is ultimately responsibility for achieving the EU limit values. However, it is important that Local Air Quality Management is used as a tool to ensure that the necessary action is taken at local level to work towards achieving the EU limit values by the dates specified in those EU Directives.

2.2.3 New particle objectives (not included in Regulations[3])

For particulates (as PM10) new objectives are proposed.

- For all parts of the UK, except London and Scotland, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times a year and an annual mean of 20 $\mu g/m^3$, both to be achieved by the end of 2010;
- For London, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 10 times a year and an annual mean of 23 $\mu g/m^3$, both to be achieved by the end of 2010;
- For Scotland, a 24 hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times a year and an annual mean of 18 $\mu g/m^3$, both to be achieved by the end of 2010.

2.2.4 Policies in place to allow the objectives for the pollutants in AQS to be achieved

The policy framework to allow these objectives to be achieved is one that that takes a local air quality management approach. This is superimposed upon existing national and international regulations in order to effectively tackle local air quality issues as well as issues relating to wider spatial scales. National and EC policies that already exist provide a good basis for progress towards the air quality objectives set for 2003 to 2008. For example, the Environmental Protection Act 1990 allows for the monitoring and control of emissions from industrial processes and various EC Directives have ensured that road transport emission and fuel standards are in place. These policies are being developed to include more stringent controls. Recent developments in the UK include the announcement by the Environment Agency in January 2000 on controls on emissions of SO_2 from coal and oil fired power stations. This system of controls means that by the end of 2005 coal and oil fired power stations will meet the air quality standards set out in the AQS.

Local air quality management provides a strategic role for local authorities in response to particular air quality problems experienced at a local level. This builds upon current air quality control

[3] The exception is the Scottish Executive which has incorporated the new PM10 objectives in their Regulations.

responsibilities and places an emphasis on bringing together issues relating to transport, waste, energy and planning in an integrated way. This integrated approach involves a number of different aspects. It includes the development of an appropriate local framework that allows air quality issues to be considered alongside other issues relating to polluting activity. It should also enable co-operation with and participation by the general public in addition to other transport, industrial and governmental authorities.

An important part of the Strategy is the requirement for local authorities to carry out air quality reviews and assessments of their area against which current and future compliance with air quality standards can be measured. Over the longer term, these will also enable the effects of policies to be studied and therefore help in the development of future policy. The Government has prepared guidance to help local authorities to use the most appropriate tools and methods for conducting a review and assessment of air quality in their District. This is part of a package of guidance being prepared to assist with the practicalities of implementing the AQS. Other guidance covers air quality and land use planning, air quality and traffic management and the development of local air quality action plans and strategies.

2.2.5 Timescales to achieve the objectives

In most local authorities in the UK, objectives will be met for most of the pollutants within the timescale of the objectives shown in Table 2.2. It is important to note that the objectives for NO_2 remain provisional. The Government has recognised the problems associated with achieving the standard for ozone and this will not therefore be a statutory requirement. Ozone is a secondary pollutant and transboundary in nature and it is recognised that local authorities themselves can exert little influence on concentrations when they are the result of regional primary emission patterns.

2.3 AIR QUALITY REVIEWS

A range of Technical Guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes LAQM.TG(03), on 'Local Air Quality Management: Technical Guidance, February 2003. This review and assessment has considered the procedures set out in the guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed in the second round that reviews should be carried out in two stages. Every authority is expected to undertake at least a first stage Updating and screening Assessment (USA) of air quality in their authority area. Where the USA has identified a risk that an air quality objective will be exceeded at a location with relevant public exposure, the authority will be required to undertake a detailed assessment. The Stages are briefly described in the following table, Table 2.3.

Table 2.3: The phased approach to review and assessment.

Level of assessment	Objective	Approach
Updating and screening assessment (USA)	To identify those matters that have changed since the last review and assessment, which might lead to a risk of the air quality objective being exceeded.	Use a check list to identify significant changes that require further consideration. Where such changes are identified, apply simple screening tools to decide whether there is sufficient risk of an exceedance of an objective to justify a detailed assessment
Detailed assessment	To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment or any necessary AQMAs.	Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

2.4 LOCATIONS THAT THE REVIEW AND ASSESSMENT MUST CONCENTRATE ON

For the purpose of review and assessment, the authority should focus their work on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 2.4 summarises the locations where the objectives should and should not apply.

Table 2.4 Typical locations where the objectives should and should not apply (England only)

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	• 1,3 Butadiene • Benzene • Lead • Nitrogen dioxide • Particulate Matter (PM_{10})	• All background locations where members of the public might be regularly exposed.	• Building facades of offices or other places of work where members of the public do not have regular access.
		• Building facades of residential properties, schools, hospitals, libraries etc.	• Gardens of residential properties.
			• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term
24 hour mean and 8-hour mean	• Carbon monoxide • Particulate Matter (PM_{10}) • Sulphur dioxide	• All locations where the annual mean objective would apply.	• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
		• Gardens of residential properties.	

Table 2.4 (contd.) Typical locations where the objectives should and should not apply (England only)

Averaging Period	Pollutants	Objectives should apply at …	Objectives should generally not apply at …
1 hour mean	• Nitrogen dioxide • Sulphur dioxide	• All locations where the annual mean and 24 and 8-hour mean objectives apply.	• Kerbside sites where the public would not be expected to have regular access.
		• Kerbside sites (e.g. pavements of busy shopping streets).	
		• Those parts of car parks and railway stations etc. which are not fully enclosed.	
		• Any outdoor locations to which the public might reasonably expected to have access.	
15 minute mean	• Sulphur dioxide	• All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

It is unnecessary to consider exceedances of the objectives at any location where public exposure over the relevant averaging period would be unrealistic, and the locations should represent non-occupational exposure.

Key Points

- The Environment Act 1995 has required the development of a National Air Quality Strategy for the control of air quality.
- A central element in the Strategy is the use of air quality standards and associated objectives based on human health effects that have been included in the Air Quality Regulations.
- The Strategy uses a local air quality management approach in addition to existing national and international legislation. It promotes an integrated approach to air quality control by the various factors and agencies involved.
- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2010.
- A number of air quality reviews are required in order to assess compliance with air quality objectives. The number of reviews necessary depends on the likelihood of achieving the objectives.

3 Information used to support this assessment

This Chapter presents the information used to support this review and assessment.

3.1 MAPS

St Albans City and District Council provided OS Landline data of the areas in the district which needed to be modelled. This enabled accurate road widths and the distance of the housing to the kerb to be determined.

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3.2 ROAD TRAFFIC DATA

3.2.1 Average flow, hourly fluctuations in flow, speed and fraction of HDV's.

AADT traffic flow data for 2002 were provided by Hertfordshire County Council and the Highways Agency for the roads of concern. To determine the hourly fluctuations in traffic flow the (then) DETR's diurnal traffic variation default figures were used (DETR 1999b).

Data on the percentage of HDVs and on free-flowing traffic speeds were also available for some road stretches. Where unavailable these were taken from the NAEI dataset. Appendix 1 summarises the traffic flow data used.

3.2.2 Traffic Growth

2002 traffic flow data was used to estimate flows in 2005 figures using traffic growth factors derived from the NRTF and the TEMPRO v4 model. TEMPRO provides regional traffic growth statistics. Details of the growth factors used in the assessment to predict traffic flows in St Albans in 2005 are given in Appendix 1.

3.3 METEOROLOGICAL DATA USED IN THE DISPERSION MODELLING

Hourly meteorological data for Heathrow for 1999, as used for St Albans City and District Council's Stage 4 assessment, was also applied to this study.

3.4 AMBIENT MONITORING

3.4.1 Nitrogen dioxide

Nitrogen dioxide concentrations were monitored:

- By continuous monitoring at the Fleetville Community Centre background monitoring site, Fleetville, St Albans. No roadside automatic monitoring is currently undertaken in St Albans' District.

- By diffusion tubes. St Albans City and District Council have also been undertaking a co-location study at the Fleetville Community Centre automatic monitoring station since 2001. Until Autumn 2002, a single diffusion tube was collocated at this site. Since then a triplicate co-location has been undertaken. To provide a reasonable estimate of the annual mean concentration, concentrations for at least 6 months of the year are needed. Therefore, annual means have not been presented where there are less than 6 months of data. No diffusion tube results were available for locations close to M1 junction 7 with the M10. Diffusion tube results were available for the three other hotspots studied in this detailed assessment.

Details of the type, locations, and concentrations recorded by the monitors (diffusion tubes and continuous monitors) are given in Appendix 2.

3.5 COMPUTER MODELLING

The modelling programmes used in this assessment make a number of assumptions during the calculations. These include no consideration of terrain relief, or direct consideration of buildings over the surface being modelled. Modelling of pollutant concentrations on roads can sometimes provide misleading information on produced contour maps. For example, polygons and circles on certain areas of the contour maps, e.g. roundabouts or the centres of roads, can be generated. This is not a deficiency in the model – it is an artefact of the data. As such, these additional features should be ignored and the wider context and implications of the contour maps be considered.

4 Nitrogen dioxide

4.1 INTRODUCTION

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x, is road traffic, which is responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are power stations, heating plant and industrial processes.

Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised to NO_2 by reaction with ozone. Elevated levels of NO_x occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse.

Nitrogen dioxide has a variety of environmental and health impacts. It is a respiratory irritant, may exacerbate asthma and possibly increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. In addition, nitrogen oxides have a lifetime of approximately 1-day with respect to conversion to nitric acid. This nitric acid is in turn removed from the atmosphere by direct deposition to the ground, or transfer to aqueous droplets (e.g. cloud or rainwater), thereby contributing to acid deposition.

4.2 LATEST STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

The National Air Quality Regulations (1997) set two provisional objectives to be achieved by 2005 for nitrogen dioxide:

- An annual average concentration of 40 μg m^{-3} (21 ppb);
- A maximum hourly concentration of 286 μg m^{-3} (150 ppb).

In June 1998, the Common Position on Air Quality Daughter Directives (AQDD) agreed at Environment Council included the following objectives to be achieved by 31 December 2005 for nitrogen dioxide:

- An annual average concentration of 40 μg m^{-3} (21 ppb);
- 200 μg m^{-3} (100 ppb) as an hourly average with a maximum of 18 exceedances in a year.

The National Air Quality Strategy was reviewed in 1999 (DETR, 1999). The Government proposed that the annual objective of 40 μg m^{-3} be retained as a provisional objective and that the original hourly average be replaced with the AQDD objective. The revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DETR, 1999; 2000) included the proposed changes. Modelling studies suggest that in general achieving the annual mean of 40 μg m^{-3} is more demanding than achieving the hourly objective. If the annual mean is achieved, the modelling suggests the hourly objectives will also be achieved.

4.3 THE NATIONAL PERSPECTIVE

The main source of NO_x in the United Kingdom is road transport, which, in 2000 accounted for approximately 42% of emissions. Power generation contributed approximately 29% and domestic sources 5%. In urban areas, the proportion of local emissions due to road transport sources is larger (NAEI, 2000).

National measures are expected to produce reductions in NO_x emissions and achieve the objectives for NO_2 in many parts of the country. However, the results of the analysis set out in the National Air Quality Strategy suggest that for NO_2 a reduction in NO_x emissions over and above that achievable by national measures will be required to ensure that air quality objectives are achieved everywhere by the end of 2005. Local authorities with major roads, or highly congested roads, which have the potential to result in elevated levels of NO_2 in relevant locations, are expected to identify a need to progress to a detailed assessment for this pollutant.

4.4 SUMMARY OF PREVIOUS AIR QUALITY REVIEW AND ASSESSMENT REPORTS

The results of the St Albans City and District Council Stage 3 air quality review and assessment suggested that there was significant risk of exceedances of the annual mean objective at relevant receptors at a number of areas across the district. St Albans declared 7 air quality management areas on the basis of the stage 3 review. The results of a Stage 4 Air Quality Review and Assessment conducted for St Albans City and District Council concluded, however, that all but 2 of these AQMAs should be revoked.

No significant changes have been identified since this Stage 4 report at the locations assessed, and therefore the conclusions of this assessment remain valid. Air quality has not therefore been reassessed at these locations in this detailed assessment. However, the updating and screening report for St Albans City and District Council of July 2003 did identify four further locations where there was a risk of exceedances of the objectives for NO_2:

- M1 around Lyebury Lane, Redbourn
- Isolated property along A4147 south of M1 junction 7 with the M10
- Area north east of M25 Junction 22 London Colney
- Peahen Crossroads, central St Albans

It is these 4 further locations which are the subject of this detailed assessment.

4.5 MONITORING DATA

Nitrogen dioxide concentrations were monitored at one site within St Albans by continuous monitoring and by diffusion tubes at further sites around the district, including at three of the four locations considered in this detailed assessment.

4.5.1 Continuous monitoring

Location of the continuous monitor

Nitrogen dioxide is measured by ozone chemiluminescence at an urban background site (OS Grid Reference 516541, 207359) at Fleetville Community Centre, Fleetville, east of St Albans city centre. The site is located approximately 90m back from the roadside of the A1057.

Measurement technique and QA/QC

Ozone chemiluminescence is the reference method specified by the EC NO_2 Directives. Routine calibration of the NO_x analyser is undertaken on a fortnightly basis by ERG Kings College, London using on-site certified calibration gas cylinders provided by NPL and traceable to National Calibration Standards. In addition, NPL also undertake a 6-monthly QA/QC audit of the monitoring site which includes calibration of the analyser using zero and span gas standards, and tests for linearity and NO_x converter efficiency. In addition to site operations, ERG also undertake data collection and ratification on behalf of St Albans City and District Council.

Summary statistics

Table 4.1 shows the measured concentrations in years 2001-2003. The concentrations measured at the Fleetville site are consistently below the annual mean and hourly objectives for nitrogen dioxide.

Table 4.1 Summary of continuous nitrogen dioxide ratified data 2001-2003.

Statistic	Concentration (μg/m^3)		
Year:	2001	2002	2003
Annual Mean NO_x	53.8	48.5	51.6
Annual Mean NO_2	28.7	26.3	29.9
Maximum Hour NO_2	126	122	135
Data Capture (%) NO_2	86	85	83

4.5.2 Diffusion tubes

Diffusion tubes at 35 locations in the district measure monthly average concentrations of nitrogen dioxide. Of these sites, 4 are located at or near the locations of interest in this detailed assessment (see Figures 5.1 to 5.5 for location maps). The measurement data for 2001-2003 for these four sites is summarised in Table 4.2 below. Appendix 2 provides a breakdown of the raw monitoring data on a monthly basis.

Diffusion tubes can under or over-read and if possible should be referred to the results of continuous monitoring. A single diffusion tube has been co-located with the continuous monitor at the Fleetville Community Centre since 2001, with a triplicate co-location being introduced midway through 2002.

The diffusion tubes are supplied and analysed by Gradko using the 20% TEA in water method. Information regarding the typical bias of these tubes was sought for years 2001-2003 from the database of collocation studies issued by UWE on behalf of DEFRA (UWE (2003)).

On the basis of the local co-location study in St Albans, 2001 diffusion tube results were bias adjusted by a factor of 1.3. No data from other co-location studies was available for this year. The 2002 results were bias adjusted by a factor of 0.99, using data from the UWE database, into which was included the local co-location data from St Albans. Finally, the 2003 results were bias adjusted by a factor of 0.95, again based on the local co-location study. The UWE database held data on one 9-month co-location for 2003 indicating that a bias adjustment of 0.99 was appropriate, a figure which is in good agreement with the local study. However, as the local St Albans co-location was for a full 12-month period, the bias from this study has been used in preference.

It should be taken into account that diffusion tubes are spot measurements and may be very sensitive to distance from the road as concentrations change rapidly with distance from the kerbside when comparing them with modelled results.

To predict the diffusion tube concentrations in 2005 from measurements in years 2001-2003, the adjustment factors given in LAQM.TG(03) have been applied.

Table 4.2 Nitrogen dioxide diffusion tube survey 2001-2003 results for St Albans corrected for bias with predictions for 2005.

Site Name	Ref No	Type	2001 Unbiased	2001 Biased	2005 Estimate based on 2001	2002 Unbiased	2002 Biased	2005 Estimate based on 2002	2003 Unbiased	2003 Biased	2005 Estimate based on 2003
Ridgeview	SA06	B	35	45	41	34	33	31	40	38	36
Peahen Public House	SA15	R	50	65	58	50	49	45	64	61	58
Lyebury Lane	SA22	R	-	-	-	50*	50*	46*	51	48	46
Redding Lane	SA24	B	-	-	-	32*	32*	30*	35	33	32

* 6 months July-December
R - Roadside
B - Background

4.5.3 Comparison of monitoring data with AQ objectives

The continuous monitoring shows that the nitrogen dioxide concentrations at the Fleetville Community Centre background site are consistently below the annual and hourly mean NO_2 objectives.

Diffusion tube SA20, and since mid 2002, SA34 and SA35, have been co-located with the continuous monitor at the Fleetville Community Centre site. Therefore it has been possible to bias adjust the diffusion tube results at the sites of concern.

SA06 is located at the Ridgeview Hotel, London Colney, over 200m from the M25 and just over 150m from the A1081 London Colney Bypass. Results from this site for 2001 predicted a slight exceedance of the annual mean NO_2 objective in 2005, but results from 2002 and 2003 were lower and predictions based on these years projected forward to 2005 indicated that results would be will below 40 ug/m^3 by this year.

SA15 is located on the first-floor balcony of the Peahen public house, above head height, at the Peahen crossroads in central St Albans. Currently measured concentrations, and predictions for 2005 indicate that concentrations of NO_2 here will exceed the objective by a large margin. All four areas of the crossroads are street canyons close to the junction, and queuing at the traffic lights occurs throughout the day.

SA22 is a roadside site located 15m from the kerbside of the M1, and SA24 is a background site located 140m from the kerbside of the M1, both near Lyebury Lane, Redbourn (between junctions 8 and 9 of the M1). Measurements from SA22 currently predict that the NO_2 objective will be exceeded in 2005 at this location, whereas at SA24, concentrations are already well below the objective.

No diffusion tube site is currently located near junction 7 of the M1 with the M10, included in this modelling study.

5 Detailed modelling of NO_2

The locations at which detailed modelling was carried out are as follows:

- M1 Lyebury Lane, Redbourn
- Isolated property next to A4147, south of M1 junction 7 with the M10
- London Colney, north east of M25 Junction 22 London Colney
- Peahen Crossroads, central St Albans

5.1 METEOROLOGICAL DATA

Hourly sequential meteorological data for the nearest suitable meteorological station, Heathrow airport, was obtained from the Meteorological Office for 1999. The meteorological data provided information on wind speed and direction and the extent of cloud cover for each hour of 1999. This is the same dataset which was used for St Albans City and District Council's Stage 4 assessment of March 2003.

5.2 TRAFFIC MODELLING SUMMARY

In this study, the concentrations of NO_2 at receptors close to the roads and junctions of interest have been modelled using ADMS-3.1 as a dispersion kernel model.

The roads were defined as volume sources, 3m deep, and were broken up in to a series of adjoining segments. The length of these segments was dictated by the way in which the OS LandLine data was digitised and varied from one or two metres in length (where the road rapidly changed direction) to hundreds of metres in length (where the road was essentially straight). The OS LandLine data was used to provide the co-ordinates of the centre line of the road, and the road widths. Therefore, the position of the volume sources (here the roads) were accurate to approximately a metre.

Where queuing of vehicles was reported, emissions from stationary vehicles exhausts were estimated on the basis that the engine power output and hence emissions were the same as those at a speed of 5 kph. Queuing vehicles were assumed to be 5 m apart. The queue length data was analysed to assess the fraction of time for which queuing vehicles are present at each 5 m interval from the junctions.

5.3 SOURCES OF BACKGROUND (NON-TRAFFIC) EMISSIONS DATA

Background emissions of oxides of nitrogen (NO_x) from sources not modelled in detail have been taken from the UK National Atmospheric Emissions Inventory (www.naei.org.uk) and scaled to the year of interest where necessary following the recommended procedure in LAQM. TG(03). The contribution to emissions from the roads modelled in detail have been omitted where this would lead to double counting of the local impact of emissions.

5.4 MODEL BIAS

No roadside NO_2 monitoring data was available for any of the locations assessed in this study, nor on nearby comparable stretches of road. However, the monitoring site at Fleetville Community Centre in St Albans was used as a reference site to permit validation of model predictions of local background: i.e. the difference between the modelled and measured values of NO_2 at the background monitoring site was used as a systematic bias adjustment of the background for the modelled results. Table 5.1 shows the values used in the calculation. This procedure assumed that the modelling error was primarily in the calculation of the local background.

Table 5.1 Calculation of Bias Adjustment for NO_2.

Annual Average NO_2 (ug/m^3)			
Automatic Monitor at Fleetville Community Centre 2002	**Model Prediction at Automatic Monitoring Site in 2002**	**Bias Adjustment of Background for 2002**	**Bias Adjustment of Background for 2005**
26.3	38.4	-12.1	-11.3*

* Predicted from bias adjustment factor for 2002 and multiplied by background year conversion factors provided in TG(03).

5.5 MODEL VALIDATION

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous **netcen** air quality review and assessments. Statistical techniques have been used to assess the likelihood that there will be an exceedance of the air quality objectives given the modelled concentration. The validation statistics are given in Appendix 3. Confidence limits for the predicted concentrations were calculated based on the validation studies by applying statistical techniques based on Student's t distribution. The confidence limits took account of uncertainties resulting from:

- Model errors at the receptor site;
- Model errors at the reference site;
- Uncertainty resulting from year to year variations in atmospheric conditions.

The confidence limits have been used to estimate the likelihood of exceeding the objectives at locations close to the roads. The following descriptions have been assigned to levels of risk of exceeding the objectives.

It would be recommended that St Albans City and District Council generally consider declaring an AQMA where the probability of exceedance in 2005 is greater than 50% ("Probable").

Table 5.2: Uncertainties in the modelled concentrations for NO_2.

Description	**Chance of exceeding objective**	**Modelled annual average concentrations, μg/m^3**	
		Likelihood of exceeding annual average objective	Likelihood of exceeding hourly average objective
Very unlikely	Less than 5%	<28	<38
Unlikely	5-20%	28-34	38-52
Possible	20-50%	34-40	52-67
Probable	50-80%	40-46	67-82
Likely	80-95%	46-52	82-95
Very likely	More than 95%	>52	>95

The confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals.

A simple linear relationship can be used to predict the 99.8th hourly percentile concentration of NO_2 from the annual concentration: the 99.8th percentile is three times the annual mean at kerbside/roadside locations. Therefore, plots of the modelled annual mean NO_2 concentrations can be used to show exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances of the hourly objective need to be adjusted so they may be used directly with the plots of annual concentration. This has been performed by simply dividing the concentrations of the confidence limits by three.

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. Table 5.3 provides a comparison of modelled and measured nitrogen dioxide concentrations. There is satisfactory agreement between the modelled and measured nitrogen dioxide concentrations at all of the sites, with a tendency for the model to underestimate the measured concentrations.

Table 5.3: Comparison of modelled and measured concentrations for 2002 (Base Year)

Diffusion Tube	Type	Location	Nitrogen dioxide concentration, $\mu g\ m^{-3}$	
			Modelled	Measured
SA06	B	Ridgeview Hostel, London Colney	29.4	36.5
SA15	R	Peahen Crossroads, central St Albans	40.8	53.9
SA22	R	Lyebury Lane, Redbourn	43.5	50*
SA24	B	Redding Lane, Redbourn	22.1	34*

* Based on 2003 data
R – Roadside
B – Background

5.6 RESULTS OF MODELLING

5.6.1 Redbourn - NO_2

Figures 5.1 and 5.2 show modelled nitrogen dioxide concentrations near Lyebury Lane and the B487 along the M1 in 2005. The model predicts that the annual average objective for 40 $\mu g\ m^{-3}$ of nitrogen dioxide is exceeded close to the roadside of the M1. However, no properties are present within or close to the area of exceedance.

Table 5.3 below shows the risk of exceeding the objectives for nitrogen dioxide at the nearest houses to the area assessed in 2005. At most it is "possible" that the annual objective will be exceeded.

Table 5.3 Probability of exceeding the objectives for nitrogen dioxide in 2005 at Redbourn.

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Buildings immediately west of M1 and South of B487	20% <P< 50% Possible	P < 5% Very Unlikely
Buildings along Lyebury Lane	P< 5% Very Unlikely	P < 5% Very Unlikely

The model predicts that no exceedances will occur at relevant locations in the area modelled. Comparison of the diffusion tube monitoring results at SA22 (roadside) and SA24 (background) suggest that the model may be underpredicting slightly at roadside locations. However, the monitoring results in table 5.3 are based on 2003, the first full year of monitoring at these sites, rather than the modelling base year of 2002. The monitoring results (Tables 4.1 and 4.2) suggest that concentrations have generally been higher in 2003 than in 2002.

Figure 5.1 2005 Concentrations (predicted) around Redbourn (North) around Lyebury Lane

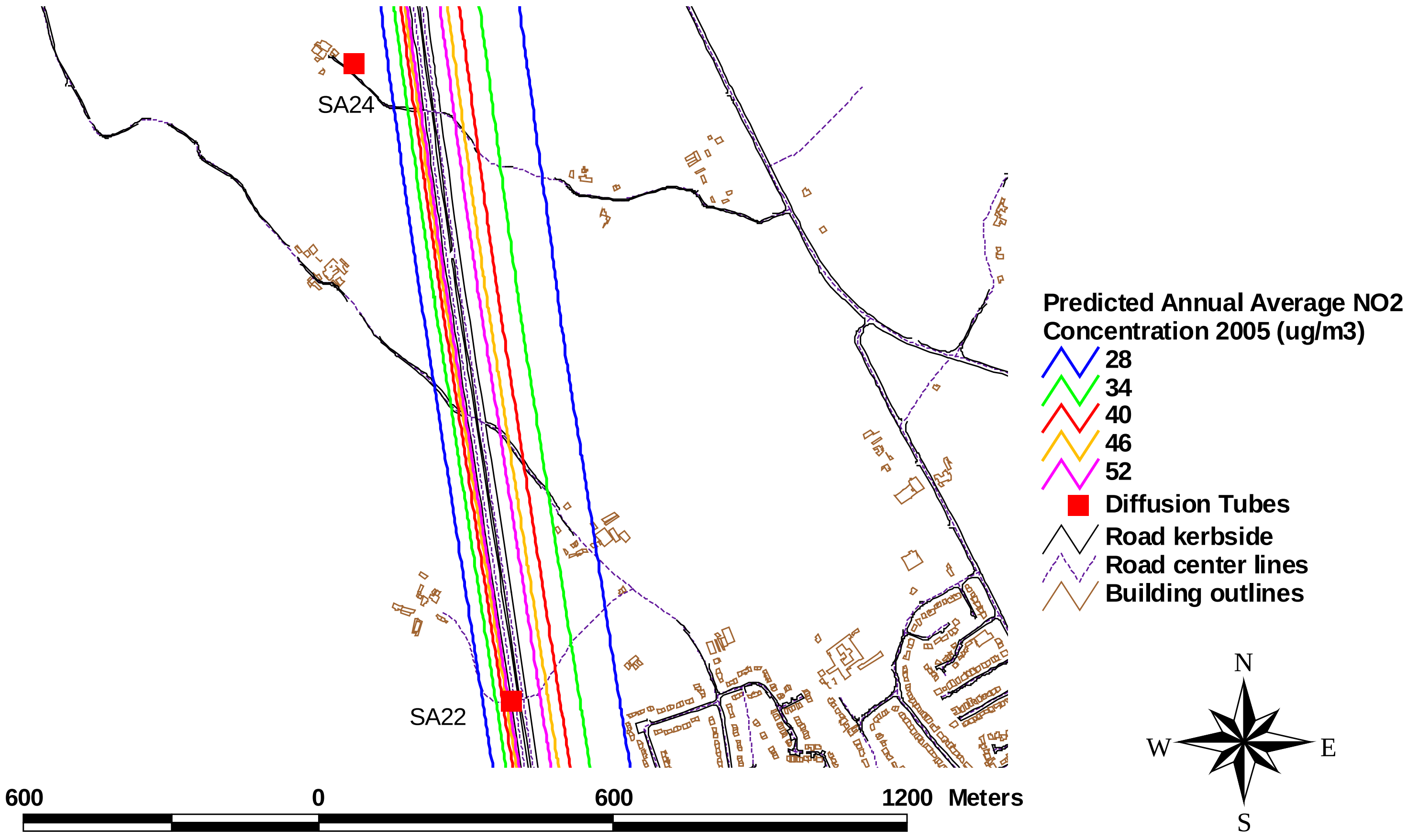
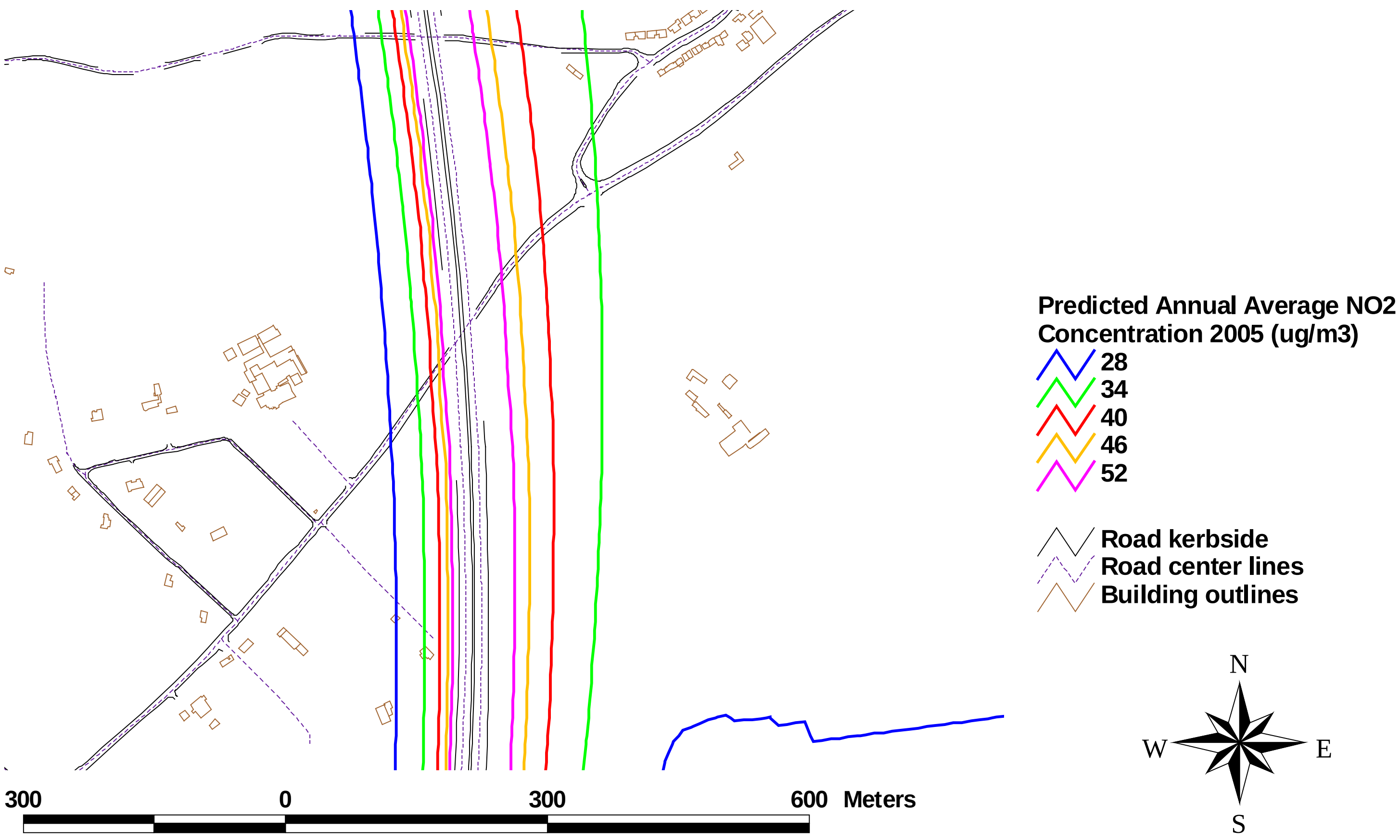


Figure 5.2 2005 Concentrations (predicted) around Redbourn (South) around the



B487

5.6.2 London Colney - NO_2

Modelling was undertaken around junction 22 of the M25 with the A1081 London Colney Bypass.

Figure 5.3 below shows the predicted NO_2 concentrations here in 2005. No buildings are identified to be within the predicted area of exceedance in this year, with all residential properties and the Ridgeview Hostel seen to be located well within the area with concentrations below 34 ug/m^3 . The Tescos supermarket building is seen to be located just on the edge of the exceedance area. However, it is anticipated that no relevant exposure will exist here.

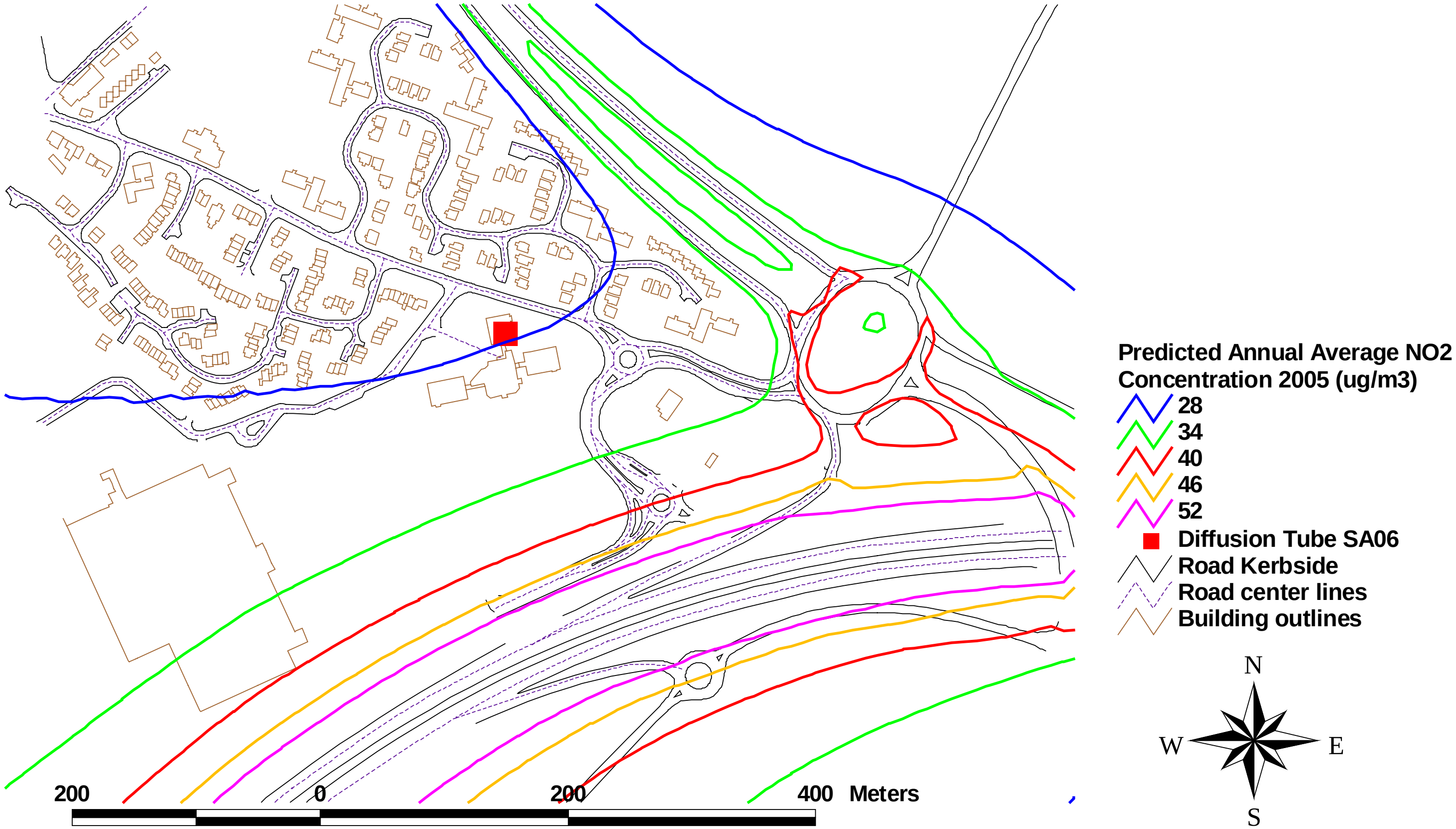
Predicted concentrations at the site of background diffusion tube SA06 are in reasonable agreement with the actual measured values.

Table 5.4 below shows the risk of exceeding the objectives for nitrogen dioxide at the nearest houses to the area assessed in 2005. At most it is "possible" that the annual objective will be exceeded.

Table 5.4 Probability of exceeding the objectives for nitrogen dioxide in 2005 at London Colney.

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Tesco supermarket	20% <P< 50% Possible	5% <P< 20% Unlikely
Unidentified Building at Sainsburys entrance	20% <P< 50% Possible	P < 5% Very Unlikely
Ridgeview Hostal	5% <P< 20% Unlikley	P < 5% Very Unlikely
Closest house	5% <P< 20% Unlikely	P < 5% Very Unlikely

Figure 5.3 2005 Concentrations (predicted) at London Colney



5.6.3 Isolated Property at M1 Junction 7 with the M10 - NO_2

An isolated property is located within the triangular area defined by the M1, M10 and the A4147. Figure 5.4 shows modelled nitrogen dioxide concentrations around this property for 2005.

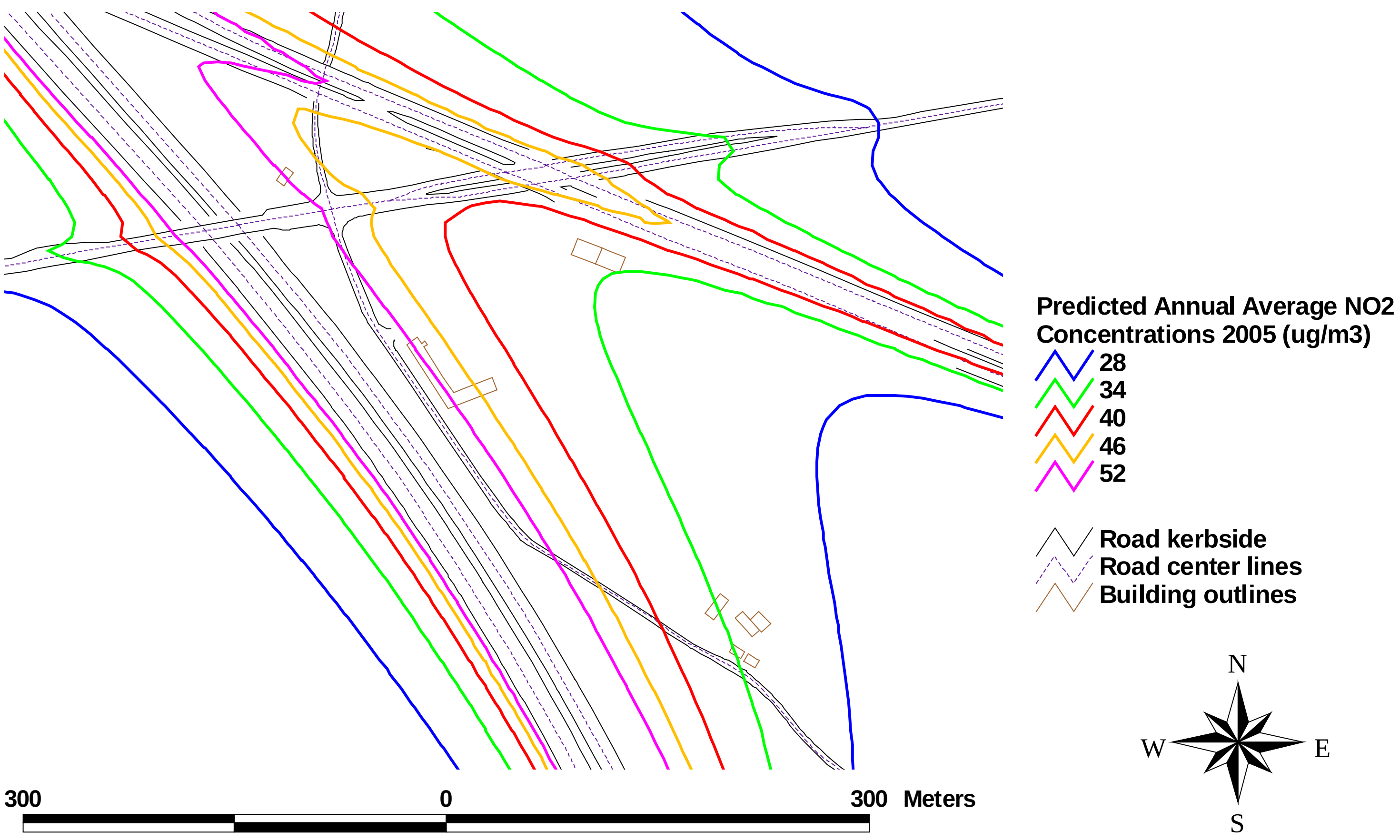
The model predicts that the annual average objective for nitrogen dioxide will be exceeded by a wide margin, with concentrations of approximately 52 ug/m^3 at the location of the property. In addition, a further unidentified building further south along the lane towards Appspond and Potters Crouch is seen to fall within the exceedance area. No other properties are assessed to fall within the exceedance area. It is "very likely" that the annual objective will be exceeded at the two locations.

No monitoring is currently undertaken at this location with which to compare the modelling results.

Table 5.5 Probability of exceeding the objectives for nitrogen dioxide in 2005 near junction 7 of the M1.

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8^{th} %ile hourly average**
Isolated house	95% <P Very Likely	20% <P< 50% Possible
Unidentified building along lane towards Appspond	95% <P Very Likely	20% <P< 50% Possible
All other properties towards Appspond	20% <P< 50% Possible	P< 5% Very unlikely

Figure 5.4 2005 Concentrations (predicted) at M1 Junction 7 with M10



5.6.4 Peahen Crossroads, Central St Albans

Modelling of NO_2 concentrations for was undertaken at the crossroad and along the 4 arms of the junction.

Figure 5.5 below shows the contour map of the modelled area for 2005. The only exceedance area predicted in 2005 is along the first 100m back from the junction along the northern façade of London Road, and at the north-eastern corner of the junction.

Diffusion tube site SA15 is located on a first floor balcony of the Peahen public house on the opposite south-eastern corner of the junction. This site has recorded concentrations consistently well above 40 ug/m^3 from 2001-2003, and prediction for 2005 are in the range 50 – 58 ug/m^3, well above the objective value for that year. Based on this monitoring, the exceedance area may therefore cover the entire area of the junction.

Table 5.6 below shows the risk of exceeding the objectives for nitrogen dioxide at the nearest locations to the area assessed in 2005. At most it is “probable” that the annual objective will be exceeded. Given the discrepancy between the monitoring and modelling results, St Albans City and District Council may wish to consider declaring any AQMA at the junction on the basis of the 34 ug/m^3 contour, within which the probability of exceedance of the 2005 annual mean objective for NO_2 is “possible”.

The discrepancy between the modelling and monitoring results may arise from the fact that all four arms of the junction are to some extent canyon-like in nature close to the junction. It is therefore likely that the model has not fully accounted for the canyon effect of canyon at the junction. In addition, it is known that the junction is congested for much of the day. However, no queuing data was available with which to assess the extent of queuing at the junction. For the purposes of the model it has been assumed that a queue of very slow moving traffic (5kph) is always present at the junction along all four arms for up to 30m back from the junction (equivalent to 5-6 vehicles always waiting) and that uncongested monitored road speeds are only applicable further than 100m from the junction. Further monitoring of traffic congestion and queuing at the junction would therefore be required in order to verify these assumptions.

Table 5.6.4A Probability of exceeding the objectives for nitrogen dioxide in 2005 at the Peahen Crossroads, Central St Albans.

Location	Probability of exceedance, P	
	Annual average objective	99.8th %ile hourly average
Peahen public house (south east corner of junction	20% <P< 50% Possible	5% <P< 20% Unlikely
North east corner of junction	50% <P< 80% Probable	5% <P< 20% Unlikely
Northern façade of London Road (first 100m from traffic lights)	50% <P< 80% Probable	5% <P< 20% Unlikely
Southern façade of London Road (first 100m from traffic lights)	20% <P< 50% Possible	P< 5% Very unlikely
Holywell Hill	5% <P< 20% Unlikley	P< 5% Very unlikely
High Street	5% <P< 20% Unlikley	P< 5% Very unlikely
Chequers Street	20% <P< 50% Possible	P< 5% Very unlikely

Figure 5.5 2005 Concentrations (predicted) Peahen Crossroads, Central St Albans

5.7 SOURCE APPORTIONMENT OF PREDICTED EXCEEDANCES

Source apportionment is the process whereby the contributions from different sources of a pollutant are determined. In local air quality, the relevant sources could include: traffic; local background; industrial and domestic. Contributions from the different types of vehicles (for example, cars, lorries and buses) can also be considered to highlight which class of vehicle is contributing most to the emissions from traffic. Source apportionment allows the most important source or sources to be identified and options to reduce ambient concentrations of pollutants can then be considered and assessed. The concentrations have been calculated using the new traffic emission factors.

The source apportionment should:

- Confirm that exceedances of NO_2 are due to road traffic (for St Albans City and District Council)
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2 within predicted areas of exceedance. This will allow traffic management scenarios to be modelled/tested to reduce the exceedances
- Quantify what proportion of the exceedances of NO_2 is due to background emissions, or, local emissions from busy roads in the local area. This will help determine whether local traffic management measures could have a significant impact on reducing emissions in the area of exceedance, or, whether national measures would be a suitable approach to achieving the air quality objectives

5.7.1 Receptors considered

Source apportionment at the isolated property on the A4147 has been considered in the case of the area of exceedance south of M1 junction 7 with the M10. At the Peahen Crossroads, the source apportionment at the north eastern corner of the junction has been considered.

5.7.2 Sources of pollution considered

We have considered the effect of the following sources in this assessment at the receptor considered:

- Background concentrations used in the assessment;
- Traffic-Light Duty Vehicles in the 1 km square local area;
- Traffic - Heavy Duty Vehicles in the 1 km square local area.

There is a complex relationship between oxides of nitrogen and nitrogen dioxide concentrations. The modelling assumed that the contribution to nitrogen dioxide concentration from road traffic could be estimated by using the relationship provided in LAQM.TG(03): the same relationship has been applied for source apportionment calculations.

The concentrations apportioned to each source category and the fraction of the total concentrations are shown in Tables 5.7 and 5.8.

Table 5.7: Isolated Property on A4147 south of M1 junction 7 with the M10: Source apportionment to concentrations of NO_2 and NO_x

Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Local LDV	9	17	61	24
Local HDV	24	46	161	65
Total Local traffic	33	63	221	89
Background	19	37	27	11
Total	52	100	248	100

Figures are rounded to the nearest whole number

From the above it may be seen that at this location motorway traffic accounts for approximately two thirds of the local NO_2 concentrations, and of this traffic contribution, HDVs account for two thirds. HDV traffic therefore contributes almost half to the local NO_2 concentrations.

Table 5.8: Peahen Crossroads, central St Albans: Source apportionment to concentrations of NO_2 and NO_x

Source category	NO_2 concentration, Contribution		NOx concentration, Contribution	
	$\mu g\ m^{-3}$	%	$\mu g\ m^{-3}$	%
Local LDV	7	15	39	22
Local HDV	19	41	111	62
Total Local traffic	25	56	150	84
Background	20	44	28.5	16
Total	45	100	179	100

Figures are rounded to the nearest whole number

From the above it may be seen that at this location motorway traffic accounts for over half of the local NO_2 concentrations, and of this traffic contribution, HDVs account for over two thirds. HDV traffic therefore contributes around 40% to the local NO_2 concentrations.

5.8 SUMMARY OF THE LIKELIHOOD OF EXCEEDING THE OBJECTIVES FOR NITROGEN DIOXIDE

The modelling results showed that it is ***very likely*** (with probability more than 95%) that an exceedance of the annual objective would occur at one of the locations modelled:

- Isolated property next to A4147, south of M1 junction 7 with the M10

The modelling results also showed that it is ***probable*** (with probability between 50% and 80%) that an exceedance of the annual objective would occur at one of the locations modelled:

- Peahen Crossroads, central St Albans

At all other receptor locations it was assessed that the risk of the UK objective for annual average NO_2 in 2005 being exceeded was at most ***possible*** (with probability between 20% and 50%).

At all receptor locations it was assessed that the risk of the UK objective for hourly NO_2 in 2005 being exceeded was at most ***possible*** (with probability between 20% and 50%).

5.9 RECOMMENDATIONS

Following the previous round of Review and Assessment, St Albans City and District Council declared 2 AQMAs for nitrogen dioxide at the following areas:

- Colney Street
- Frogmore

As no significant changes in traffic emissions or public exposure have been detected since the publication of the Stage 4 report in March 2003, these areas have not been remodelled. Below are our recommendations for the 4 areas assessed in this report

5.9.1 Peahen Crossroads, Central St Albans

The UK objective for annual average NO_2 is predicted to be exceeded in 2005 along the northern façade of London Road from the corner with Chequers Road for 100m to the corner of the first access road. We therefore recommend that St Albans City and District Council declare an air quality management area for NO_2 at this location.

However, the results from diffusion tube site SA15 suggest that the exceedance area may be larger than the area predicted by modelling. Uncertainty in the modelling results is likely to result from the canyon nature of all four streets leading away from the crossroads, and from the lack of data on traffic queuing and congestion at the junction. In view of this uncertainty, St Albans City and District Council may wish to take a precautionary approach, and declare the AQMA on the basis of the 34 ug/m^3 contour inside which an exceedance of the objective is considered “possible”. We also recommend that St Albans City and District Council extend their monitoring efforts in this location.

5.9.2 M1 Junction 7 with M10

It is predicted that the UK annual average objective for NO_2 will be exceeded by a large margin at the isolated property along the A4147 between the fork of the M10 and the M1 south of junction. A further second unidentified building south of the A4147 is also seen to be within the area of exceedance. However it is not known whether relevant exposure exists at this site. It is recommended that St Albans City and District Council declare an air quality management area at these buildings should relevant exposure be found to exist here, and that diffusion tube monitoring be extended to these locations.

5.9.3 M1 near Redbourn

No exceedances of the UK annual average objective for NO_2 in 2005 have been predicted at relevant locations in this area. No further action is therefore required.

5.9.4 London Colney near Junction 22 of the M25

No exceedances of the UK annual average objective for NO_2 in 2005 have been predicted at relevant locations in this area. No further action is therefore required.

5.10 FURTHER ACTIONS TO BE TAKEN

Should St Albans City and District Council be satisfied and in agreement with the contents of this report, it should be then be forwarded to DEFRA for approval. DEFRA will then forward the report to their external assessors who will comment on the work. DEFRA will then return the critique of the work to St Albans City and District Council.

St Albans should then forward a copy of this critique to **netcen**. St Albans should also consider if they could answer any of the questions directly.

6 References

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Appendices

CONTENTS

Appendix 1

Traffic Data

CONTENTS

Table A1.1 - Traffic data for St Albans City and District Council.

Location	AADT 2002	% HDV 2002	Average Speed (kph)
Redbourn area:			
M1 between junctions 8 and 9	139632	15.7	110
A5183 south of junction 9	19652	2.5	80
M1 junction 7 area:			
M1 south of junction 7	143008	15.5	110
M10 south of junction	26116	12.4	110
A4147	11901	3.5	80
Peahen Crossroads, St Albans City centre:			
London Road	19099	7.8	5-50
Holywell Hill	20548	4.2	5-60
Chequers Street	11945	9.7	5-30
High Street/Verulam Road	7547	2	5-50
M25 Junction 22/London Colney			
M25	123700	16.7	115
M25 Eastbound off-slip	5557	8.8	30-115
A1081 London Colney Bypass	25032	8.8	110

Table A1.2 - Traffic Growth Factors used to predict traffic flows in future years

Year		Growth
From	To	Central
2000	2001	1.020
2000	2002	1.043
2000	2005	1.113
2001	2005	1.091
2002	2005	1.067

Appendix 2

Monitoring Data

CONTENTS

Monthly diffusion tube data for St Albans 2003

Location	Class	X	Y	Address	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unbiased Annual mean ppb	Unbiased Annual mean ug/m3	Bias Adjusted 2003 Annual mean ug/m3	Estimated 2005 Annual mean ug/m3
SA06	I	518692	203494	Ridgeview Hostel, Barnet Rd, London Colney	19.4	26.1	19.7	20.0	18.9	19.8	17.9	17.1	25.1	19.8	25.8	18.8	20.7	39.5	37.6	36.0
SA15	K	514712	207096	Peahen PH, Holywell Hill, St Albans	30.5	35.3	32.9	39.8	28.5	38.4	28.3	39.5	38.9	29.9	33.9	28.7	33.7	64.4	61.3	**58.1**
SA22	R	509431	212775	Lybury Lane	22.9	31.8	30.2	37.2	20.2	26.1	18.8	26.1	26.8	25.7	30.6	23.0	26.6	50.8	48.4	**45.8**
SA24	B	509111	214071	Redding Lane	18.0	23.7	17.8	25.3	12.6	15.6	11.5	13.5	18.4	20.8	22.8	18.8	18.2	34.8	33.1	31.7

K – kerbside
R - Roadside
I - intermediate
B - Background

NR – No result
Predicted Exceedances of the 2005 objective for annual mean NO_2 **in bold**

Monthly diffusion tube data for St Albans 2002

Location	Class	X	Y	Address	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unbiased Annual mean ppb	Unbiased Annual mean ug/m3	Bias Adjusted 2002 Annual mean ug/m3	Estimated 2005 Annual mean ug/m3
SA06	i	518692	203494	Ridgeview Hostel, Barnet Rd, London Colney	19.9	16	20.6	NR	16.2	9.2	18.8	13.6	19.4	15.9	23.9	20.0	17.6	33.6	**33.3**	**31.1**
SA15	k	514712	207096	Peahen PH, Holywell Hill, St Albans	29.3	25.6	19.1	11.4	19.9	21.4	36.7	25.7	32.1	24.1	34.9	31.3	26.0	49.6	**49.1**	**45.2**
SA22	R	509431	212775	Lybury Lane	-	-	-	-	-	-	22.0	23.9	34.3	19.6	29.5	29.0	26.4	50.4	49.9	**45.9**
SA24	B	509111	214071	Redding Lane	-	-	-	-	-	-	12.9	11.5	21.3	13.1	NR	25.1	16.7	32.0	31.7	**29.6**

K – kerbside
R - Roadside
I - intermediate
B - Background

NR – No result
Predicted Exceedances of the 2005 objective for annual mean NO_2 **in bold**

Monthly diffusion tube data for St Albans 2001

Location	Class	X	Y	Address	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Unbiased Annual mean ppb	Unbiased Annual mean $\mu g/m^3$	Bias Adjusted 2001 Annual mean ug/m3	Estimated 2005 Annual mean ug/m3
SA06	i	518692	203494	Ridgeview Hostel, Barnet Rd, London Colney	29	25	27	12	7	14	16	20	17	20	21	8	18	35	45	**40**
SA15	k	514712	207096	Peahen PH, Holywell Hill, St Albans	NR	38	40	18	23	25	22	28	28	24	24	17	26	50	65	**58**

K – kerbside
R - Roadside
I - intermediate
B - Background

NR – No result
Predicted Exceedances of the 2005 objective for annual mean NO_2 **in bold**

Appendix 3

Model validation
Nitrogen dioxide roadside concentrations

CONTENTS

INTRODUCTION

The dispersion model ADMS-3 was used to predict nitrogen dioxide concentrations at roadside locations. ADMS-3 is a PC-based model that includes an up-to-date representation of the atmospheric processes that contribute to pollutant dispersion.

The model was used to predict

- the local contribution to pollutant concentrations from roads; and
- The contribution from urban background sources.

The contribution from urban background sources was calculated from the ADMS-3 output using the NETCEN Local Area Dispersion System (LADS) model. The LADS model provides efficient algorithms for applying the results of the dispersion model over large areas.

The model was verified by comparison with monitoring data obtained at a number of roadside, kerbside or near-road monitoring sites in London.

- London Marylebone
- Camden Roadside
- Haringey Roadside
- London Bloomsbury
- London North Kensington
- London A3 Roadside

London Marylebone site is located in a purpose built cabin on Marylebone Road opposite Madame Tussauds. The sampling point is located at a height of 3 m, around 1 m from the kerbside. Traffic flows of over 80,000 vehicles per day pass the site on six lanes. The road is frequently congested. The surrounding area forms a street canyon and comprises of education buildings, tourist attractions, shops and housing

Camden Roadside site (TQ267843) is located in a purpose built cabin on the north side of the Swiss Cottage Junction. The site is at the southern end of a broad street canyon. Sampling points are approximately 1 m from the kerbside of Finchley Road at a height of 3 m. Traffic flows of 37,000 vehicles per day pass the site and the road is often congested. Pedestrian traffic is also high. The surrounding area mainly consists of shops and offices.

London North Kensington site (TQ240817) is located within the grounds of Sion Manning School. The sampling point is located on a cabin, in the school grounds next to St Charles Square, at a height of 3 m. The surrounding area is mainly residential.

London A3 monitoring station (TQ193653) is within a self-contained, air-conditioned housing immediately adjacent to the A3 Kingston Bypass (6 lane carriageway). Traffic flow along the bypass is approximately 112,000 vehicles per day and is generally fast and free flowing with little congestion. The manifold inlet is approximately 2.5 m from the kerbside at a height of approximately 3 m. The surrounding area is generally open and comprises residential dwellings and light industrial and commercial properties.

London Bloomsbury monitoring station (TQ302820) is within a self-contained, air-conditioned housing located at within the southeast corner of central London gardens. The gardens are generally laid to grass with many mature trees. All four sides of the gardens are surrounded by a busy (35,000 vehicles per day), 2/4 lane one-way road system which is subject to frequent congestion. The nearest road lies at a distance of approximately 35 metres from the station. The manifold inlet is approximately 3 metres high. The area in the vicinity of the manifold is open, but there are mature trees within about 5 metres.

London Haringey site (TQ339906) is located in a purpose built cabin within the grounds of the Council Offices. The sampling point is at a height of 3 m located 5 m from High Road Tottenham (A1010) with traffic flows of around 20,000 vehicles per day. The road is frequently congested. The surrounding area consists of shops, offices and housing.

MODEL APPLICATION

Study area

Two study areas were defined- a local study area and an urban background study area. The local study area was defined for each of the monitoring sites extending 200 m in each direction (NSEW) from the monitoring site. Roads in the study area were identified. Each road in the study are was then treated as a quadrilateral volume source with depth 3 m, with spatial co-ordinates derived from OS maps. The urban background study area extended over an 80 km x 80 km area covering the London area. The background study area was divided into 1 km x 1 km squares-each 1 km square was then treated as a square volume source with depth 10 m.

Traffic flows in the local study area

Traffic flows, by vehicle category, on each of the roads within the local study area for 1996 were obtained from the DETR traffic flow database. The traffic flows were scaled to 1998 by factors shown in Table A3.1 obtained by linear interpolation from Transport Statistics GB, 1997.

Table A3.1 Traffic growth 1998:1996

	Growth factor
Cars	1.05
Light goods vehicles	1.05
Heavy goods vehicles	1.04
Buses	1.00
Motorcycles	1.00

Traffic flows follow a diurnal variation. Table A3.2 shows the assumed diurnal variation in traffic flows.

Table A3.2 Assumed diurnal traffic variation

Hour	Normalised traffic flow
0	0.20
1	0.11
2	0.10
3	0.07
4	0.08
5	0.18
6	0.49
7	1.33
8	1.97
9	1.50
10	1.33
11	1.46
12	1.47
13	1.51
14	1.62
15	1.74
16	1.94
17	1.91
18	1.53
19	1.12
20	0.88
21	0.68
22	0.46
23	0.33

Vehicle speeds in the local study area

Vehicle speeds were estimated on the basis of TSGB, 1997 data for central area, inner area and outer area average traffic speeds in London, 1968-1995 and for non-urban and urban roads for 1996. Table A3.3 shows the traffic speeds applied to each of the sites. The low speeds in Central London reflect the generally high levels of congestion in the area.

Table A3.3 Traffic speeds used in the modelling

Site	Road class	Vehicle speed, kph
London Marylebone	Central London	17.5
Camden Roadside	Central London	17.5
London Bloomsbury	Central London	17.5
London A3 Roadside	Non-urban dual carriageway	88
London Haringey	Outer London	32
London North Kensington	Background site	Not applicable

Vehicle emissions in the local study area
Vehicle emissions of oxides of nitrogen were estimated using the Highways Agency Design Manual for Roads and Bridges, 1999 (DMRB). DMRB provides a series of nomograms that allow the effect on emission rates of the proportion of heavy goods vehicles and the average vehicle speed to be taken into account. The estimated emissions are based on average speeds and take account of the variations in emissions that follow from normal patterns of acceleration and deceleration. DMRB provides estimates of the emissions of particulate material from vehicle exhausts.

Emissions in the urban background study area
Emission estimates for each 1 km square in the urban background study area were obtained from two emission inventories. The London inventory for 1995/6 (LRC, 1997) was used for most of the urban background study area: the National Atmospheric Emission Inventory, 1996 was used for areas within the urban background study area not covered by the London inventory.

The emission estimates for each square for 1996 were scaled to 1998 using factors taken from DMRB.

Meteorological data
Meteorological data for Heathrow Airport 1998 was used to represent meteorological conditions. The data set included wind speed and direction and cloud cover for each hour of the year. It was assumed that a surface roughness of 0.5 m was representative of the suburban area surrounding Heathrow Airport.

The meteorological conditions over London are affected by heat emissions from buildings and vehicles. This “urban heat island” effect reduces the frequency and severity of the stable atmospheric conditions that often lead to high pollutant concentrations. In order to take this into account the Monin-Obukhov length (a parameter used to characterise atmospheric stability in the model) has been assigned a lower limit as shown in Table A3.4.

Table A3.4: Monin-Obukhov limits applied

Site	Limit, m	Note
London Marylebone	100	Large conurbation
Camden Roadside	100	Large conurbation
London Bloomsbury	100	Large conurbation
London A3 Roadside	30	Mixed urban/industrial
London Haringey	30	Mixed urban/industrial
London North Kensington	100	Large conurbation
Small towns <50,000	10	
Urban background area	100	
Rural	1	

Surface roughness
The surface roughness is used in dispersion modelling to represent the roughness of the ground. Table A3.5 shows the surface roughness values applied.

Table A3.5 Surface roughness

Site	Surface roughness, m	Note
London Marylebone	2	Street canyon
Camden Roadside	1	City
London Bloomsbury	1	City
London A3 Roadside	0.5	Suburban
London Haringey	1	City
London North Kensington	1	Suburban
Urban background area	1	

Model output
The local model was used to estimate:

- Annual average road contribution of oxides of nitrogen ;
- road contribution to oxides of nitrogen concentrations for each hour of the year.

The urban background model was used to estimate:

- the contribution from urban background sources to annual average oxides of nitrogen concentrations;
- the contribution from roads considered in the local model to urban background concentrations;
- the contribution from urban background sources to oxides of nitrogen concentrations for each hour of the year.

Background concentrations
A rural background concentration of 20 $\mu g\ m^{-3}$ was added to the urban background oxides of nitrogen concentration.

Calculation of annual average nitrogen dioxide concentrations
Nitrogen dioxide is formed as the result of the oxidation of nitrogen oxides in air, primarily by ozone. The relationship between oxides of nitrogen concentrations and nitrogen dioxide concentrations is complex; an empirical approach has been adopted.

The contribution from locally modelled roads to urban background oxides of nitrogen concentrations was first subtracted from the calculated urban background concentration. The annual average urban background nitrogen dioxide concentration was then calculated from the corrected annual average urban background oxides of nitrogen concentration using the following empirical relationship based on monitoring data from AUN sites:

For $NO_x > 23.6$ μg m^{-3}

$$NO_2 = 0.348.NO_x + 11.48 \text{ μg m}^{-3}$$

For $NO_x < 23.6$ μg m^{-3}

$$NO_2 = 0.833.NO_x \text{ μg m}^{-3}$$

The contribution of road sources to nitrogen dioxide concentrations was then calculated using the following empirical relationship (Stedman):

$$NO_2 = 0.162.NO_x$$

The contributions from road and background sources to annual average nitrogen dioxide concentrations were then summed.

The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site) = NO_2(modelled, site) + NO_2(measured, LNK) - NO_2(modelled, LNK)

Calculation of 99.8th percentile hourly average concentrations
A simple approach has been used to estimate 99.8th percentile values. The approach relies on an empirical relationship between 99.8th percentile of hourly mean nitrogen dioxide and annual mean concentrations at kerbside/roadside sites, 1990-1998:

NO_2(99.8th percentile) = 3.0 NO_2(annual mean)

99.8 th percentile values were calculated on the basis of the modelled annual mean.

The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site) = NO_2(modelled, site) + NO_2(measured, LNK) - NO_2(modelled, LNK)

RESULTS

Modelled results are shown in Table A3.6. Fig. A3.1 shows modelled annual average nitrogen dioxide concentrations plotted against the measured values. Similarly Fig. A3.2 shows modelled 99.8th percentile average nitrogen dioxide concentrations plotted against measured values.

Table A3.6 Comparison of modelled and measured concentrations

Site	Nitrogen dioxide concentration, ppb			
	Annual average		99.8th percentile hourly	
	Modelled	Measured	Modelled	Measured
London A3	32	30	94	73
North Kensington	24	24	70	70
Bloomsbury	28	34	83	78
Camden	32	33	95	89
London Marylebone	45	48	134	121
Haringey	22	28	65	77

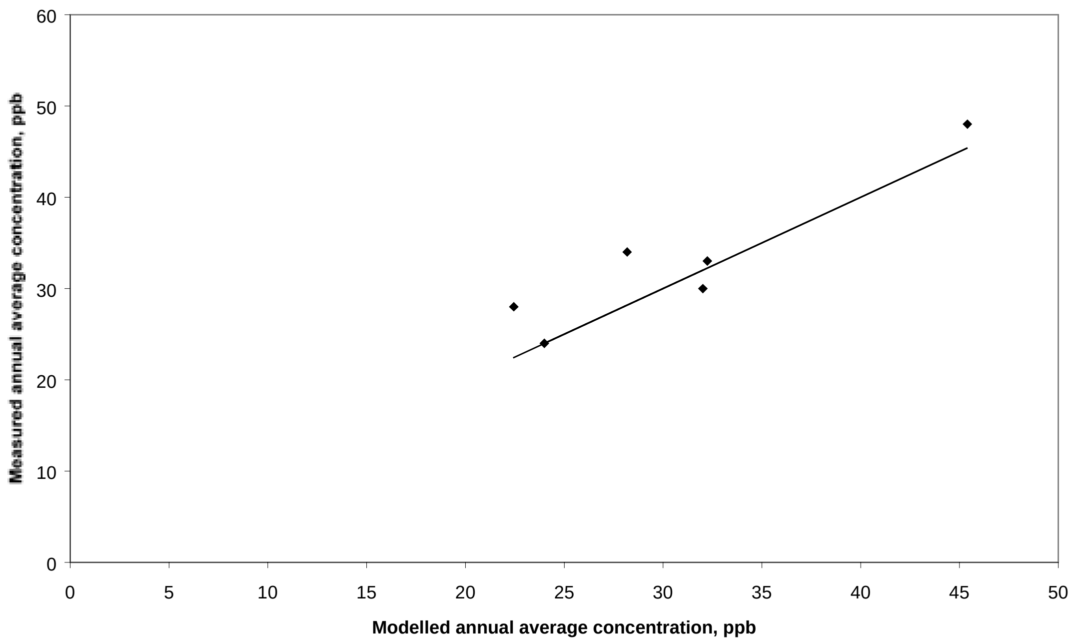

Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

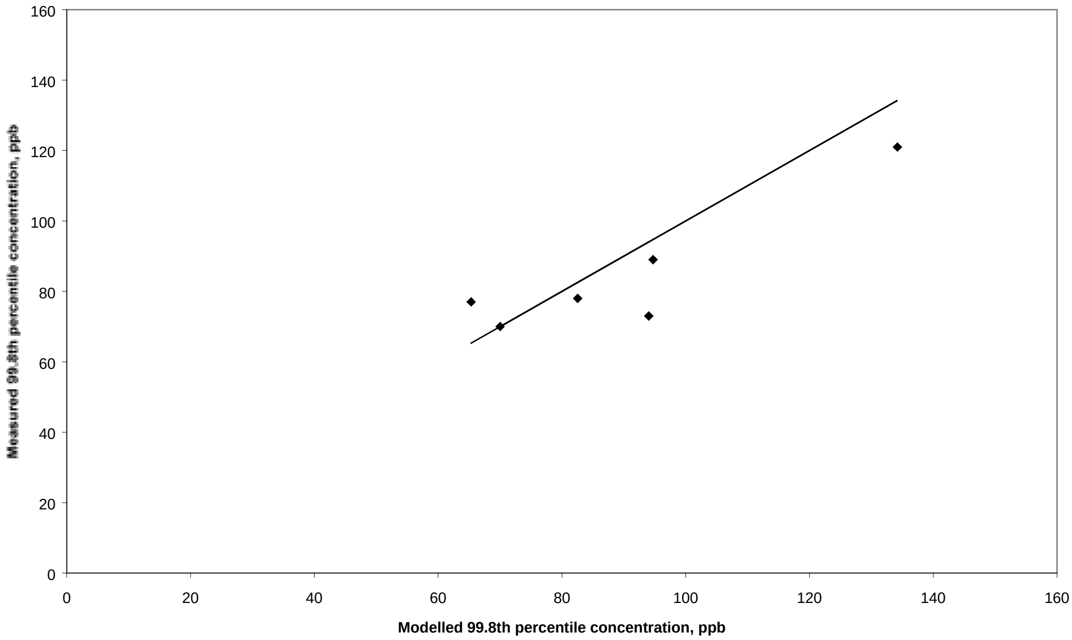

Fig. A3.2 Comparison of modelled and measured 99.8[th] percentile hourly average nitrogen dioxide concentrations

DISCUSSION

Model errors
The error in the modelled annual average at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was 12% with five degrees of freedom.

The error in the 99.8 th percentile concentration at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was also 12% with five degrees of freedom.

Year to year variation in background concentrations
Nitrogen dioxide concentrations at monitoring sites show some year to year variations. Reductions in emissions in the United Kingdom are responsible for some of the variation, but atmospheric influences and local effects also contribute to the variation.

In order to quantify the year to year variation monitoring data from AUN stations with more than 75% data in the each of the years 1996-1998 was analysed using the following procedure.

First, the expected concentrations in 1997 and 1996 were calculated from the 1998 data.

$$c_e = \frac{d_{1998}}{d_y}.c_{1998}$$

where c_{1996} is the concentration in 1998;
d_{1998}, d_y are correction factors to estimate nitrogen dioxide concentrations in future years (1996=1, 1997=0.95, 1998=0.91) from DETR guidance;

The difference between the measured value and the expected value was then determined for each site and normalised by dividing by the expected value. The standard deviation of normalised differences was determined for each site. A best estimate of the standard deviation from all sites was then calculated. The standard deviation of the annual mean was 0.097 with 2 degrees of freedom. The standard deviation of the 99.8th percentile hourly concentration was 0.21 with 2 degrees of freedom.

Short periods of monitoring data
Additional errors can be introduced where monitoring at the reference site (used to calibrate the modelling results against) takes place over periods less than a complete year, typically of three or six months.

In this case, a whole year of data was available at the monitoring site (1999 in Glasgow Centre), and so no correction was necessary for short periods of monitoring.

Confidence limits
Upper confidence limits for annual mean and 99.8th percentile concentrations were estimated statistically from the standard deviation of the model error and the year to year standard deviation:

$$u = c + \sqrt{(t_m s_m)^2 . \left(1 + \frac{1}{k}\right) + (t_y s_y)^2 + \sum (t_p s_p)^2 / k}$$

where:

s_m, s_y, s_p are the model error standard deviation , the year to year standard deviation and the standard error introduced using part year data;

c is the concentration calculated for the modelled year;

t_m, t_y, t_p are the values of Student's t distribution for the appropriate number of degrees of freedom at the desired confidence level;

k is the number of reference sites used in the estimation of the modelled concentration.

In many cases, the concentration estimate is based on a single reference site (k=1). However, improved estimates can be obtained where more than one reference site is used.

Table A3.7 shows confidence levels for predictions as a percentage of modelled values

Table A3.7 Upper confidence levels (k=1) for modelled concentrations for future years

Confidence level	Annual mean	99.8th percentile
80 %	+19%	+27%
90%	+31%	+47%
95%	+44%	+70%

In practical terms,

- there is less than 1:5 chance (i.e.100-80=20%) that the 40 μg m^{-3} objective will be exceeded if the modelled annual average concentration in 2005 is less than 34 μg m^{-3} (i.e. 40/1.19);
- there is less than 1:20 (i.e. 100-5=5%) chance that the objective will be exceeded if the modelled roadside concentration is less than 28 μg m^{-3} (i.e. 40/1.44).

- Similarly, there is less than 1:5 chance that the 200 μg m^{-3} 99.8th percentile concentration will be exceeded if the modelled concentration for 2005 is less than 157 μg m^{-3};
- there is less than 1:20 chance that the objective will be exceeded if the modelled concentration in 2005 is less than 117 μg m^{-3}.

In the figures shown in the report, the intervals of confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals.

A simple linear relationship can be used to predict the 99.8th percentile concentration of NO_2 from the annual concentration: the 99.8th percentile is three times the annual mean at kerbside/roadside locations. Therefore, plots of the modelled annual mean NO_2 concentrations can be used to show exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances of the hourly objective need to be adjusted so they may be used directly with the plots of annual concentration. This has been performed by simply dividing the concentrations of the confidence limits by three.

The following table shows the difference between assigning symmetrical confidence intervals and assigning intervals based directly on the statistics.

Table A3.8a Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations (μg m^{-3})			
		Annual average objective (symmetrical intervals)	Symmetrical intervals	Annual average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 28		< 28	
Unlikely	5 to 20%	28 to 34	6.0	28 to 34	6.0
Possible	20 to 50%	34 to 40	6.3	34 to 40	6.3
Probable	50 to 80%	40 to 46	6.3	40 to 47	7.5
Likely	80 to 95%	46 to 52	6.0	47 to 58	10.3
Very likely	More than 95%	> 52		> 58	

Table A3.8b Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations (μg m^{-3})			
		Hourly average objective (symmetrical intervals)	Symmetrical intervals	Hourly average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 39		< 39	
Unlikely	5 to 20%	39 to 52	13.2	39 to 52	13.2
Possible	20 to 50%	52 to 67	14.3	52 to 67	14.3
Probable	50 to 80%	67 to 81	14.3	67 to 85	18.1
Likely	80 to 95%	81 to 94	13.2	85 to 113	28.7
Very likely	More than 95%	> 94		> 113	