Air Quality Review and Assessment – Stage 4

A report produced for St Albans City and District Council

John Abbott

January 2003

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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. 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 first step in this process is to undertake a review of current and potential future air quality. A minimum of two air quality reviews are recommended in order to assess compliance with air quality objectives; one to assess air quality at the outset of the Air Quality Strategy and a second to be carried out towards the end of the policy timescale (2005). The number of reviews necessary depends on the likelihood of achieving the objectives. Each of these two reviews is split into components. For the first round of air quality review and assessment, there four components. The components are: Stages 1 to 3; and Stage 4 and Action Plans. Stage 4 and Action Plans are normally completed in parallel. Not all local authorities have to complete all the components.

This report is equivalent to a Stage 4 air quality review and assessment for St Albans as outlined in the Government's published guidance.

St Albans City and District Council has completed a Stage 3 Air Quality Review and Assessment. The results of this indicted that exceedences of the annual mean objective for nitrogen dioxide (NO_2) are likely within 50-100m of the M1 and M25 in the St Albans City and District Council area. As a result of this air quality review and assessment, St Albans City and District Council has declared six Air Quality Management Areas (AQMAs) including specific residential properties close to the M1 and M25.

[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.

The general approach taken to this Stage 4 assessment was to:

- Identify the improvement needed in concentrations of nitrogen dioxide at selected receptors (mostly housing) in the Air Quality Management Area, including the receptors where the greatest improvements were needed;
- Consider recent continuous monitoring and diffusion tube measurements;
- Identify the contributions of the relevant sources to the exceedences (local traffic, background sources, and other relevant sources);
- Use monitoring data from the NO_2 continuous monitor located at Fleetville Community Centre, St Albans and Furzehill School, Borehamwood to assess the ambient concentrations produced by the road traffic and to calibrate the output of the NO_2 modelling studies;
- Model the concentrations of NO_2 around the selected AQMAs, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Consider three scenarios to improve air quality and identify the improvements in air quality that might be possible for nitrogen dioxide;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations;
- Consider any changes that are needed to the existing Air Quality Management Areas;
- Consider the feasibilities of implementing the options in a very simple way.

The monitoring and modelling carried out for this assessment show that the expected area of exceedence of the objective for nitrogen dioxide is limited to properties in AQMA No 7. The reduction needed in annual mean NO_2 concentrations to ensure that concentrations at all relevant receptors in the AQMAs did not exceed 40 $\mu g\ m^{-3}$ was 7 $\mu g\ m^{-3}$ for the properties closest to the M25 in Moore Mill Lane.

The source apportionment work identified emissions of oxides of nitrogen (NO_x) from traffic on roads close to the AQMA as the important source from which emissions might be reduced. The general background of NO_x cannot be easily reduced except by national or regional measures. Emissions of NO_x from local traffic accounted for approximately 41 % of the modelled oxides of nitrogen concentration at the property closest to the M25 on Moore Mill Lane.

The following scenarios were considered to try and reduce the emissions of NO_x and so reduce the concentrations of NO_2 at the most affected receptors:

1. **Scenario 1** Reduce speed to 80 kph;
2. **Scenario 2** Reduce car and LGV traffic by 20 %
3. **Scenario 3** Reduce all traffic by 20%

In addition consideration was given to improving dispersion by planting trees between the motorway and the residential properties.

None of these measures would be sufficient to eliminate the exceedence of the objective for nitrogen dioxide at all relevant receptor locations in St Albans AQMA No 7.

The following changes to the AQMAs in St Albans are recommended.

AQMA	Changes recommended to the existing Air Quality Management Areas
No 1	Revoke
No 2	Revoke
No 3	Revoke
No 4	Revoke
No 5	Not in District
No 6	Revoke
No 7	No change recommended

Acronyms and definitions

AADTF	Annual Average Daily Traffic Flow
ADMS	an atmospheric dispersion model
AQDD	an EU directive (part of EU law) - Common Position on Air Quality Daughter Directives, commonly referred to as the Air Quality Daughter Directive
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AP	Action Plan
AUN	Automatic Urban Network (DEFRA funded network)
base case	In the context of this report, the emissions or concentrations predicted at the date of the relevant air quality objective (2005 for nitrogen dioxide)
CO	Carbon monoxide
d.f.	degrees of freedom (in statistical analysis of data)
DETR	Department of the Environment Transport and the Regions (now DEFRA)
DEFRA	Department of the Environment, Farming and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards (UK panel)
EU	European Union
GIS	Geographical Information System
HA	Highways Agency
kerbside	0 to 1 m from the kerb
LADS	Urban background model specifically developed for Stage 3 Review and Assessment work by NETCEN. This model allowed contributions of the urban background and road traffic emissions to be calculated
Limit Value	An EU definition for an air quality standard of a pollutant listed in the air quality directives
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient (between two variables)
receptor	In the context of this study, the relevant location where air quality is assessed or predicted (for example, houses, hospitals and schools)
roadside	1 to 5 m from the kerb
SD	standard deviation (of a range of data)
SO_2	Sulphur dioxide
TEMPRO	A piece of software produced by the DEFRA used to forecast traffic flow increases
UWE AQMRC	University of the West of England Air Quality Management Resource Centre

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APPENDICES

Maps reproduced within this document

1 Introduction to this Stage 4 air quality assessment

This section outlines the reason that the Stage 4 air quality review and assessment was commissioned, and briefly explains what a Stage 4 air quality review and assessment is.

1.1 PURPOSE OF THE STUDY

St Albans City and District Council has completed a Stage 3 Air Quality Review and Assessment. The results of this indicted that exceedences of objectives for nitrogen dioxide (NO_2) are likely within 50-100 m of the M1 and M25 motorways in the St Albans City and District Council area. As a result of this air quality review and assessment, St Albans City and District Council has declared six air quality management areas.

St Albans City and District Council now requires further review and assessment of its air quality – a Stage 4 review and assessment – as specified under Section 84 of the Environment Act (1995).

1.2 BRIEF EXPLANATION OF A STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT

The 1995 Environment Act places duties on local authorities with regard to local air quality review and, where potential problems are identified, the management of local air quality. The air quality review is designed as a multi-stage process, with progressively more complex assessments at each stage.

If a local authority declares an air quality management area, Section 84(1) of the Environment Act 1995 requires the local authority to carry out a further assessment of existing and likely future air quality in the AQMA. This further assessment is called a Stage 4 air quality review and assessment, and is intended to supplement information the authority already has.

For each pollutant where there is an exceedence of the air quality, the Stage 4 should calculate:

- how great an improvement is needed; and
- the extent to which different sources contribute to the problem (source apportionment).

1.3 OVERVIEW OF APPROACH TAKEN

The general approach taken to this Stage 4 assessment was to:

- Identify the improvement needed in concentrations of nitrogen dioxide at selected receptors in the Air Quality Management Area, including the receptors where the greatest improvements were needed;
- Collect and interpret additional data to support the Stage 4 assessment, including detailed traffic flow data around locations where exceedences of the NO_2 objective were predicted;
- Consider recent continuous monitoring and diffusion tube measurements;
- Identify the contributions of the relevant sources to the exceedences (local traffic, background sources, and other relevant sources);
- Use monitoring data from the NO_2 continuous monitors located at Fleetville Community Centre, St Albans and at Furzehill School, Borehamwood to assess the

ambient concentrations produced by the road traffic and to calibrate the output of the NO_2 modelling studies;

- Model the concentrations of NO_2 around the selected AQMAs, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Consider three scenarios to improve air quality and identify the improvements in air quality that might be possible for nitrogen dioxide;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations;
- Consider any changes that are needed to the existing Air Quality Management Areas;
- Consider the feasibilities of implementing the options in a simple way

1.4 RELEVANT DEFRA DOCUMENTATION USED

This report has used the guidance in LAQM.TG4 (00), published in May 2000. Reference has also been made to recent guidance LAQM.TG (03) published in January 2003.

1.5 NUMBERING OF TABLES AND FIGURES

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

1.6 POLLUTANTS CONSIDERED IN THIS REPORT

St Albans have only declared an AQMA for nitrogen dioxide, and this is the only pollutant considered in this report.

1.7 UNITS OF CONCENTRATION USED AND CONVERSIONS TO OTHER UNITS

This report presents concentrations of nitrogen dioxide in units of $\mu g/m^3$, which is consistent with units used in the current UK Air Quality Strategy.

To convert concentrations of nitrogen dioxide between $\mu g\ m^{-3}$ and ppb (parts per billion), use the following relationships:

$$\mu g\ m^{-3} / 1.91 = ppb$$

$$1.91 \times ppb = \mu g\ m^{-3}$$

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2 The UK 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).

2.1 UPDATED AIR QUALITY STANDARDS AND OBJECTIVES

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 district, 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.

This study essentially forms part of the requirements of Section 84 of the Part IV Air Quality of the Environment Act 1995.

2.2 OVERVIEW OF THE PRINCIPLES AND MAIN ELEMENTS OF THE 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 actors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with a target dates of 2003, 2004 and 2005 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the NAQS 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 that 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 2008 are shown in Table 2.2. The table shows the standards in ppb and $\mu g\ m^{-3}$ with the number of exceedences that are permitted (where applicable) and the equivalent percentile.

2.2.2 The difference between 'standards' and 'objectives' in the UK AQS

Air quality *standards* (in the UK AQS) are the concentrations of pollutants in the atmosphere that can broadly be taken to achieve a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups. The standards have been set at levels to avoid significant risks to health.

The *objectives* of the UK air quality policy are framed on the basis of the recommended standards. The objectives are based on the standards, but take into account feasibility, practicality, and the costs and benefits of fully complying with the standards.

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 exceedences 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) for the purpose of Local Air Quality Management

Pollutant	Concentration limits		**Averaging period**	**Objective** [number of permitted exceedences a year and equivalent percentile]	
	(μg m^{-3})	(ppb)		**(μg m^{-3})**	date for objective
Benzene	16.25	5	**running annual** mean	**16.25**	by 31.12.2003
1,3-butadiene	2.25	1	**running annual** mean	**2.25**	by 31.12.2003
CO	11,600	10,000	**running 8-hour** mean	**11,600**	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 exceedences 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 exceedences a year or ~ equivalent to the 90th percentile]	by 31.12.2004
	40	-	**annual** mean	**40**	by 31.12.2004
	266	100	**15 minute** mean	**266** [maximum of 35 exceedences a year or equivalent to the 99.9th percentile]	by 31.12.2005
SO_2	350	132	**1 hour** mean	**350** [maximum of 24 exceedences a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour** mean	**125** [maximum of 3 exceedences a year or equivalent to the 99th percentile]	by 31.12.2004

Notes

1. Conversions of ppb and ppm to (μg m^{-3}) correct at 20°C and 1013 mb.
2. The objectives for nitrogen dioxide are provisional.
3. PM_{10} measured using the European gravimetric transfer standard or equivalent. The Government and the devolved administrations see this new 24-hour mean objective for particles as a staging post rather than a final outcome. Work has been set in hand to assess the prospects of strengthening the new objective.

2.2.3 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 European Union 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 framework directive. 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, sulphur dioxide.

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.

2.2.4 Recent changes to the UK National Air Quality Standards

DEFRA issued a consultation document in 2001 with proposed changes to the UK AQS for benzene, carbon monoxide and particulate matter (DEFRA, 2001). The proposed changes are:

For ***benzene***

- An objective derived from the long-term policy aim of **3.25 $\mu g/m^3$ as a running annual mean** recommended by UK EPAQS (Expert Panel on Air Quality Standards). The objective for benzene included in the 2000 Strategy is 16 $\mu g/m^3$ as a running annual mean to be achieved by 2003. This is derived from the EPAQS recommended standard. The UK adopted the second EU Air Quality Daughter Directive (which sets limit values for benzene and carbon monoxide) in 2000. This Daughter Directive sets a limit value for benzene of 5 $\mu g/m^3$ as an annual mean to be achieved by 2010.

For ***carbon monoxide***

- Replacing the existing objective derived from the recently agreed EU limit value. The objective for carbon monoxide included in the 2000 Strategy is 11.6 mg/m^3 as a running 8-hour mean to be achieved by 2003. This is derived from the UK EPAQS recommended standard. The second EU Air Quality Daughter Directive sets a limit value for carbon monoxide of 10 mg/m^3 as a maximum daily 8-hour mean to be achieved by 2005. DEFRA propose to set a new objective of achieving the EU limit value by the end of 2003, which is **10 mg/m^3 as a maximum daily 8-hour mean** to be achieved by 2005.

For ***particulates*** new provisional objectives of

- 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 time s per 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 10-14 times per year and an annual mean of 23-25 $\mu g/m^3$, 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 per year and an annual mean of 18 $\mu g/m^3$, both to be achieved by the end of 2010.

New objectives came into force towards the end of 2002 following the adoption of the Air Quality (England) Amendment Regulations, 2002. Local Authorities are not required to assess their air quality against these new objectives as part of the Stage 4 Review and Assessment.

2.2.5 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 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.

2.2.6 Timescales to achieve the objectives for the pollutants in AQS

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 – THE APPROACHES AND EXPECTED OUTCOMES

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.TG4(00) May 2000, on ‘Review and Assessment: Pollutant Specific Guidance’ and LAQM.TG(03) ‘Review and Assessment: Technical Guidance’. This review and assessment has considered the procedures set out in this technical 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 therefore that reviews should be carried out in three stages. All three stages of review and assessment may be necessary and every authority is expected to undertake at least a first stage review and assessment of air quality in their authority area. The Stages are briefly described in the following table, Table 2.3.

Table 2.3 Brief details of Stages in the Air Quality Review and Assessment process

Stage	Objective	Approach	Outcome
First Stage Review and Assessment	• Identify all significant pollutant sources within or outside of the authority's area.	• Compile and collate a list of potentially significant pollution sources using the assessment criteria described in the Pollutant Specific Guidance	
	• Identify those pollutants where there is a **risk** of exceeding the air quality objectives, and for which further investigation is needed.	• Identify sources requiring further investigation.	• Decision about whether a Stage 2 Review and Assessment is needed for one or more pollutants. If not, no further review and assessment is necessary.
Second Stage Review and Assessment	• Further screening of significant sources to determine whether there is a significant risk of the air quality objectives being exceeded.	• Use of screening models or monitoring methods to assess whether there is a risk of exceeding the air quality objectives.	
	• Identify those pollutants where there is a **risk** of exceeding the objectives, and for which further investigation is needed.	• The assessment need only consider those locations where the highest likely concentrations are expected, and where public exposure is relevant.	• Decision about whether a Stage 3 Review and Assessment is needed for one or more pollutants. If, as a result of estimations of ground level concentrations at suitable receptors, a local authority judges that there is no significant risk of not achieving an air quality objective, it can be confident that an Air Quality Management Area (AQMA) will not be required. • However, if there is doubt that an air quality objective will be achieved a third stage review should be conducted.

Table 2.3 (contd.) Brief details of Stages in the Review and Assessment process

Stage	Objective	Approach	Outcome
Third Stage Review and Assessment	• Accurate and detailed assessment of both current and future air quality. Assess the **likelihood** of the air quality objectives being exceeded.	• Use of validated modelling and quality-assured monitoring methods to determine current and future pollutant concentrations.	
	• Identify the geographical boundary of any exceedences, and description of those areas, if any, proposed to be designated as an AQMA.	• The assessment will need to consider all locations where public exposure is relevant. For each pollutant of concern, it may be necessary to construct a detailed emissions inventory and model the extent, location and frequency of potential air quality exceedences.	• Determine the location of any necessary Air Quality Management Areas (AQMAs). Once an AQMA has been identified, there are further sets of requirements to be considered. • A further assessment of air quality in the AQMA is required within 12 months which will enable the degree to which air quality objectives will not be met and the sources of pollution that contribute to this to be determined. A local authority must also prepare a written action plan for achievement of the air quality objective. Both air quality reviews and action plans are to be made publicly available.

Table 2.3 (contd.) Brief details of Stages in the Review and Assessment process

Stage	Objective	Approach	Outcome
Fourth Stage Review and Assessment **(to support the Action Plan)**	• Further accurate and detailed assessment of both current and future air quality. Should concentrate on areas where the Stage 3 assessment indicated exceedences of the objectives are likely.	• Use of validated modelling and quality-assured monitoring methods to determine current and future pollutant concentrations.	• Confirm outcome of original AQMA designation and alter if necessary (for example, as a result of changes in the emission factors used in the modelling)
	• Source apportionment in regions where there are exceedences. Understand contributions from traffic, industrial, domestic and background sources.	• Analyse modelling results.	• Understand the contributions from the various sources, and therefore select the source where action can be taken to reduce emissions
	• Assess a range of scenarios to improve air quality and reduce or eliminate the risk of air quality objectives being exceeded.	• Liaise with stakeholders such as the Highways Agency, the Environment Agency and the local industry to help define scenarios	• Identify the most likely scenarios to improve air quality and use these in the modelling. Incorporate scenarios into any Action Plan produced.
	• Identify the geographical boundaries of any exceedences in the scenarios.	• Analyse modelling results.	• Incorporate modelling results of the scenarios into any Action Plan produced. Consider how to implement any Action Plan to improve air quality.

Local authorities are expected to have completed review and assessment of air quality by December 2000. A further review will also need to be completed for the purposes of the Act before the target date of 2003.

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

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

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 exceedences 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.

3 Stage 4 Air Quality Review and Assessment and Action Planning

This section contains information about Stage 4 Air Quality Review and Assessments and Action Plans. It explains the relationships between the Stage 4 and Action Plans, what each document should contain, and the timescales for producing the documents.

3.1 THE RELATIONSHIPS BETWEEN A STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT AND AN ACTION PLAN

If a local authority declares an air quality management area, Section 84(1) of the Environment Act 1995 requires that local authority to carry out a further assessment of existing and likely future air quality in the AQMA. This further assessment is called a Stage 4 air quality review and assessment, and is intended to supplement information the authority already has. It is a duty of the LA to complete this Stage 4 air quality review and assessment.

For each pollutant where there is an exceedence of the air quality, the Stage 4 should calculate:

- how great an improvement is needed; and
- the extent to which different sources contribute to the problem (source apportionment of traffic, industrial, domestic and background – if appropriate).

This should give a clear picture of the sources which authorities can control or influence. It should ensure that Action Plans strike a balance between the contribution from local authorities and the contribution that must come from other sectors. It should allow them to target their responses more effectively and ensure that the relative contributions of industry, transport and other sectors are cost effective and proportionate. It should include, in particular, an estimate of the costs and feasibility of different abatement options to allow for the development of proportionate and effective Action Plans (although this information could be included within the Action Plan, rather than the Stage 4). Further liaison with other agencies (including, in particular, the Environment Agency and the Highways Agency) is likely to be essential.

Essentially, the production of the Stage 4 air quality review and assessment and the Action Plan are activities that the LA can complete in parallel, rather than sequentially.

3.2 RECENT DEFRA GUIDANCE ON STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT

DEFRA have issued guidance on what they expect in a Stage 4. This expands on the information that is available in LAQM.G1(00) - Framework for review and assessment of air quality. It has been incorporated into new policy guidance LAQM.PG(03).

Essentially, the Stage 4 provides the technical justification for the measures an authority includes in its Action Plan. DEFRA expect that the Stage 4 will allow Local Authorities:

- To calculate more accurately how much of an improvement in air quality is needed to deliver the air quality objectives within the AQMA
- To refine their knowledge of the sources of pollution so that air quality Action Plans can be properly targeted
- To take account of national policy developments that may come to light after the AQMA declaration (the revision of the vehicle emission factors is an example of this kind of policy development)
- To take account of local policy developments, for example, new transport schemes in the vicinity of the AQMA or of any new major housing or commercial developments
- To carry out more intensive monitoring in the problem areas to confirm earlier findings
- To corroborate other assumptions on which the designation of the AQMA was based and to check that the original designation is still valid, and does not need amending
- To respond to comments made by statutory consultees (if there were any relevant comments made)

3.3 ACTION PLANS

Local authorities are required to prepare a written Action Plan for each AQMA setting out the actions they intend to take in pursuit of the air quality objectives. This has to include a timetable for implementing the plan.

The Action Plan should contain the scenarios that have been modelled in the Stage 4 review and assessment. It should contain a summary of the air quality improvements that might be possible for each of the scenarios identified. The Stage 4 provides the technical justification for the measures an authority includes in its Action Plan.

The Action Plan should also contain simple estimates of the costs and feasibilities of implementing those scenarios. The Action Plan may also consider the non-health benefits of implementing scenarios in the Action Plan, for example, reductions in road traffic accident deaths as a result of road improvements that also reduce vehicle emissions.

The LA can then identify which scenario(s) offer the most cost-effective or cost-beneficial way of improving air quality.

3.4 STAGE 4 AND ACTION PLAN TIMESCALES

The Environment Act does not set any deadline for completing action plans, but the Government expects authorities to begin preparing them as soon as they have designated an AQMA, and in parallel with their further assessment of air quality required under section 84(1) of the Environment Act. Authorities should not wait until they have completed their further assessment of air quality before beginning their Action Plans. They should aim to consult on their draft AQMA Action Plans within 9-12 months of designation, and should have AQMA Action Plans in place within 12-18 months of designation.

Local authorities are required under section 84(2)(a) of the Environment Act to report on the further assessment of air quality (i.e. the Stage 4 Air Quality Review and Assessment) **within 12 months of designating the Air Quality Management Area**.

4 Information used to support this assessment

This section lists the key information used in this review and assessment.

4.1 MAPS AND DISTANCES OF RECEPTORS FROM ROADS

St Albans City and District Council provided detailed OS landline data of the parts of the District covered by the AQMAs including the M1 and M25 roads. Individual buildings or groups of buildings (receptors) were identified from the electronic OS Landline maps of the areas and the distances of these receptors from the road determined from the maps.

4.2 ROAD TRAFFIC DATA

The main roads of concern for the Stage 4 assessment were the M25 and M1 motorways and the A40 trunk road. Traffic flow and vehicle mix data for these roads were taken from the NAEI inventory for 2000. Table 4.1 shows AADT traffic flows used in the assessment. Traffic flows on motorway link roads were estimated on the basis that one third of vehicles turn left, one third turn right and one third carry straight on at the junction. It was assumed that the vehicles travelled at the speed limits on these roads. A diurnal profile was applied to the traffic flows typical of the outer London.

Table 4.1: Annual average daily traffic flows, 2000

	Total flow	Heavy duty vehicles
M25 east of A5183	122111	20365
M25, below A405 junction	114937	20467
M25, west of M1	126522	16993
A5183, north of M25	11982	420
A5183, south of M25	12490	548
M1, south of M25	62979	5161
M1, north of M25	145177	20374
M1, north of M25	119976	18894
A405, south of M25	38485	2552
A405 north of M25	23997	2109

4.2.1 Traffic Growth

The National Roads Traffic Forecast (NRTF, 1997) indicates that in the absence of further information on the severity of capacity limitations a central estimate is considered the most likely outcome. Therefore, in this assessment, we have assumed that traffic volume will increase in future years by factors calculated from the DETRs TEMPRO central traffic flow forecast software. Details of TEMPRO factors used are given in Table 4.2.

Table 4.2: Traffic growth factors applied

Year	Low	High
1991	1	1
1992	1.014	1.014
1993	1.028	1.028
1994	1.043	1.043
1995	1.057	1.057
1996	1.071	1.071
1997	1.078	1.099
1998	1.085	1.128
1999	1.092	1.156
2000	1.099	1.184
2001	1.106	1.213
2002	1.121	1.237
2003	1.137	1.261
2004	1.154	1.286
2005	1.169	1.31
2006	1.185	1.334
2007	1.2	1.359
2008	1.215	1.383
2009	1.23	1.408
2010	1.245	1.432

4.3 AMBIENT MONITORING

4.3.1 Nitrogen dioxide

Nitrogen dioxide concentrations were monitored at a background continuous monitoring sites at Fleetville Community Centre, St Albans and at Furzehill Middle School, Borehamwood. The site operated from 1999 through 2001 and continued during 2002. Data up to the end of 2002 was considered in this assessment. However, the ratification of data for 2002 was not complete and so 2001 data has been used in preference where possible. Data from these sites was provided by the Environmental Research Group, Kings College who operate these sites and other sites within the Hertfordshire and Bedfordshire Air Quality Network.

Nitrogen dioxide diffusion tube measurements were made at 34 locations throughout St Albans City and District. Of these sites, sites SA21 and SA23-SA31 are located within or close the AQMAs. The diffusion tube sites SA20, SA34 and SA35 are collocated with the continuous monitor at Fleetville Community centre.

4.4 EMISSION FACTORS USED IN THIS REVIEW AND ASSESSMENT

The vehicle emission factors used for national mapping have recently been revised by DEFRA[3]. The most recent emission factors have been used in this Stage 4.

In the St Albans's Stage 3, older emission factors were used. Using the newer factors will result in differences in the modelled results between the Stage 3 and the Stage 4.

[3] The new set of emission factors on the NAEI website (www.naei.org.uk/emissions/index.php) approved by DEFRA and DTLR for use in emissions and air quality modelling, following consultation of the TRL Report "Exhaust Emission Factors 2001: Database and Emission Factors" by TJ Barlow, AJ Hickman and P Boulter, TRL, September 2001

5 Stage 4 Review and Assessment for Nitrogen Dioxide

This section summarises

- the work that was done at Stage 3 and the areas of exceedence of the air quality objectives for nitrogen dioxide;
- monitoring that was completed for the Stage 3 Air Quality Review and Assessment;
- the additional monitoring that has been done after Stage 3 to confirm the predicted concentrations in the Air Quality Management Area or to more generally assess concentrations around St Albans;
- the Stage 4 modelling, which includes predictions of concentrations of nitrogen dioxide for a range of Action Plan scenarios to improve air quality.

5.1 LATEST STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

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 $\mu g\ m^{-3}$ (21 ppb);
- 200 $\mu g\ m^{-3}$ (100 ppb) as an hourly average with a maximum of 18 exceedences in a year.

The National Air Quality Strategy was reviewed in 1999 (DETR, 1999). The Government proposed that the annual objective of 40 $\mu g\ m^{-3}$ 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, 2000) and the Air Quality Regulations (2000) include the proposed changes.

The new hourly objective is slightly more stringent than the original hourly objective. Modelling studies suggest that in general achieving the annual mean of 40 $\mu g\ m^{-3}$ is more demanding than achieving either the former or current hourly objective. If the annual mean is achieved, the modelling suggests the hourly objectives will also be achieved.

5.2 KEY FINDINGS OF THE STAGE 3 REVIEW AND ASSESSMENT

The Stage 2 air quality assessment for St Albans identified areas that required further assessment of nitrogen dioxide. A Stage 3 Review and Assessment was completed, which involved detailed dispersion modelling around selected hotspots to predict areas of exceedence of the nitrogen dioxide objectives (CES, 2000).

The CES report concluded that the air quality objectives for nitrogen dioxide are expected to be met in 2005 across the majority of the City and district of St Albans. The majority of exceedances of the annual mean objective were predicted to occur within 50 to 100 metres of the three motorways in the District. As a result no large residential areas were predicted to be affected by exceedances of the annual mean objective, although isolated properties in the vicinity of the motorway were affected. The area of most concern was identified as probably the residential area west of Bricket Wood near the A405 and it's junction with the M25.

5.3 AREA DECLARED BY ST ALBANS AS AN AIR QUALITY MANAGEMENT AREA

The following areas were declared by St Albans as AQMAs:

Area 1: Domestic property at Searches Farm, Searches Lane, Bedmond abbots Langley WD5 0SB.

Area 2: Domestic property at Norrington End Farm, Redding Lane, Redbourn, Herts, AL3 7PU.

Area 3: Domestic properties at St Agnells Farm, Lybury Lane, Redbourn, AL3 7JL; St Agnells Farm Cottage, Lybury Lane, Redbourn, AL3 7JL.

Area 4: Domestic properties at Nicholls Farm, Lybury Lane, Redbourn, St Albans AL3 7JH; Oaklands Nicholls Farm, Lybury Lane, Redbourn, AL3 7JH: Nicholls farm Bungalow, Flamsteadbury, Redbourn, AL3 7DJ; 1 Nicholls Farm Cottages, Lybury Lane, Redbourn, AL3 7JH; 2 Nicholls Farm Cottages, Lybury Lane, Redbourn, AL3 7JH;

Area 5: Not declared

Area 6: Domestic Properties in the northern area of Bricket Wood including:
-Flats 1-14 Ronald Court, Oakwood Road, Bricket Wood, St Albans, AL2 3ET.
-Odd Nos. 1-25 and Even Nos. 4-26 Oakwood Road,. Bricket Wood, St Albans
-Nos 1 and 3 Five Acres Avenue, Bricket Wood, St Albans, AL2 3PY
-Nos. 3, 5, 11 Old Watford Road, Bricket Wood, St Albans, AL2 3RS
-Any mobile residential properties situated on Five Acres Country Club, Bricket Wood, St Albans, AL2 3PY
-Domestic properties on St Albans City and District Council caravan site, Bricket Wood, St Albans
-Woodbury Manor, Black Green Cottage, Pandora, Hoof Prints, Lye Lane, Bricket Wood, St Albans, AL2 3TW

Area 7: Domestic properties in Frogmore including:
-Nos 111, 113, 115, 117, 119, 120, 121, 122, 123, 124, 125, 125a, 126, 127, 127a, 127b, 127c, 128, 129, 129a, 129c, 130, 131, 131a, 132, 133, 133a, 134, 135, 162, 164 Radlet Road, Frogmore, AL2 3EL
-Nos. 1-7 Moore Mill Lane, Colney Street, St Albans, AL2 3UA
-Rosmore, Meadow View, Harentor, Moore Mill Lane, Colney Street, St Albans, AL2 3UA

5.4 MONITORING

5.4.1 QA/QC of continuous monitoring data

The continuous monitoring station is included in the Herts and Beds Air Pollution Monitoring Network operated by SEIPH Environmental Research Group, Kings College. The data are checked and ratified by the operator prior to release.

5.4.2 Summary of continuous monitoring data

Table 5.1 summarises the measurements of nitrogen dioxide concentrations at the Fleetville Community Centre and Furzehill Middle School continuous monitoring stations.

Table 5.1: Summary of continuous monitoring data

Site	Period	Data capture, %	NO_x, concentration, $\mu g\ m^{-3}$ as NO_2	NO_2 Concentration, $\mu g\ m^{-3}$	
				Period average	Period 99.8th percentile hourly mean
Fleetville Community Centre	1999	62	64.1	30.5	111
	2000	92	57.4	30.5	103
	2001	86	51.1	26.2	90
	2002&	84	48.5	26.3	
Furzehill School	1999 – 28/2/02 to end	74	46.8	27.2	94
	2000 whole year	99	59.6	32	94
	2001 whole year	86	56.7	31	99
	01/01/02-28/8/02	99		25	90

& Part ratified

5.4.3 Method of adjustment of bias in the reported diffusion tube concentrations

In this report, we have assessed the bias in diffusion tube data using the concentrations recorded using diffusion tubes collocated with the Fleetville Community Centre continuous monitoring site. Table 5.2 shows the concentrations measured by continuous monitor and by diffusion tube at the site for relevant periods.

Table 5.2: Assessment of bias in nitrogen dioxide diffusion tube measurements

	Continuous monitor concentration, $\mu g\ m^{-3}$	Diffusion tube concentration $\mu g\ m^{-3}$	Bias, %
2002, 12 months	26.3	24.2	-8.0
2002, July-December	24.1	27.6	+14.5
2002, October-December	28.9	31.0 (SA20)	+7.3
		33.6 (SA34)	+14.2
		29.8 (SA35)	+3.1

5.4.4 Estimation of annual mean nitrogen dioxide concentrations from short-term monitoring data

It was only possible to carry out a diffusion tube monitoring survey at sites within the AQMA for 6 months between July and December 2002. The measurements at these diffusion tube sites were adjusted to provide estimates of annual mean concentrations during 2001 by reference to measurements made over the same period at other sites in the region. Table 5.3 provides details of measurements used to derive the adjustment factor.

Table 5.3: Adjustment factors used to estimate annual mean concentrations from part year data.

Long term site	Data period	Annual mean 2001	Period mean	Ratio
Fleetville Community Centre	2002, whole year	26.2	26.3	0.996
London Brent		36.5	29.1	1.254
London Teddington		29.0	25.4	1.142
West London		51.9	45.3	1.146
Average				1.13
Fleetville Community Centre	2002, July-December	26.2	24.1	1.09
London Brent		36.5	33.5	1.09
London Teddington		29.0	27.8	1.04
West London		51.9	47.2	1.10
Average				1.08

Concentrations recorded by the diffusion tubes for 2000 and 2001 are summarised in Table 5.2.

5.4.5 Factors used to predict future diffusion tube concentrations from current concentrations

The DEFRA Review and Assessment: Technical Guidance. LAQM.TG (03) provides factors to project forward concentrations at background locations, based on the concentrations measured in recent years. The DEFRA Review and Assessment: Pollutant Specific Guidance. LAQM.TG4 (00) similarly provides factors for roadside locations.

Background

- 2001 to 2005 0.908

Kerbside

- 2001 to 2005 0.908

The projected concentrations at each of the diffusion tube sites are shown in Table 5.2.

Table 5.2 Diffusion tube measurements: annual average

Location	Class	OS Ref X	OS Ref Y	Address	Period mean, measured	Period mean, bias adjusted	2001, estimate, bias adjusted	2005, estimate, bias adjusted
SA01	k	5151	2077	Museum of St Albans, Hatfield Road	36.9	40.1	45.3	41.1
SA02	I	5141	2065	Holywell Hill, St Albans	29.4	32.0	36.1	32.8
SA03	b	5149	2074	St Peters Street, St Albans	29.0	31.6	35.7	32.4
SA04	b	5167	2092	17 Pondfield Crescent, Marshalswick, St Albans	21.2	23.0	26.0	23.6
SA05	b	5101	2118	Ben Austins, Redbourn	22.0	23.9	27.0	24.5
SA06	i	5186	2035	Ridgeview Hostel, Barnet Rd, London Colney	29.4	32.0	36.1	32.8
SA07	i	5120	2022	Waterdale, Bricket Wood	36.3	39.4	44.6	40.5
SA08	b	5174	2039	Bowmans Green JM1, Telford Rd, London Colney	30.6	33.2	37.5	34.1
SA09	k	5135	2143	High Street, harpenden	37.6	40.9	46.2	42.0
SA10	b	5144	2143	Crabtree Lane, Harpenden	23.5	25.5	28.9	26.2
SA11	b	5128	2102	Redbourn JM1, Crouch Hall Lane, Redbourn	27.1	29.5	33.3	30.2
SA12	i	5128	2022	Ashridge Drive, Bricket Wood	28.5	30.9	35.0	31.7
SA13	k	5177	2141	Wheathampstead High Street	27.1	29.5	33.3	30.2
SA14	b	5175	2139	Adult Education Centre, Wheathampstead	22.2	24.1	27.2	24.7
SA15	k	5147	2071	Peahen PH, Holywell Hill, St Albans	49.7	54.0	61.0	55.4
SA16	i	5136	2044	Tippendale Lane, St Albans	32.5	35.3	39.9	36.2
SA17	i	5177	2047	London Colney Roundabout	31.1	33.8	38.2	34.7
SA18	i	5139	2081	Batchwood Drive, St Albans	24.4	26.6	30.0	27.3
SA20	b	516541	207359	Fleetville Community Centre, Royal Rd, St Albans	24.3	26.4	29.8	27.1
SA21		513317	202665	Lye Lane, BricketWood	36.1	39.2	44.3	40.3
SA22		509434	202665	Lybury Lane	50.4	44.0	47.6	43.2
SA23		509024	212779	St Agnells	31.9	27.9	30.1	27.3
SA24		509117	214082	Redding Lane	32.1	28.0	30.3	27.5
SA25		511353	203756	Searches Farm	38.0	33.2	35.9	32.6
SA26		512569	202728	Oakwood Road	37.1	32.4	35.0	31.7
SA27		512690	202713	Five Acres Avenue, Bricket Wood	35.3	30.9	33.3	30.3
SA28		512985	202659	Garnett Drive, Bricket Wood	35.0	30.5	33.0	29.9
SA29		513022	202624	Meadow Close, Bricket Wood	36.7	32.0	34.6	31.4
SA30		515390	202564	Smug Oak Lane	43.2	37.7	40.7	37.0
SA31		515297	502774	Radlett Road	46.6	40.7	44.0	39.9

K = Kerbside, I = Intermediate, B = Background

5.4.6 Comparison of the monitoring results with the relevant air quality objectives

The annual average nitrogen dioxide concentrations measured at the background continuous monitoring sites at Fleetville Community Centre and Furzehill School were substantially less than 2005 objective of 40 μg m^{-3}. Background concentrations are expected to decrease between 2001 and 2005 and so it is unlikely that the objective will be exceeded at background locations.

Nitrogen dioxide concentrations are predicted to exceed the 2005 objective outside the AQMAs on the basis of diffusion tube measurements at the SA01 Museum of St Albans, SA07 Waterdale, Brickets Wood, SA09 High Street, Harpenden and SA15 Peahen public house. Diffusion tube measurements within or near to the AQMAs indicate that the objective will be exceeded at diffusion tube locations SA21 Lye Lane and SA22 Lybury Lane. The measurement at SA31 Radlett Road also indicates potential exceedence.

5.5 OVERVIEW OF THE AIR QUALITY MODELLING FOR THIS STAGE 4 ASSESSMENT

5.5.1 Summary of the models used in this Stage 4 assessment

The air quality impact from roads has been assessed using our proprietary urban model. There are two parts to this model:

- The *Local Area Dispersion System (LADS) model*. This model calculates background concentrations of oxides of nitrogen on a 1 km x 1 km grid. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 1998 NAEI Area Emissions Inventory.
- The *DISP model*. This model is a tool for calculating atmospheric dispersion using a 10 m x 10 m x 3 m volume-source kernel to represent elements of the road. The volume source depth takes account of the initial mixing caused by the turbulence induced by the vehicles. The volume source depth was increased when modelling the emissions from the M25 in the area of AQMA No7 to 15 m because the road travels through a cutting and key receptors are very close to the motorway. Estimates of emissions from vehicles have been calculated using the latest (and finalised for this round of Review and Assessment) vehicle emission factors.

Further details of the models are given in Appendix 4.

Particular attention was paid to the avoidance of “double counting” of the contribution from major roads in the modelled areas. Thus the emissions from sections of roads modelled using DISP were removed from LADS inventory.

5.5.2 Validation and verification of the model

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. Details of the model validation are given in Appendix **2**.

Verification of the modelled involves comparison of the modelled results with any local monitoring data at relevant locations. Table 5.3 compares modelled predictions of oxides of nitrogen and nitrogen dioxide with measured values at Fleetville Community Centre and at Furzehill School.

Table 5.3: Comparison of modelled and measured concentrations, 2001

	Oxides of nitrogen concentration, μg m^{-3}		Nitrogen dioxide concentration, μg m^{-3}	
	Modelled	Measured	Modelled	Measured
Fleetville Community Centre	77	51	37.1	30.5
Furzehill School	61	57	31.5	31

The Fleetville Community Centre and Furzehill School sites are both fairly distant from the motorways affecting the air quality in the AQMAs. Comparison at these sites only provides partial verification of the model for application near to motorways. Further verification has been achieved by reference to verification studies for near motorway sites carried out for other local authorities during the Stage 3 Review and Assessment. Model predictions of nitrogen dioxide concentrations were compared with measured concentrations at three sites:

- Garnish Hall in Epping Forest District approximately 100m from the junction of the M11 and M25;
- Portsmouth Arms in Basingstoke and Deane District approximately 50 m from the M3;
- Erewash District site approximately 50 m from the M1.

Table 5.4 shows the modelled and measured nitrogen dioxide concentrations.

Table 5.4: Comparison of modelled and measured concentrations near motorways in other local authorities

	Nitrogen dioxide concentration, μg m^{-3}	
	Modelled	Measured[$]
Garnish Hall	40	35
Erewash	40	45
Portsmouth Arms	43	33

$ part year data adjusted to modelled year

5.5.3 Bias adjustment of the model

Bias adjustment is the process where the concentrations of the model are adjusted to agree with local air quality monitoring data. In this case, the model has been used to predict concentrations at the site of the Fleetville Community Centre and Furzehill School continuous monitors. The mean difference in the modelled and measured nitrogen dioxide concentration has been used to correct for modelled bias.

For the 2005 modelled predictions of concentrations, the model bias has been corrected for expected future declines in concentrations of nitrogen dioxide. The model bias correction applied to 2005 predictions was –3.2 μg m^{-3}. An alternative assessment of the model bias would include all five continuous monitoring sites considered above: however, in this case the calculated bias is almost the same.

5.5.4 Comparison of modelled concentrations with forecasts based on diffusion tube measurements

Table 5.5 shows the modelled concentrations for 2005 compared with the forecasts based on the diffusion tube measurements at sites in or close to the AQMAs (see Table 5.2).

Netcen's urban model uses an empirical method to take account of the proportion of the oxides of nitrogen emitted from local roads converted to nitrogen dioxide. A factor of 0.16 is applied to the contribution of oxides of nitrogen from the local road to calculate the contribution from the road of nitrogen dioxide concentrations. An alternative value for the factor, dependent on total oxides of nitrogen concentrations has recently been proposed (LAQM.TG(03)). The results of the application of the LAQM.TG(03) factor are also shown: the difference between the two methods is small.

The model predictions and diffusion tube-based forecasts are in close agreement except at diffusion tube site SA30. SA30 was mounted on a bridge over the motorway and may not be representative of ground level concentrations in the area.

Table 5.5: Comparison of modelled concentrations with diffusion tube estimates for 2005

	Concentration, $\mu g\ m^{-3}$		
Site	Modelled	Modelled, LAQM.TG(03) factor	Diffusion tube estimate
SA21	44.5	46.7	40.3
SA22	Incorrect OS reference		
SA23	Incorrect OS reference		
SA24	24.5	27.6	27.5
SA25	30.5	33.4	32.6
SA26	30.1	32.8	31.7
SA27	29.7	32.4	30.3
SA28	30.1	32.8	29.9
SA29	30.4	33.7	31.4
SA30	48.3	50.1	37.0
SA31	41.5	43.0	39.9

5.6 IMPROVEMENTS NEEDED IN AIR QUALITY

5.6.1 The improvement that is needed – general points

A key step in the Stage 4 Review and Assessment process is to identify the improvements needed in air quality, when there are exceedences of the UK air quality objectives.

An important point to note is that the Local Authority does not need to attempt to improve air quality beyond the air quality objective that is being exceeded. This applies even if that authority has taken a precautionary approach and deliberately set the boundary of their AQMA at, for example, the 36 $\mu g/m^3$ contour rather than the 40 $\mu g/m^3$ contour, in the case of the annual mean NO_2 objective.

For example, an AQMA may have been declared for NO_2, and for administrative reasons, the boundary of the AQMA may include houses where the concentrations of NO_2 are not predicted to exceed the annual mean objective of 40 $\mu g/m^3$. Let us say the maximum exceedence of the annual mean NO_2 objective at a relevant receptor in the AQMA was 43 μg/m^3. The maximum improvement that would be needed in this example AQMA will therefore be 3 μg/m^3. In this example, this will mean that some houses in the AQMA will experience concentrations of NO_2 possibly much lower than the annual mean objective.

5.6.2 Areas of predicted exceedence of the air quality objectives considered in this Stage 4 assessment

St Albans City and District Council identified six AQMAs on the basis of the Stage 3 Review and Assessment where it was considered likely that the annual mean objective for nitrogen dioxide would not be achieved.

The following contour maps show the areas where the modelling has predicted exceedences the annual mean NO_2 objective (in 2005).

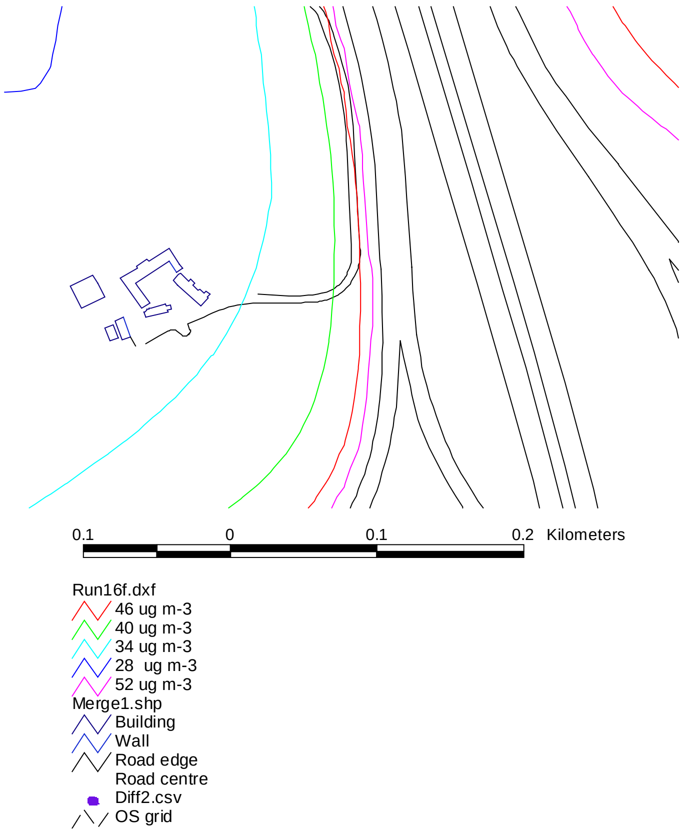

Fig. 5.1: Modelled nitrogen dioxide concentrations, 2005, AQMA No 1, Searches Farm

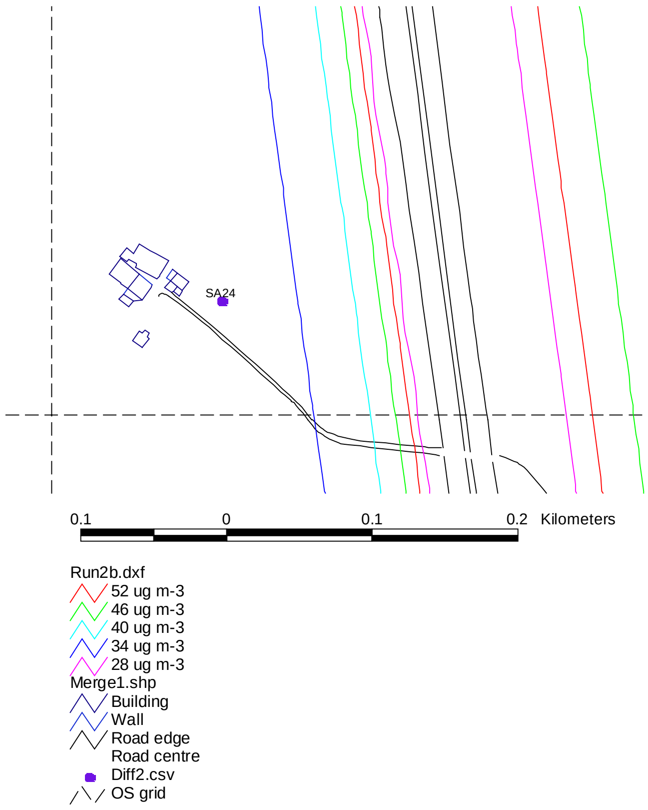

Fig. 5.2: Modelled nitrogen dioxide concentrations, 2005, AQMA No 2, Norrington End Farm

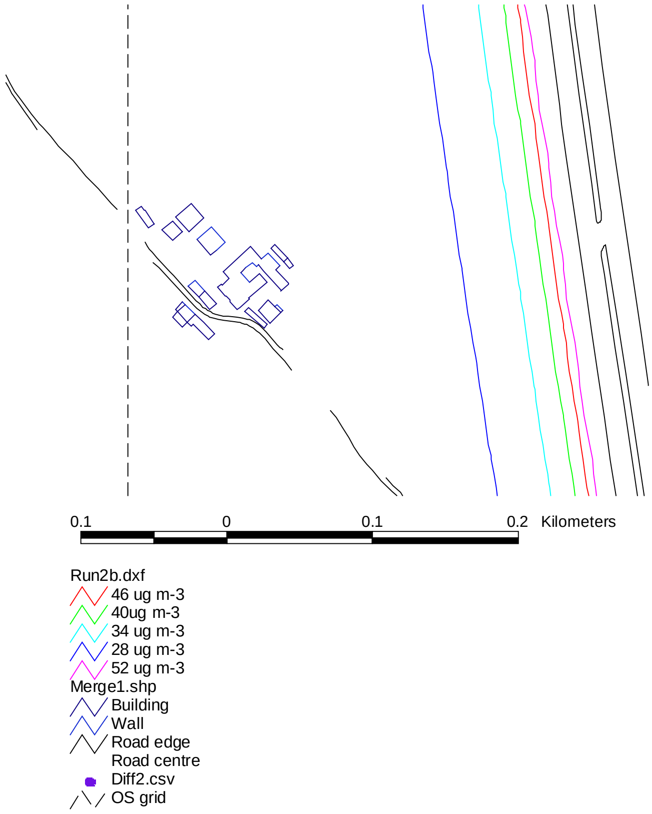

Fig. 5.3: Modelled nitrogen dioxide concentrations, 2005, AQMA No3 , St Agnells farm and St Agnells farm Cottage

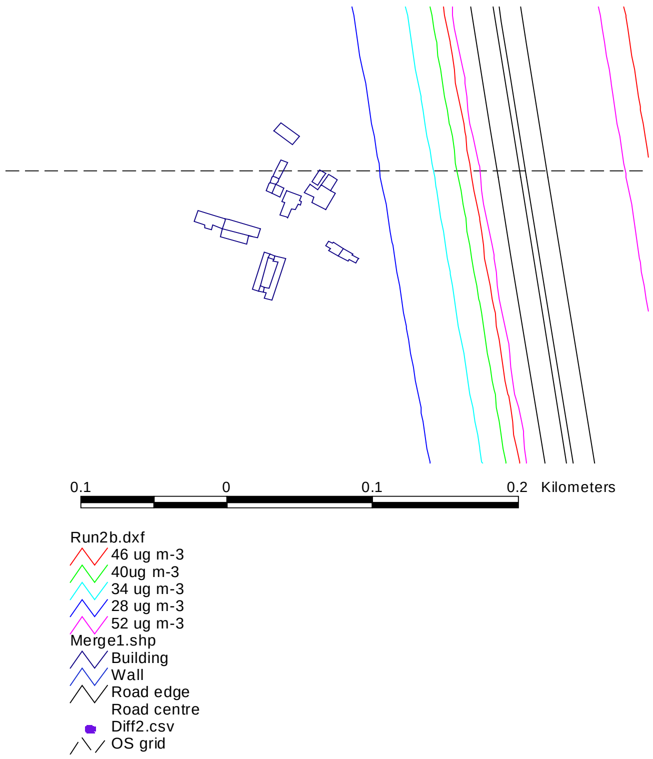

Fig. 5.4: Modelled nitrogen dioxide concentrations,2005, AQMA No 4, Nicholls Farm

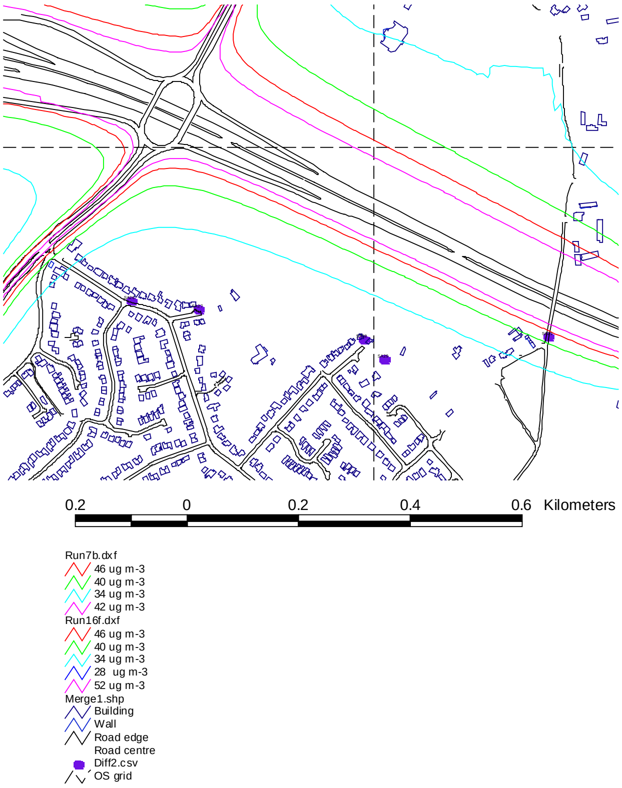

Fig. 5.5: Modelled nitrogen dioxide concentrations, 2005, AQMA No 6, Brickets Wood

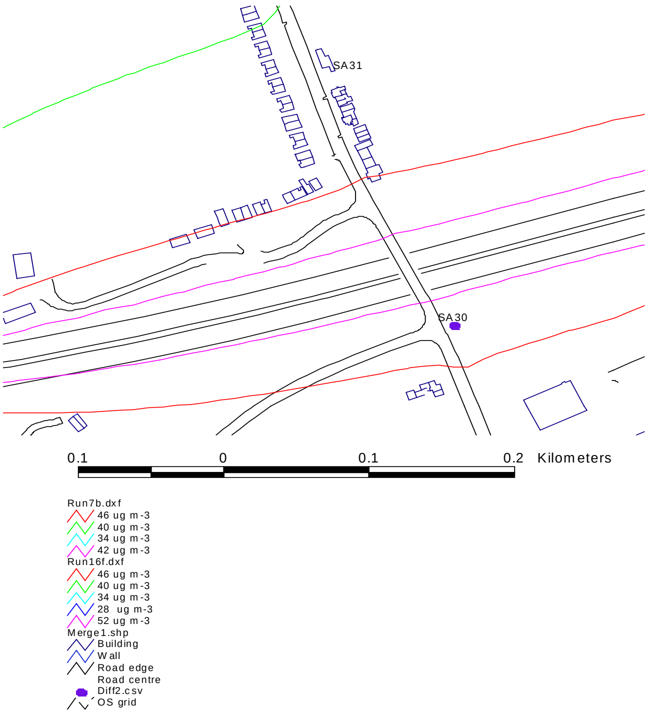

Fig .5.6: Modelled nitrogen dioxide concentrations, 2005. AQMA No 7, Frogmore

5.6.3 Magnitude of exceedence of the air quality objectives – the improvements needed

AQMA No 1 contains residential properties at Searches Farm. Fig. 5.1 shows that nitrogen dioxide concentrations are expected to be markedly less than the 40 $\mu g\ m^{-3}$ objective at these properties. No improvement is needed in AQMA No 1 and so the AQMA should be revoked.

AQMA No 2 contains residential properties at Norrington End Farm. Fig. 5.2 shows that nitrogen dioxide concentrations are expected to be markedly less than the 40 $\mu g\ m^{-3}$ objective at these properties. The modelled predictions are confirmed by the diffusion tube measurements at SA24. No improvement is needed in AQMA No 2 and so the AQMA should be revoked.

AQMA No 3 contains residential properties at St Agnells Farm. Fig. 5.3 shows that nitrogen dioxide concentrations are expected to be markedly less than the 40 $\mu g\ m^{-3}$ objective at these properties. No improvement is needed in AQMA No 3 and so the AQMA should be revoked.

AQMA No 4 contains residential properties at Nicholls Farm. Fig. 5.4 shows that nitrogen dioxide concentrations are expected to be markedly less than the 40 $\mu g\ m^{-3}$ objective at these properties. No improvement is needed in AQMA No 4 and so the AQMA should be revoked.

AQMA No 6 contains residential properties in Brickets Wood close to the M25 and the A405. The closest properties to the roads are at Woodbury Manor and at the junction of Oakwood Road and the A405. Fig. 5.5 shows that nitrogen dioxide concentrations are expected to be less than the 40 $\mu g\ m^{-3}$ objective at these properties. The modelled predictions are confirmed by the diffusion tube measurements at SA21, 26,27, 28 and 29. No improvement is needed in AQMA No 6 and so the AQMA should be revoked.

AQMA No 7 contains residential properties in Frogmore and Colney Street either side of the M25. Modelled predictions show that the objective is unlikely to be met within the designated AQMA. The diffusion tube measurement at SA31 near the outer edge of the AQMA furthest from the M25 also indicates that the area of exceedence is likely to extend as far as the diffusion tube site. Comparison of the diffusion tube measurements with the modelled predictions suggests that the model may overestimate nitrogen dioxide concentrations in the area, possibly because the motorway passes through a cutting at this point. It is therefore recommended that the AQMA No 7 is kept and that the boundaries of the AQMA should remain unchanged. The closest properties to the motorway are along Moore Mill Lane. Concentrations of 47 $\mu g\ m^{-3}$ are predicted for 2005 and so a 7 $\mu g\ m^{-3}$ improvement is required if the 40 $\mu g\ m^{-3}$ objective is to be met.

5.7 SOURCE APPORTIONMENT OF ‘BASE CASE’ PREDICTIONS

Source apportionment is the process whereby the contributions from the 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 source apportionment should:

- Confirm that exceedences of NO_2 are due to road traffic (for St Albans)
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2 within St Albans's AQMA. This will allow traffic management scenarios to be modelled/tested to reduce the exceedences
- Quantify what proportion of the exceedences of NO_2 are 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 exceedence, or, whether national measures would be a suitable approach to achieving the air quality objectives

5.7.1 What is the 'base case'?

The base case in this assessment is defined as the annual mean concentrations of NO_2 that are predicted in the absence of any measures to improve air quality in St Albans. They are the concentrations that should be relevant to defining the current extent of the Air Quality Management Area.

The concentrations in the base case have been calculated using the new traffic emission factors.

Source apportionment is the process whereby the contributions from the 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 source apportionment should:

- Confirm that exceedences of NO_2 are due to road traffic (for St Albans)
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2 within St Albans' AQMAs. This will allow traffic management scenarios to be modelled/tested to reduce the exceedences
- Quantify what proportion of the exceedences 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 exceedence, or, whether national measures would be a suitable approach to achieving the air quality objectives

5.7.2 What is the 'base case'?

The base case in this assessment is defined as the annual mean concentrations of NO_x and NO_2 that are predicted in the absence of any measures to improve air quality in St Albans.

5.7.3 Receptors considered

The most sensitive receptors in AQMA No7 along Moore Mill Lane have been considered.

5.7.4 Sources of pollution considered

We have considered the effect of the following sources in this Stage 4 assessment at the receptor considered:

Background from sources outside the local 1 km x 1 km square
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 multiplying the contribution to oxides of nitrogen concentrations by a factor of 0.16: the same factor has been applied for source apportionment calculations.

The concentrations apportioned to each source category and the fraction of the total concentrations are shown in Table 5.6.

Table 5.6: Source apportionment to concentrations of NO_2 and NO_x

Source category	NO2 concentration, µg m^{-3}		NOx concentration, µg m^{-3}	
	Contribution	Fraction	Contribution	Fraction
Local LDV	2	0.05	15	0.11
Local HDV	6	0.14	40	0.30
Total Local traffic	9	0.19	55	0.41
Background	38	0.81	79	0.59
Total Local traffic	47	1.00	133	1.00

Examination of Table 5.6 shows that the traffic in the 1 km square containing the AQMA makes a significant contribution to the total oxides of nitrogen concentration. The major part of this local contribution comes from heavy duty vehicles on the M25. However, local background levels arising from sources outside the 1 km square are already high so that there is little “headroom” between the background nitrogen dioxide concentration (38 µg m^{-3}) and the objective (40 µg m^{-3}).

The local background is itself made up largely from road transport sources outside the immediate 1 km square. It may be concluded that reduction of the nitrogen dioxide concentration within AQMA no 7 will require the implementation of area-wide strategies to reduce emissions from road transport.

5.8 OPTIONS CONSIDERED TO IMPROVE AIR QUALITY AND THE EFFECTS OF THOSE OPTIONS

5.8.1 The options (Action Plan scenarios) considered

The Government's 10-Year Strategy transport plan - "Transport 2010 - The Ten Year Plan" - was announced on 20 July 2000. It sets out the Governments long-term strategy for delivering a quicker, safer, more reliable and environmentally friendly transport system, setting out what can be achieved over the next ten years. Full details of the plan can be found on the Department of Transport, Local Government and the Regions website – www.dtlr.gov.uk.

Multi-Modal Studies form an important part of the Government's 10-year strategy. Of these, the Orbit study considers the development of a long term strategy for the M25 and the transport corridor around London.

The recommendations from these studies, which may include major transport investment schemes, will be directed to the South East England Regional Assembly (SEERA) for incorporation in the Regional Transport Strategy and the Regional Planning Guidance. In the case of Orbit, the recommendation will also be sent to the Greater London Authority (GLA) and the East of England Local Government Conference (EELGC). The ten year plan for transport gives a clear signal that the Government will implement proposals that come out of multi-modal studies. Key points of the study are:

Study start date:	February 2000
Report date:	Autumn 2002
Study Website:	www.orbitproject.com
Purpose:	To develop a long-term sustainable management strategy for the M25 and transport corridor around London.
What prompted the study	Congestion on the M25 London orbital and adjacent routes with very limited orbital rail alternatives and congested radial rail alternatives.
Results	The final study report was completed in Autumn 2002. Orbit is reporting to three Regional Planning Bodies; South East England Regional Assembly (SEERA), London Mayor and East of England Local Government Conference (EELGC). Orbit is nearing completion and consultation on the strategy is currently underway. The proposals include better ways of managing traffic, reducing the need to travel, new rail schemes and orbital coach services and some motorway widening. Area-wide charging on motorways has been recommended

A general option that would apply to all the scenarios considered is to reduce the general background concentrations (i.e. concentrations over a scale of hundreds of metres) of NO_x. This option would be particularly helpful in St Albans AQMA No.7. However St Albans City and District Council cannot act alone on reducing background concentrations and must rely on regional measures as outlined above.

The following options have been considered in the context of other proposals provided by the 10 year strategy to assess their potential to reduce the nitrogen dioxide concentration at the most sensitive receptors in the St Albans AQMA No 7.

The four options are:

1. A reduction in vehicle speeds to 80 kilometres per hour on the nearest sections of motorway

2. A 20% reduction in car and light goods vehicle traffic on the nearest section of the motorway;

3. A 20 % reduction in all traffic on the nearest section of the motorway.

4. Construction of a tree barrier between the motorway and the residential properties.

5.8.2 Effects of those options on concentrations

Table 5.7 summarises the reductions in nitrogen dioxide that might be possible if the scenarios that have been considered are fully implemented.

The assessment of the impact of the construction of a tree barrier can only be made in a rudimentary way. It has been assumed that a 10 m high tree barrier will increase the initial mixing depth from 15 m for the existing cutting to 25 m for the cutting with tree barrier. It has also been assumed that close to the road, the oxides of nitrogen concentrations are reduced pro rata with initial mixing depth.

Table 5.7: Effects of the scenarios considered on nitrogen dioxide concentrations at properties on Moore Mill Lane.

Scenario	Nitrogen dioxide concentration, $\mu g\ m^{-3}$
Baseline	47
Reduction in speed to 80 kph	46
20% reduction in car and light goods traffic	46
20 % reduction in all traffic	45
Tree barrier	43

None of the options considered will be effective in reducing concentrations to below the objective level at the most sensitive receptors in AQMA No 7. Reducing the vehicle speeds and reducing traffic flows by 20 % will have only small marginal benefits. The greatest benefit appears to arise from allowing a tree barrier to grow between the road and the houses: however, several assumptions have been made in order to make an assessment possible and the prediction should be considered to be speculative.

5.9 SIMPLE ASSESSMENT OF THE FEASIBILITIES OF THE OPTIONS CONSIDERED

This section of the report provides a simple assessment of the feasibility of the options considered to try and reduce or eliminate the chances of exceedences of the air quality objectives for NO_2 in St Albans. It is not intended as a full cost-benefit assessment; DEFRA do not require such as analysis in a Stage 4 assessment.

The feasibility of reducing traffic on the motorway network around London is the subject of regional multi-modal studies. The studies are not yet complete. However, it seems unlikely that reductions in traffic beyond the 20% considered above will be possible. It follows that it is unlikely that achievement of the objective for nitrogen dioxide at the properties closest to the motorways in the St Albans AQMA No 7 by means of realistic traffic reductions alone will be feasible.

It is likely to be several years before a tree barrier would be effective in promoting dispersion. It is unlikely that an effective tree barrier would be in place for the objective year of 2005. The efficacy of a tree barrier is unproven.

6 Implications of this Stage 4 air quality review and assessment for St Albans

This section highlights the implications of this Stage 4 assessment for St Albans.

The section:

- explains any changes that may be needed to the current extent of the current Air Quality Management Area
- and comments on the effects that new national policy developments have had and may have in the future on the predicted air quality in St Albans.

6.1 CHANGES TO THE AIR QUALITY MANAGEMENT AREA AS A RESULT OF THIS STAGE 4 MODELLING

DEFRA have specified that the Stage 4 assessment must comment on any changes that might be necessary to extent of the AQMA as a result of the Stage 4 modelling.

The following table summarises any changes that might be needed.

Table 6.1 Summary of changes to the Air Quality Management Area in St Albans as a result of this Stage 4 assessment

AQMA	Changes recommended to the existing Air Quality Management Areas
No 1	Revoke
No 2	Revoke
No 3	Revoke
No 4	Revoke
No 5	Not in District
No 6	Revoke
No 7	No change recommended

7 The next steps for St Albans

7.1 OBTAINING DEFRA APPROVAL

DEFRA will need to approve this Stage 4 assessment. St Albans should now send a copy of this report to DEFRA. DEFRA will then forward this report to their external assessors who will comment on the work. DEFRA will then forward the critique of the work to St Albans.

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.

7.2 LOCAL CONSULTATION ON THIS STAGE 4 ASSESSMENT

St Albans can ask for feedback from stakeholders who may be interested in the outcome of this Stage 4 air quality review and assessment. Important local stakeholders may include:

External to St Albans

- The Highways Agency (for the M25)
- Adjoining local authorities

Internal

- Local residents in the AQMA
- The traffic department
- The planning department

Efficient ways of disseminating the information include:

- placing the report on the local authority web site
- producing a small poster for display in the local authority offices
- producing a small poster for display in other public places (post offices, libraries etc.)

7.3 IMPLEMENTING THE OPTIONS IDENTIFIED TO IMPROVE AIR QUALITY

If St Albans CDC wishes to seriously consider implementing one or more of the options identified, they should now consider a more detailed cost benefit analysis. This could be completed as part of the Action Plan.

8 References

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DEFRA (2001) The air quality strategy for England, Scotland, Wales and Northern Ireland. A consultation document on proposals for air quality objectives for air quality objectives for particles, benzene, carbon monoxide and polycyclic hydrocarbons. Published by DEFRA in partnership with the Scottish Executive, The National Assembly for Wales and the Department of the Environment for Northern Ireland.

DEFRA (2003) Review and Assessment: Technical Guidance. Part IV of the Environment Act 1995. Local Air Quality Management. LAQM.TG(03) January 2003.

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DETR (1999b) Road Traffic Statistics: 1999. Table 3.3: Traffic distribution by time of day.

DETR (2000) Concentrations of a range of air pollutants in the UK. See http://www.aeat.co.uk/netcen/airqual/index.html

DETR (2000) Review and Assessment: Pollutant Specific Guidance. Part IV of the Environment Act 1995. Local Air Quality Management. LAQM.TG(00) May 2000.

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EA (1998b) Guidance for estimating the air quality impact of stationary sources. Guidance Note 24.

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netcen. Air Quality Review and Assessment Stage 3. Reports for Epping Forest District Council, Erewash District Council, Basingstoke and Deane District Council

NAEI (1998) The National Atmospheric Emissions Inventory for 1998.

Stedman, J.R., Bush, T. and King. K. (1988) An empirical model for estimating roadside nitrogen dioxide concentrations in the UK. AEA Technology Report AEAT-4291.

9 DEFRA compliance checklist

DEFRA Stage 4 requirements compliance checklist
This section has been introduced to indicate where the work expected by DEFRA in a Stage 4 air quality review and assessment can be found in this document. Only nitrogen dioxide is considered in this Stage 4.

Work area	**Included or considered?**	**Location within the report and comments**
Monitoring		
• Has further monitoring been undertaken?	yes	5.4
• Is the 'totality' of the monitoring effort sufficient?		
• Has monitoring confirmed 2005 exceedances?	partially	5.4.6
• Has sufficient detail of QA/QC procedures been provided?	yes	5.4.1
• Has monitoring amended the conclusions of Stage 3?	yes	6.1
Modelling		
• Has further modelling been undertaken?	yes	5.5
• Is the further modelling considered appropriate?		
• Has the model been appropriately validated?	yes	5.5.2, 5.5.3, 5.5.4, Appendix 1
• Has modelling confirmed 2005 exceedances?	For AQMA 7	5.6.1
• Has modelling amended the conclusions of Stage 3?	yes	6.1
General		
• Have both the magnitude and geographical extent of any exceedences been further changed?	yes	6.1
• Has the decision to declare an AQMA been reversed at Stage 4?	Yes, partially	6.1
• Is this decision soundly based?		
• Has the authority taken account of the new vehicle emission factors	yes	4.4
• Has the authority considered source apportionment?	yes	5.7
• Has the authority considered the cost effectiveness of different abatement options?	as far as possible	5.9
• Has the authority considered feasibility and effectiveness of different abatement options?	as far as possible	5.9
• Has the authority considered the extent to which air quality improvement is required?	yes	5.6.3

Work area	Included or considered?	Location within the report and comments
Monitoring & modelling work		
• Have monitoring uncertainties been addressed fully?	yes	5.4.1
• Does the additional monitoring assessment appear sufficiently robust?		
• Have modelling uncertainties been addressed?	yes	Appendix 1
• Has the model been carefully validated?	yes	Appendix 1
• Does the overall modelling assessment appear sufficiently robust?		
AQO exceedances & AQMA declaration		
• Have areas of exceedence been further defined?	no	6.1
• Is the decision to amend or revoke the AQMA(s) at Stage 4, soundly based?		No decision taken yet to amend the AQMA
• Is the decision reached based principally on monitoring?		
• Is the decision reached based principally on modelling?		
General		
• Has the authority focused on areas already identified as predicted to exceed objectives?	yes	5.6
• Has consideration been given to the exposure of individuals in relevant locations?	yes	
• Has the authority considered new national policy developments?	yes	
• Has the authority considered new local developments?	None identified	
• Does the report reach the expected conclusions? (in part/full?)		
• Has the authority undertaken further liaison with other agencies (in particular HA and EA?)	Not yet	

Appendices

CONTENTS

Appendix 1

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 King'ston 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}

$$NO_2 = 0.348.NO_x + 11.48 \ \mu g \ m^{-3}$$

For $NO_x < 23.6$ µg m^{-3}

$$NO_2 = 0.833.NO_x \ \mu g \ m^{-3}$$

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

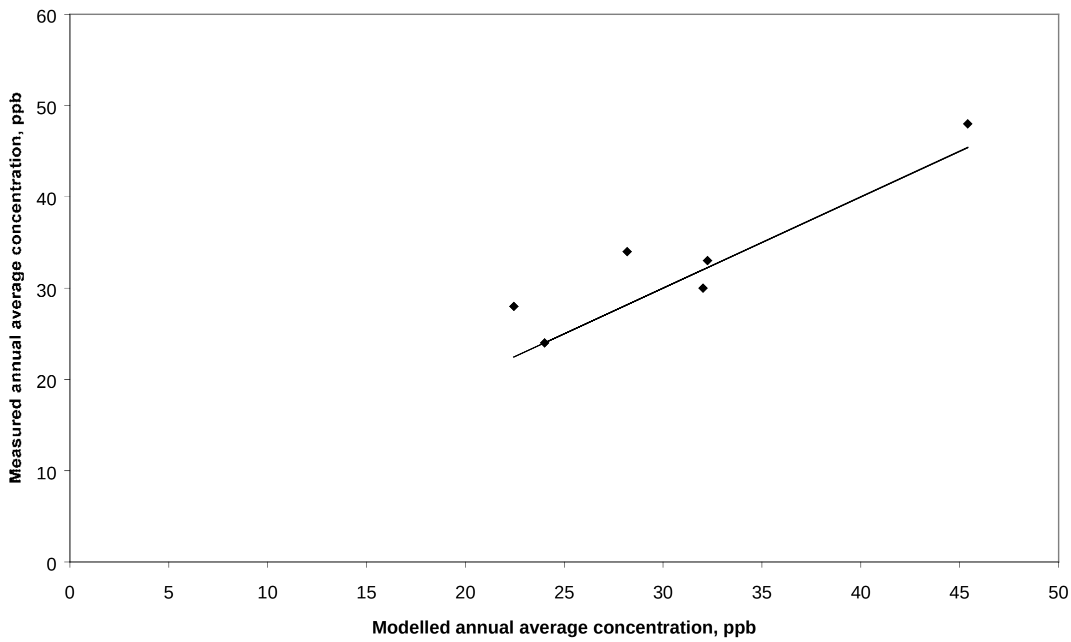

Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

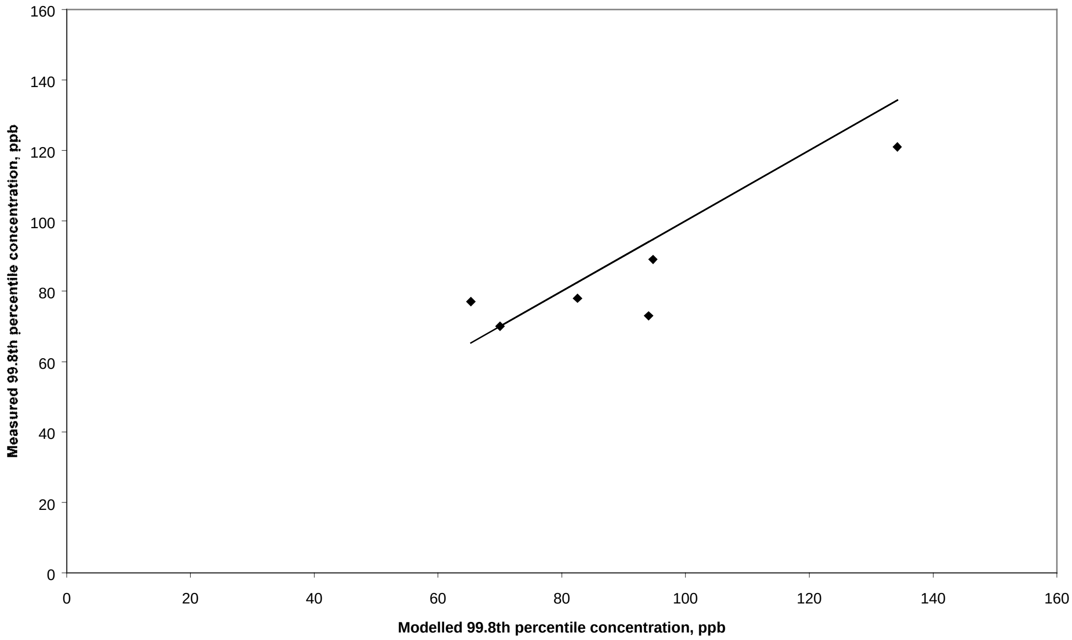

Fig. A3.2 Comparison of modelled and measured 99.8th percentile hourly average nitrogen dioxide concentrations

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 exceedences 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 exceedences of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedences 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 ($\mu g\ m^{-3}$)			
		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	

Appendix 2

Descriptions of selected models and tools

CONTENTS

Simple screening models[4]

Design Manual for Roads and Bridges (DMRB) - This screening method was formulated by the former Department of Transport. The method gives a preliminary indication of air quality near roads, and is more suited to rural motorways and trunk roads than city centre traffic conditions. It is a simple procedure based on tables and nomograms; originally published in August 1994, a revision has been produced in 1999, which is more applicable to urban road situations. The DMRB method requires information on vehicle flow, HGV mix, vehicle speed and receptor-road distances. It contains a useful database of vehicular emission factors for future years.

In the revision of the DMRB method the following pollutants can be estimated:

- the maximum 8-hour mean CO concentration;
- the 98th percentile and the maximum of hourly mean NO2 concentrations;
- the annual average benzene and annual average 1,3 butadiene concentration;
- the annual mean and the fourth highest daily mean PM10 concentrations.

The method adopts the annual mean concentration as the base statistic. Background pollutant levels are included explicitly in the calculations by adding an amount to the annual mean traffic contribution using the Air Quality Archive (paragraph 6.09) or default values. Surrogate statistics are used to convert annual means to National Air Quality Strategy statistics. Details of the road layout cannot be specified.

DI Stack Height Calculations - This screening procedure, based on nomograms, estimates a chimney height which should ensure that ground level concentrations of a pollutant do not exceed a specified standard or guideline for that pollutant for more than about 5 minutes, under weather conditions which are likely to occur 98% of the time. Therefore, the method does not take into account worst-case meteorology. Strictly speaking, this screening method is applicable to only to the smaller processes which come under local authority control i.e. Part B processes and non-combustion sources. The method can be used to check whether a process has a stack of adequate height. The results should be treated with caution in cases of extreme weather condition's, complex topography or complicated configuration of buildings. Heights determined using the method should be regarded as a guide, rather than a accurate definition of the discharge chimney height.

Guidance for Estimating the Air Quality Impact of Stationary Sources (GSS); this guide provides precalculated dispersion results for stack emissions expressed as nomograms, was published by the Environment Agency (EA) in 1998. The nomograms are based on a large number of computations using ADMS. They cover 10 stack heights, 4 categories of surface roughness, 3 averaging times and 3 climate types. The predicted pollutant concentrations are comparable with the prescribed air quality

[4] The on simple screening models has been taken from LAQM.TG3 Review and Assessment: *Selection and use of dispersion models.*

objectives. The model is limited to a range of stack heights and exit velocities, and cannot treat building wake effects or non-buoyant source releases.

More sophisticated dispersion models

ADMS V3.1 (Atmospheric Dispersion Modelling System)

This is a new generation multi-source dispersion model using an up-to-date representation of atmospheric dispersion. Specific features include the ability to treat both wet and dry deposition, building wake effects, complex terrain and coastal influences. ADMS-3 can model releases from point, area, volume and line sources and can predict long-term and short-term concentrations, Urban and rural dispersion co-efficients are included and calculations of percentile concentrations are possible.

DISP A Tool for Calculating Atmospheric Dispersion using a Point-Source Kernel

Overview

A road is defined as a series of straight-line segments {S_i, where i = 1 to n} with length L_i m a uniform width W_i m. The road is assigned an emission rate per unit length E g $m^{-1}s^{-1}$. The emission rate is calculated using the DMRB.

Each segment is then converted to a regularly spaced matrix of $N \times M$ points running parallel and perpendicular to line such that the distance between adjacent points is less than 1 m. Each point has a emission rate of $(L_i \times E) \div (N \times M)$ g s^{-1}.

A 10 m × 10 m grid covering all the roads to be modelled is defined and the emissions all the points within each grid cell are summed to produce a matrix of emissions on a 10 m × 10 m grid. This matrix is used as input to the “disp” tool.

The “disp” tool also takes, as input, the results from the dispersion modelling of a 10 m 10 m × 3 m volume source using ADMS.

The LADS model is used to provide background concentrations.

The contribution from the local sources to the LADS background is calculated by aggregating the 10 m × 10 m grid emissions onto a 1 km × 1 km grid and using these emissions as input to LADS with background NO_x concentrations set to zero. The resulting NO_x concentrations are the contribution from the local sources to the LADS background.

1. Outline Methodology

1.1 DISP relies on the linearity of passive atmospheric dispersion. External to DISP, a complex set of sources, including points, lines and areas is discretised into a set of point sources (with spacing chosen carefully to avoid artefacts of the discretisation, whilst at the same time using as few point sources as possible). The set of point sources is fed as input to DISP.

1.2 DISP also takes as input the annual-average concentration on a polar grid (non-uniform in radius), for a unit point source at the origin of co-ordinates. In addition, a set of receptors is input at which the total concentration resulting from the set of sources is required.

1.3 DISP then proceeds to take each source in turn and calculates its contribution to annual average concentration at each receptor, using interpolation of the dispersion kernel to calculate the concentration at an arbitrary distance and angle from a particular source.

2. Interpolation Method

2.1 In the **radial** direction, a linear interpolation is carried out on log-transformed variables (both concentration and radius). This procedure anticipates that the behaviour will approximate power-law. For ground-level sources, the behaviour is expected to be similar to a power-law behaviour for an individual weather condition, so the actual behaviour is more like a sum over power laws. For an elevated source, similar behaviour is expected beyond the point of maximum concentration on the ground, but not before it. In either case, the accuracy of the log-log interpolation for a given radial spacing has to be determined by inspection (see Section 5).

2.2 In the angular direction, a linear interpolation is used.

2.3 In height, a log-concentration/linear height interpolation is used.

3. The Dispersion Matrix Grid

3.1 The dispersion matrix is generated using ADMS 3, for which the output grid is limited to 32*32 points. The radial co-ordinate needs to cover a wide range – with the minimum set at typically 10 m (in this assessment, set at 10 m) and the maximum at 20 km – so the spacing is chosen to be non-uniform. The radii are defined so that the fractional change (delta-radius divided by mean radius) stays the same. This leads to logarithmically-spaced radii. Radii chosen according to the prescription

$$r_n = r_0 \exp(\alpha n)$$

where r_n is the n th radius, r_0 is the first radius (lowest of interest) and α is a constant. Typically α is around 0.25 for 32 radii and r_0 =10m. Thus only two parameters define the set of radii.

3.2 It would have been preferable to choose the angular spacing to be 10° when sequential meteorological data are used, but only 32 angles are allowed by ADMS 3. In this case, the angular spacing is chosen as 13.3°, given that ADMS chooses to send auxiliary plumes 3.3 degrees on either side of the centreline of an angular sector. This will minimise artefacts in the variation with angle, caused by the choice of a discrete number of plumes to represent the integration over the sector. Alternatively, two runs of ADMS can be done, with 18 angles in each. In this assessment, one run of ADMS was sufficient.

3.3 In height, a logarithmic spacing is again used, except for near the ground, where there is a lower limit on spacing set by the initial vertical sigma. A suggested list of heights is 2.5, 3.5, 5.0, 7.0, 10.0, 14.0, 20.0, 28.0, 40.0, 55.0, 75.0, 100.0, 140.0, 200.0, 280.0, 400.0, 550.0, 750.0, 1000. (all heights in m). This assumes an initial vertical standard deviation of 2.5 m.

4. Code Design

4.1 The code starts by reading in the set of dispersion matrices (corresponding to various heights), taking the logarithm of the concentration magnitudes for the interpolation process later (*being careful about zeroes). It then reads in the receptor coordinates, and writes a header in the log file.

4.2 The code then reads in the number of sources (which it uses to check the integrity of the source file) and starts an 'outer' loop over sources. Point sources are read in and used one at a time (so the code is not dimensioned on the number of sources). For each source, the first task is to calculate a 2-dimensional dispersion matrix (concentration as a function of radius and angle), which is interpolated in height from the dispersion matrices.

4.3 The code then starts an 'inner' loop over receptors, adding a contribution to the concentration counter for each receptor in turn from the current point source. The contribution is worked out by finding the radial distance and angle (on a horizontal plane) from the current point source to the current receptor, bracketting these values by values in the dispersion matrix and carrying out a 2-dimensional interpolation (log-log in radius, lin-lin in angle) to get the contribution per unit emission. The result is then multiplied by the emission strength of the source and the contribution added to the receptor's counter (provided it is not too small).

4.4 After looping over all receptors, another source is read from the source file and the process repeated. After all sources have been read in, the results in the receptor concentration counters are output to a results file (and also samples of the results are output to the log file for checking purposes).

5. Overview of the Test Strategy

5.1 Test 1 checks the reading in of the dispersion matrix, and writing to an output file. The receptors are set to be the precise locations used for the dispersion matrix, and a unit source at the origin is used, so the output should echo exactly the dispersion matrix values.

5.2 Test 2 checks that the interpolation in angle is working properly by introducing a simple dispersion matrix (only one radius, 24 angles, with the concentration increasing linearly with angle); a single source is put at the origin and receptors are placed at the half-angles. The concentrations should come out half way between the values at the bounding angles (since lin-lin interpolation is used).

5.3 Test 3 checks that the interpolation in radius is working properly by introducing a simple dispersion matrix with only two angles (6 radii); the concentrations increase exponentially. Receptors are placed at the mid radii (in log space). The concentrations should be at the mid values (in log space).

5.4 Test 4 checks that the interpolation is height is working properly by introducing an especially simple dispersion matrix with only two levels, which is constant with angle and radius at each level (but a different value at the two levels); the single point source is put at the mid height. the concentrations are set at 1 and e^1, so the mid-point concentration should be $e^{0.5}$.

5.5 Test 5 tests the summing over source magnitudes for a given receptor concentration counter. Uses the same dispersion matrix as Test 4, but introduces 3 point sources at the same location: the concentration result should be 3 times as large.

5.6 Test 6 checks the warnings on height and distance. Uses the same matrix as for Test 4. Sets the source above 3.5 m (the height of the highest level) and sets the last radial receptor beyond the last radius of the matrix.

5.7 Test 7 checks that the source switch that selects which set of data to be used works correctly. A special dispersion matrix with 3 sets of data, each one a uniform matrix but with the three sets having different values. The 3 sources in the source file each select a different set. The summed concentration is checked.

5.8 Test 8 fabricates a line source at 45 degrees to the axes and introduces a dispersion matrix with a cut off to zero beyond a fairly short radius. This should lead to an elongated concentration pattern which falls to zero within a certain distance of the line.

5.9 Tests 9-24 examine the accuracy of the interpolation process with a 'real' dispersion matrix – actually one that mimics the LPAM dispersion model. Tests 9-15 look at radial interpolation for sources at various heights; Tests 16-24 examine height interpolation.

5.10 For Tests 9-15, two matrices are set up, based on the same dispersion process but with radii displaced such that the second matrix has radii at the mid points (in log space) of the radial bands of the first matrix. The receptors are placed at the 'matrix points' of the second matrix, at a selected height, and the concentrations are worked out two ways, once using the first dispersion matrix – which will involve interpolation – and once using the second matrix – with no interpolation. The results are differenced in a spreadsheet and the fractional error examined. This is repeated for a range of heights.

5.11 For Tests 16-24, another two matrices are used, with the second having levels which are at the mid points (linear) of the height bands of the first (but with all radii and angles the same). Again the concentration at a selected height is worked out two ways, once with each matrix (i.e. with and without interpolation), the results differenced in a spreadsheet and the fractional error examined. This is repeated for a range of heights.

Local Area Dispersion System (LADS) model

Background concentrations of oxides of nitrogen were calculated on a 1 km x 1 km grid using results from the dispersion model ADMS 3.1. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 1999 National Atmospheric Emission Inventory disaggregated inventory. Large individual point sources emitting in excess of 15 g/s of nitrogen oxides were excluded from the modelled inventory because they would unreasonably increase the ground level concentrations. Each 1 km x 1 km grid square in the emission inventory was treated as a volume source with height of 10 m to allow for the initial mixing of pollutants. A surface roughness value of 1 m was used to represent surface conditions and is typical of urban areas.

Hourly sequential meteorological data has been used as part of this model.

The model calculated concentrations of oxides of nitrogen: a non-linear relationship derived from monitoring data obtained from the Department of the Environment, Transport and the Regions Automatic Urban Network was used to convert annual average oxides of nitrogen concentrations to annual average nitrogen dioxide concentrations.

The validation of the model is shown in Appendix 3.

DETR’s TEMPRO traffic forecast model

TEMPRO V3.1 was made available by DETR in November 1997. It is based on the 1997 National Road Traffic Forecasts, i.e. the most recent version of the NRTF used for the National Atmospheric Emissions Inventory forecasts.

According to the supporting documentation, TEMPRO is linked to the National Trip End Model forecasts of growth in car traffic and underlying car ownership within specified areas in an average weekday. The trip ends are not constrained by the capacity of the network, but the trip distance does seem to take account of capacity constraints and congestion at district level.

In summary, it seems that TEMPRO is based on a "demand to travel" and car ownership basis on a district level, with actual traffic flow constrained by current road capacity in the area. It is primarily designed as a tool for local planners to use for evaluating land use changes and traffic redistribution schemes.