AEAT/ENV/R/1202

Air Quality Review and Assessment Stage 3 Update - Norwich City Council

A report produced for the City of Norwich

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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.

This report contributes to the stage three air quality review process for the City of Norwich. Issues not fully resolved in the stage 2/3 process have been considered again here in order to aid decision making on designating any Air Quality Management Areas. This report investigates current and potential future pollutant concentrations through an examination of the location and size of principal traffic emission sources, emissions modelling exercises and by reference to monitored air quality data.

Earlier stages identified a risk of exceedance of the PM_{10} objective in 11 streets in the City of Norwich and the possibility of exceedance of the PM_{10}, SO_2 and lead objectives due to industrial sources. It has already been found that there is a risk of exceedance of the NO_2 objective and so the level of this exceedance has been determined and the most appropriate AQMA considered. As part of this report modelling has been undertaken at the appropriate locations, using DMRB and the Environment Agency model GSS.

Modelling suggested that The City of Norwich need to declare an Air Quality Management Area (AQMA) for Nitrogen Dioxide. The extent of the predicted exceedances has been considered based on modelling and traffic growth scenarios. Norwich City Council have considered the likelihood of receptor exposure to exceedances and decided the appropriate locations of AQMAs in the city. Three AQMAs have been proposed, Castle, Grapes Hill and St Augustines.

[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.

Acronyms and definitions

AADT	annual average daily traffic
ADMS	an atmospheric dispersion model
AQDD	Common Position on Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AUN	Automatic Urban Network
CO	Carbon monoxide
D1	HMIP dispersion modelling notes; Technical Guidance Note (Dispersion) D1
d.f.	degrees of freedom
DETR	Department of the Environment Transport and the Regions
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
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. This model allowed contributions of the urban background and road traffic emissions to be calculated
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NETCEN	National Environmental Technology Centre
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient
roadside	1 to 5 m from the kerb
SD	standard deviation
SO_2	Sulphur dioxide
TEMPRO	A piece of software produced by the DETR used to forecast traffic flow increases
UWE AQMRC	University of the West of England Air Quality Management Resource Centre

Contents

1 Introduction

1.1 PURPOSE OF THE STUDY

The City of Norwich completed a First Stage Air Quality Review for the local authority area. The Stage 2 and 3 review and assessments were combined and this document considers further the conclusions of that study. It is already clear that a declaration of an Air Quality Management Area (AQMA) will be made for NO_2 around some of the more heavily trafficked roads in Norwich where exceedances of the objectives are likely. In this reports **netcen** appraises the stage 3 report and draws conclusions for the review and assessment of nitrogen dioxide. This document will also consider whether there is any risk of other exceedances of the objectives and the need for further AQMAs. When fully considered this document will make recommendations for the geographical scope of the AQMA(s). **netcen** an operating division of AEA Technology plc was commissioned by the City of Norwich to add to the existing stage 3 review and assessment process before the move is made to the final stage of this review and assessment cycle.

1.2 GENERAL APPROACH TAKEN

The approach taken in this study was to:

- Collect and interpret additional data to complete the third stage assessment around locations where exceedences were predicted;
- Use monitoring data to assess the ambient concentrations produced by the road traffic and to validate the output of the modelling studies.
- Model the potential pollutant concentration effects of any significant industrial sources in the local and any neighbouring authorities.

1.3 POLLUTANT SPECIFIC GUIDANCE USED IN THIS ASSESSMENT

The Air Quality Strategy (AQS) for the UK contains objectives for pollutants (see Table 2.2). The Pollutant Specific Guidance (LAQM.TG4(00)) has been revised and reissued to match the AQS. This report has been used in this analysis.

1.4 NUMBERING OF FIGURES AND TABLES

The numbering scheme is such that the figures and tables are numbered according to the chapter that they relate to.

1.5 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g/m^3$ (which is consistent with the presentation of the AQS 2000 objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is part of the Third Stage Air Quality review for The City of Norwich. This chapter, Chapter 1 has summarised the need for the work and the approach to completing the study.

Chapter 2 of the report describes the most recent developments in the Air Quality Strategy 2000 (AQS) and presents the latest objectives. In addition, it discusses when implementation of an AQMA is required.

Chapter 3 contains details of the information used to conduct the stage 3 review and assessment for The City of Norwich.

Chapter 4 describes in detail the methods used in this assessment of NO_2. The results of the analysis are displayed in tabular and graphical form.

Chapter 5 describes in detail the methods used in this assessment of PM_{10}. The results of the analysis are displayed in tabular and graphical form.

Chapter 6 describes in detail the methods used in this assessment of SO_2. The results of the analysis are displayed in tabular and graphical form.

Chapter 7 describes in detail the methods used in this assessment of Lead. The results of the analysis are displayed in tabular and graphical form.

Chapter 8 briefly considers other pollutants covered by the objectives.

Chapter 9 concludes the findings of the report.

2 The updated Air Quality Strategy

2.1 THE NEED FOR AN AIR QUALITY STRATEGY

The Government published its proposals for review of the 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 Air Quality Strategy, the Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

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

Recently **provisional new road transport emissions** have been issued. However we have run the DMRB model on the existing emission factors as authorities have been **advised to wait until the next round of review and assessments before using new emission factors (unless the local Authority are undertaking Stage 4 Review and Assessment**. Some initial studies show that the new emission factors will show higher NO_2 concentrations. If these initial studies are correct, the current emission factors could underestimate 2005 NO_2 emissions by between 5% and 10% (UWE AQMRC). If the currently used emission factors are underestimating (which is yet to be concluded) then it is important to bear in mind difference the new emissions factors could make.

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

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

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

- The use of a health effect 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 AQS will provide a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles 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 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.

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 (µg/m^3)	(ppb)	**Averaging period**	**Objective** [number of permitted exceedences a year and equivalent percentile] (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	**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
SO2	266	100	**15 minute** mean	**266** [maximum of 35 exceedences a year or equivalent to the 99.9th percentile]	by 31.12.2005
	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.

2.2.2 Policies in place to allow these objectives 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 which 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. 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 Borough. 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.

2.2.3 Timescales to achieve the objectives

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

2.3 AIR QUALITY REVIEWS

A range of Technical Guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes the Technical Guidance Note LAQM.TG4(98), and the latest version LAQM.TG4(00) August 2000, on 'Review and Assessment: Pollutant Specific Guidance'. This review and assessment has considered the procedures set out in the guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed 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.

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.

Key Points

- The Environment Act 1995 has required the development of an Air Quality Strategy for the control of air quality.
- A central element in the Strategy is the use of air quality standards and associated objectives based on human health effects that have been included in the Air Quality Regulations.
- The Strategy uses a local air quality management approach in addition to existing national and international legislation. It promotes an integrated approach to air quality control by the various actors and agencies involved.
- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2005 (2008 for one lead objective).
- A number of air quality reviews are required in order to assess compliance with air quality objectives. The number of reviews necessary depends on the likelihood of achieving the objectives.

3 Information used to support this assessment

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

3.1 MAPS

The City of Norwich provided detailed maps of the area in OS landline data form. This GIS base map of the area enabled accurate road widths to be determined.

3.2 ROAD TRAFFIC DATA

3.2.1 Average flow, hourly fluctuations in flow, queue length, speed and fraction of HGV's.

The City of Norwich provided traffic count data for the majority of roads. The traffic count data was supplied as Annual Average Daily Traffic (AADT). The road sections of concern were all urban areas with speed limits of 30 mph. Speed data for each individual link was also supplied. An HGV percentage for each of the traffic counts was also supplied

3.2.2 Traffic Growth

Traffic growth will be influenced by redevelopment schemes that are planned at a local level, and planned and enforced at national levels. The potential effects of any development should be considered in the review and assessment process. There were two traffic growth prediction scenarios supplied, a low growth and a high growth scenario, the high growth prediction has been used so that concentration predictions from DMRB will be conservative. This traffic flow forecast had been made using factors from the DETR's TEMPRO traffic flow forecast database which provides regional traffic growth statistics.

3.3 REVIEW AND ASSESSMENT REPORTS

The review and assessment reports to date have been used particularly for the review of nitrogen dioxide where the modelling for traffic has already been completed. The information in the reports has been used to assess the options and decision making process for an AQMA.

3.4 AMBIENT MONITORING

Where available monitoring data has been used for the different pollutants and is detailed in the relevant chapters.

4 Review and Assessment for Nitrogen Dioxide

4.1 INTRODUCTION

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

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

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

4.2 STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

In June 1998, the Common Position on Air Quality Daughter Directives (AQDD) agreed at Environment Council set 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 $\mu g/m^3$ (105 ppb) as an hourly average with a maximum of 18 exceedences in a year.**

The 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, 1999; 2000) includes 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.

4.3 THE NATIONAL PERSPECTIVE

The main source of NO_x in the United Kingdom is road transport, which, in 1996 accounted for approximately 47% of the emissions of 2.1 million tonnes per year as NO_2. Power generation contributed 22% and domestic sources 4% of the remainder. In urban areas, the proportion of local emissions due to road transport sources is larger.

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

4.4 MODELLING RESULTS

The modelling phase for NO_2 has already been completed in the review assessment process and so is not remodelled here. Instead the implications of the modelling results have been considered and recommendations for subsequent AQMAs will be made.

4.5 RECOMMENDATIONS

The previous modelling predicts that it is likely that exceedence of the annual average objective for NO_2 will occur at a number of the locations assessed. Predicted concentrations of nitrogen dioxide have been presented as plots extending over the areas of concern. The plots allow an assessment of the likelihood of meeting the air quality objectives to be made at each location. Recommendation is given to consider declaration of air quality management area in locations where there is more than a 50 % chance of exceeding the objective.

The Government has decided that the objective should apply in the non-occupational outdoor locations where a person might reasonably be expected to be exposed (e.g. in the vicinity of housing, schools or hospitals etc) over the averaging time of the objective. Consideration should therefore be given to possible patterns of personal exposure and the potential for non-occupational exposure in assessing the risk to human health in using these results to declare an Air Quality Management Area.

It is concluded here that the modelling already performed in the stage 3 review and assessment process is overestimating nitrogen dioxide concentrations. There are two reasons for this:

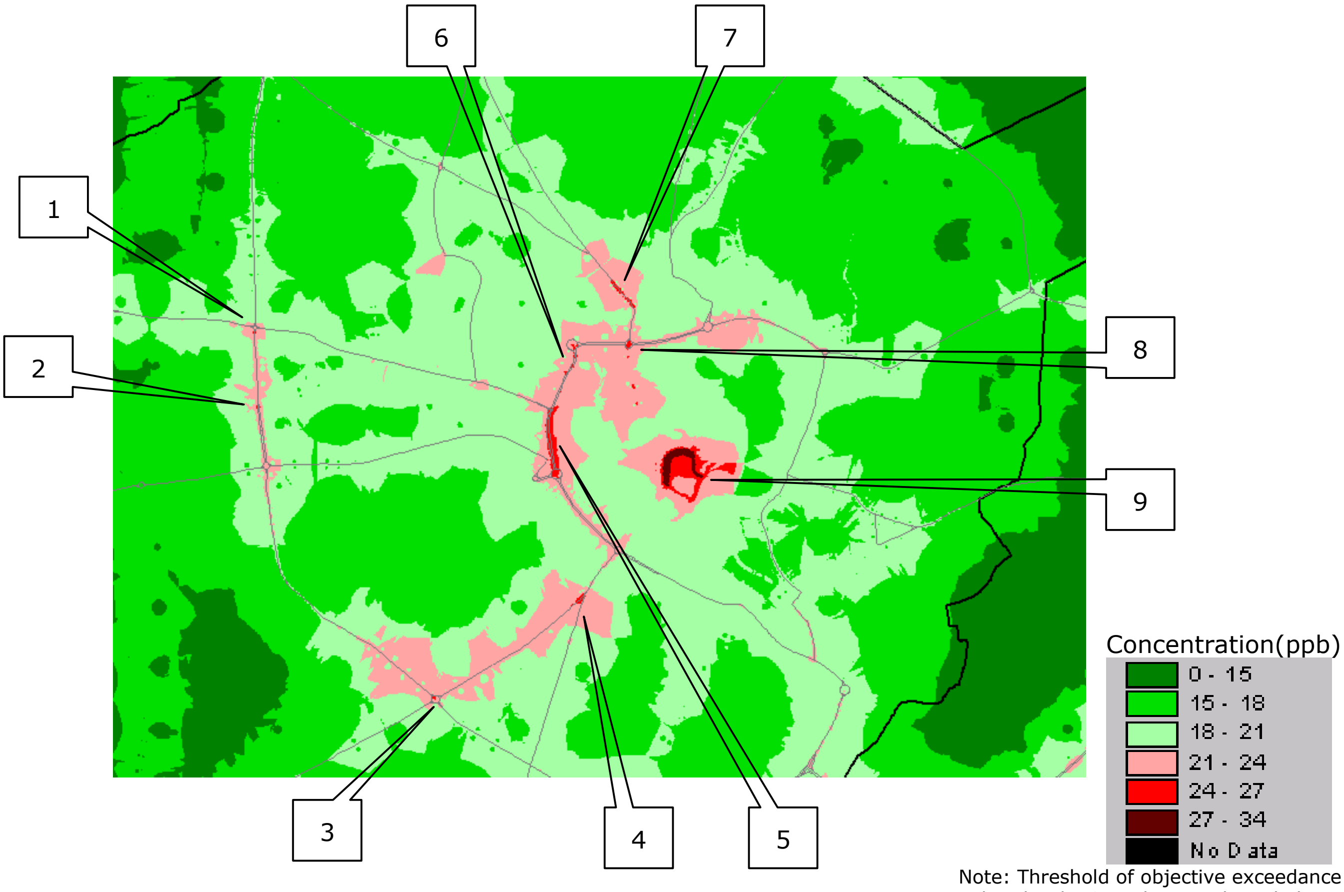
Diffusion tube bias:
There has been no adjustment of the diffusion tubes to take into account the bias as per UK governmental guidelines. The diffusion tubes have been identified as over-reading by 15% and so this needs to be applied.

Model Bias:
There has also been no correction for model bias. Again this is recommended in UK governmental guidance. Despite looking at the diffusion tube data, use was not made of the comparison to the continuous monitor site data. It is clear from figure 9 (Chatterton 2001) that model validation, focusing on sites appropriately modelled and close to roadside locations , results in an over-read of approximately 2%

When the model bias and the diffusion tube bias are combined an over-read of approximately 17% is apparent. Therefore the 40$\mu g/m^3$ objective would thus equate to an unadjusted model result of 47$\mu g/m^3$. Therefore the area exceeding the objective has been exaggerated.
In order to ensure an appropriate AQMA is declared bearing this analysis in mind, **netcen** have provided assistance to Norwich City council by discussing the likelihood of receptor exposure to exceedances and the appropriate location of the AQMA boundary.
As a result of much careful consideration Norwich City Council have decided that a low traffic growth scenario is the most appropriate. Using this scenario it can be seen from the plotted concentration predictions, even when over-estimations have been taken into account, that there are still areas predicted to exceed the objective. An exceedance is considered to be any area that is greater than 24ppb (46$\mu g/m^3$). This is because the plots (Chatterton, 2001) are exaggerated as a result of there being no diffusion tube bias and model bias adjustment.

Using the Low traffic growth scenario and a correction for model and diffusion tube biases, there are 9 locations in Norwich where NO_2 concentration is predicted to exceed the objectives.

Figure 4.5, Areas predicted to exceed the 2005 NO_2 objective within Norwich City Council



Note: Threshold of objective exceedance considered to be 24 ppb as explained above

Two of the exceedance areas are do not intercept with any properties, areas 4 and 6. Therefore there are 7 remaining areas with receptors and predicted exceedances of the NO_2 objective. These are:

Area 1: A140 Guardian Road/ A1074 Dereham Road Junction
Area 2: A140 Guardian Road/B1108 Earlham Rd Junction
Area 3: A11 Newmarket Road/A140 Mile End Road Junction
Area 5: A147 Barn Rd/A147 Chapel Field Road
Area 7: St Augustine's Street
Area 8: St Crispins Rd/ St Augustine's Street Junction
Area 9: Area surrounding Norwich Castle (inc. Castle Meadow, Cattle market)

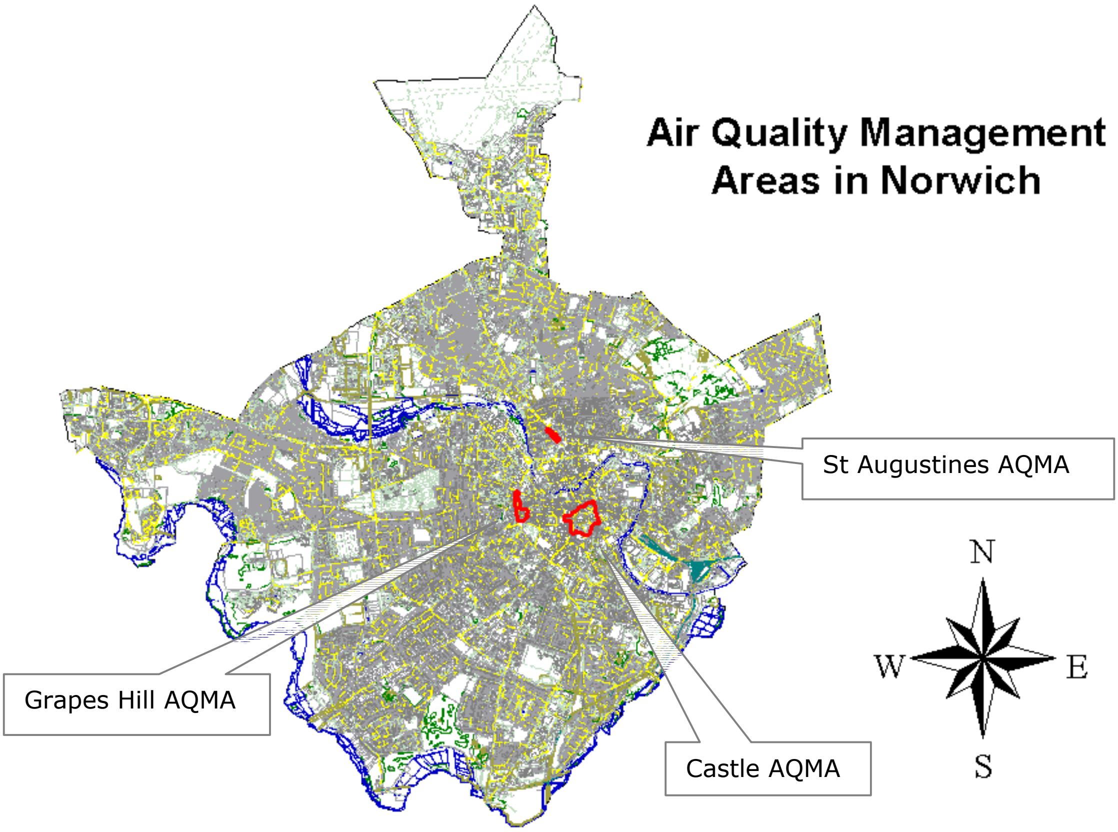
It is therefore recommended that Norwich City Council declare and Air Quality Management Area(s) for the above locations.

4.6 CONCLUSIONS FOR NO_2 CONCENTRATIONS IN THE CITY OF NORWICH

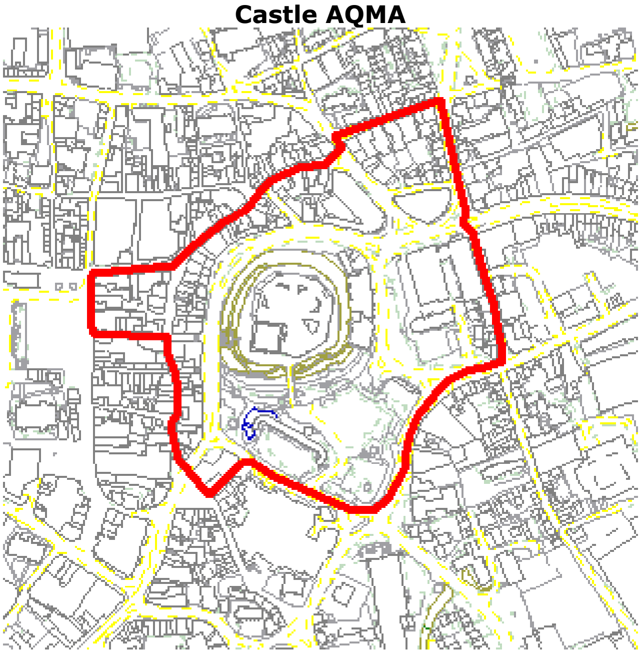
It is recommended that Norwich City Council consider an Air Quality Management Area(s) for the locations predicted to exceed the NO_2 objective where there are relevant receptors.

4.7 NO_2 AIR QUALITY MANAGEMENT AREAS IN NORWICH

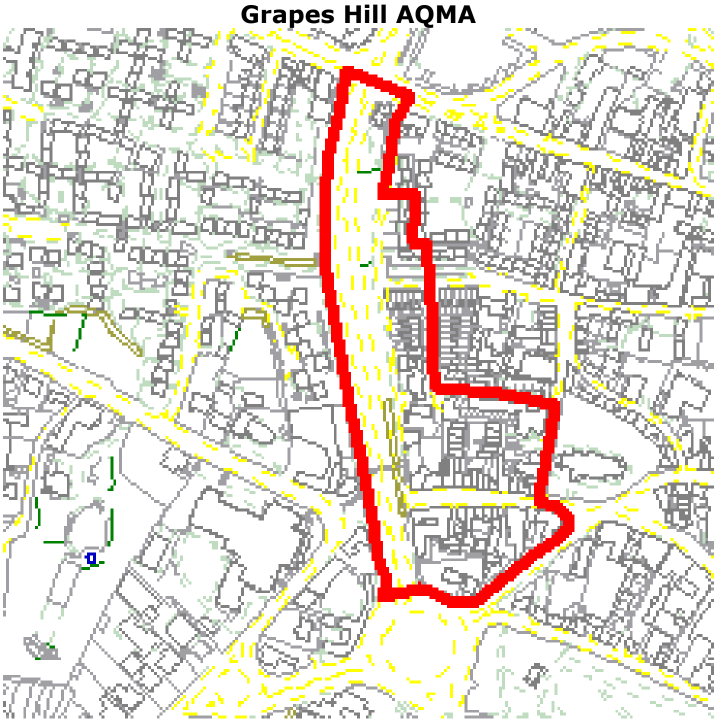
Norwich City Council found there to be no relevant receptors within areas 1,2,3,4,6, or 8 (figure 4.5). Therefore there remained only 3 areas that were predicted to have exceedances of the objective at a relevant location.
Having given much consideration to the traffic growth scenarios used in the modelling and the location of relevant receptors and also the conclusions of this report Norwich City Council have decided to declare 3 Air Quality Management Areas for Nitrogen Dioxide. These are to be based on the predicted exceedances at areas; 5,7 and 9 (figure 4.5). The locations and extent of the AQMAs have been given much consideration by Norwich City Council and are displayed on the following diagrams.


Air Quality Management
Areas in Norwich
St Augustines AQMA
N
W
E
S
Grapes Hill AQMA
Castle AQMA

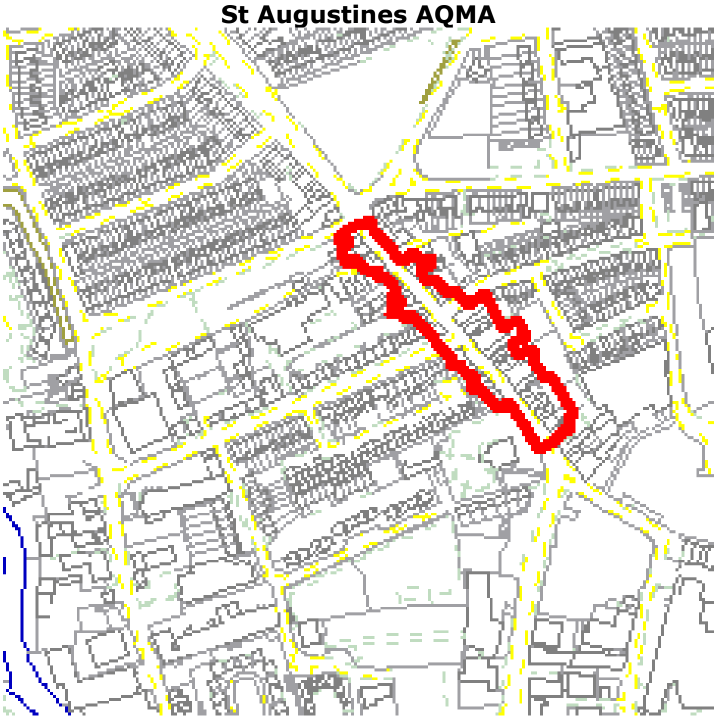
Castle AQMA



Grapes Hill AQMA



St Augustines AQMA



5 Review and assessment for PM_{10}

5.1 INTRODUCTION

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. Particles are often classed as either primary (those emitted directly into the atmosphere) or secondary (those formed or modified in the atmosphere from condensation and growth). PM_{10} particles (the fraction of particulates in air of very small size, <10μm aerodynamic diameter) can potentially pose significant health risks as they are small enough to penetrate deep into the lungs. Larger particles are not readily inhaled.

A major source of fine primary particles is combustion processes, in particular diesel combustion, where transport of hot exhaust vapour into a cooler tailpipe or stack can lead to spontaneous nucleation of "carbon" particles before emission. Secondary particles are typically formed when low volatility products are generated in the atmosphere, for example the oxidation of sulphur dioxide to sulphuric acid. The atmospheric lifetime of particulate matter is strongly related to particle size, but may be as long as 10 days for particles of about 1μm in diameter.

Concern about the potential health impacts of PM_{10} has increased very rapidly over recent years. Increasingly, attention has been turning towards monitoring the smaller particle fraction, $PM_{2.5}$, which is capable of penetrating deepest into the lungs, or to even smaller size fractions or total particle numbers.

5.1.1 Standards and objectives for particulate matter

The Air Quality Strategy objectives to be achieved by 31st December 2004 are:

- An annual average concentration of 40 $\mu g\ m^{-3}$ (gravimetric);
- A maximum 24-hourly mean concentration of 50 $\mu g\ m^{-3}$ (gravimetric) not to be exceeded more than 35 times a year.

5.2 THE NATIONAL PERSPECTIVE

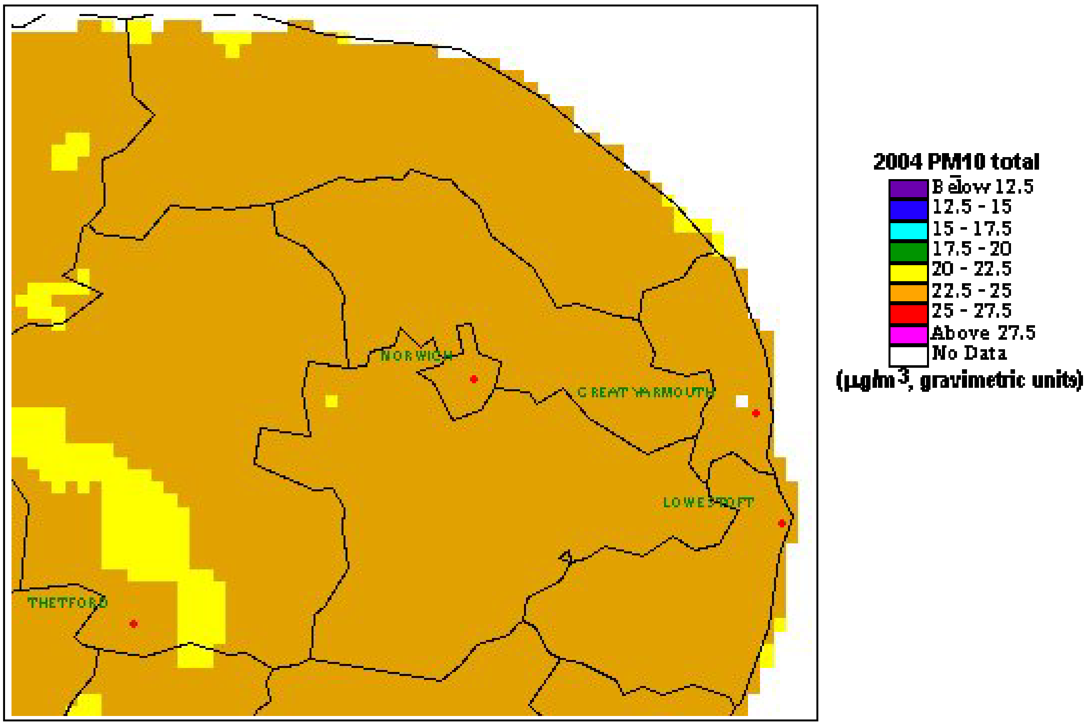
National UK emissions of primary PM_{10} have been estimated as totalling 213,000 tonnes in 1996. Of this total, around 24% was derived from road transport sources, 38% from industrial sources, 16% from power stations and 17% from domestic and other low-power combustion. It should be noted that, in general, the emissions estimates for PM_{10} are less accurate than those for the other pollutants with prescribed objectives, especially for sources other than road transport.

The Government established the Airborne Particles Expert Group (APEG) to advise on sources of PM_{10} in the UK and current and future ambient concentrations. Their conclusions were published in January 1999 (APEG, 1999). APEG concluded that a significant proportion of the current annual average PM_{10} is due to the secondary formation of particulate sulphates and nitrates, resulting from the oxidation of sulphur and nitrogen oxides. These are regional scale pollutants and the annual concentrations do not vary greatly over a scale of tens of kilometres. There are also natural or semi-natural sources such as wind-blown dust and sea salt particles. The impact of local urban sources is superimposed on this regional background. Such local sources are generally responsible for winter episodes of hourly mean concentrations of PM_{10} above 100 $\mu g/m^3$ associated with poor dispersion. However, it is clear that many of the sources of PM_{10} are outside the control of individual local authorities and the estimation of future concentrations of PM_{10} are in part dependent on predictions of the secondary particle component.

5.3 BACKGROUND CONCENTRATIONS OF PM_{10}

Estimates of background concentrations of PM_{10} were obtained for the Norwich City Council area using the maps on the UK National Air Quality Information Archive web site http://www.aeat.co.uk/netcen/airqual/home.html. Figure 5.3 shows that the estimated annual average background concentration for 2004 in Norwich was in the range 22.5-25 μg/m^3.

Figure 5.3: Background PM_{10} concentrations 2004 (μg/m^3)



5.4 MONITORING DATA

Location of the continuous monitor
PM_{10} concentrations are measured in Norwich centre by a Tapered Element Oscillating Microbalance (TEOM) as a part of the DEFRA automatic monitoring network.
The monitoring station is located within a central Norwich public garden (OS Grid Reference: TG230089). The nearest road is located approximately 12 metres away at St George's Street although traffic flow is free flowing and very light. The surrounding area is generally open and comprises of residential and light industrial premises. It is an Urban Centre Site, which is defined as 'Non-kerbside site located in an area representative of typical population exposure in town or city centre areas e.g. pedestrian precincts and shopping areas'.

Measurement technique and QA/QC
The TEOM method is widely used throughout the United Kingdom for the measurement of PM_{10} concentrations and is the method used in DEFRA automatic monitoring networks. It differs from the European gravimetric transfer reference method specified in the revised objectives. The DEFRA are currently undertaking detailed intercomparisons between the TEOM analyser and the European gravimetric transfer reference sampler in order to develop a robust relationship between the two methods. Pending the results of these investigations, DEFRA Pollutant Specific Guidance recommends that TEOM data can be used with a reasonable degree of confidence provided that the TEOM measurements are multiplied by a factor of 1.3. The factor of 1.3 has been used as appropriate in this review. In order to distinguish between concentrations measured by TEOM and gravimetric methods, concentrations are reported as μg m^{-3} (TEOM) or μg m^{-3} (gravimetric).

It is possible to obtain a 2004 background PM_{10} annual mean from the maps on the UK National Air Quality Information Archive web site but there are uncertainties associated with these maps and so where possible PSG advises the use of monitored data instead.
Predictions for background PM_{10} in 2004 were made following the procedure in Box 8.5 of PSG. The calculation is shown in figure 5.4.

Figure 5.4: Step by Step process for calculating PM_{10} annual mean for 2004 from monitored data (from Box 8.5 PSG).

Select Annual Mean concentrations for the latest full year: PM_{10} (monitored, $year_n$)

Annual Mean concentration for 2001($_n$) monitored at Norwich Centre (TEOM) = 15.12

A Multiply annual mean by 1.3 to correct for TEOM:
15.12 x 1.3 = **19.66**

B Obtain 1996 secondary PM_{10} concentrations for the local area from internet map: PM_{10} (secondary 1996)
= **14.1**

C Adjust secondary PM_{10} to $year_n$ using factors in Table 8.2: PM_{10} (secondary, $year_n$) = PM_{10} (secondary, 1996) x factor (f)
= B x f
= 14.1 x 0.893
= **12.59**

E Calculate Local Primary PM_{10} for $year_n$:
PM_{10} (primary, $year_n$) = PM_{10} (measured, $year_n$) – PM_{10} (secondary, $year_n$) – PM_{10} (coarse).
(Assume PM_{10} coarse = 10.5μg/m^3)
= A – C - 10.5
= 19.66 - 12.59 - 10.5
= **-3.43**

F Adjust local primary PM_{10} for $year_n$ to 2004 using factors in Table 8.3
PM_{10} (primary, 2004) = PM_{10} (primary $year_n$) x factor
= E x f
= -3.43 x 0.9
= **-3.09**

G Obtain Secondary PM_{10} for 2004 from secondary PM_{10} for 1996 using factors in table 8.2
PM_{10} (secondary, 2004) = PM_{10} (secondary, 1996) x Factor
= B x f
= 14.1 x 0.829
= **11.69**

H Calculate Total PM_{10} for 2004
PM_{10} (total, 2004) = PM_{10} (primary, 2004) + PM_{10} (secondary, 2004) + PM_{10} (coarse)
(Assume PM_{10} coarse = 10.5 μg/m^3)
= F+G+10.5
= -3.09+11.69+10.5
= **19.10**

This figure of 19 $\mu g/m^3$ is lower than that of the Air Quality Archive Maps (which suggest a maximum 24.6 in the area and an average 23.4 across the Local Authority). Measured data are preferable and so a conservative estimate of 20 $\mu g/m^3$ has been taken to represent the 2004 PM_{10}.

Table 5.4a: Summary Statistics from Norwich Centre continuous PM_{10} monitor for 2001

	Concentration, $\mu g/m^3$
Annual Average	15
Maximum daily average	39
90th %ile daily	35
Data capture	95.5%

The 90th percentile daily average concentration (equivalent to 35 exceedences per year) recorded was 2.29 times the average value over the monitoring period. Analysis of data from monitoring stations throughout the UK 1992-97 indicates that 90th percentile daily average concentration is typically 1.68 times the annual average value (DETR, 1999). It is concluded that the concentration distribution at this site is typical of that at other UK sites.

The 90th percentile concentration is 35 $\mu g/m^3$ gravimetric which is less than the objective value of 50 $\mu g/m^3$. It is concluded that it is likely that the objective would be met at this monitoring site.

The annual average concentration is 15 $\mu g/m^3$ gravimetric. This value is less than the annual average objective value of 40 $\mu g/m^3$. It is concluded that it is likely that the objective would be met at this monitoring site.

Table 4.3a shows a summary of the gravimetric results from the monitoring site compared to the objective levels. The 24 hour objective is not exceeded at the monitoring site.

Table 5.4b Summary of the Results from the Norwich Centre Monitoring Site compared to the Objective Levels

Percentile	Norwich City Centre ($\mu g/m^3$)	Objective level ($\mu g/m^3$)
90th ile 24-hour mean	35	50
Annual mean	15	40

5.5 IMPACT OF ROAD TRAFFIC ON PM_{10}

5.5.1 Prediction for 2004

As recommended in TG4(00), DMRB has been used to predict PM_{10} concentrations for 2004 from road traffic .The estimated background concentration for 2004 of 20 $\mu g/m^3$ has been used to provide total predicted PM_{10} concentrations. Estimated traffic flows for 2004 have been supplied by Norwich City Council, the predictions were made using the DETR's TEMPRO database and the higher prediction of the two scenarios it produces (low growth or high growth) has been used as a conservative estimate.

Guidance TG4(00) states that the 24-hour objective is highly unlikely to be exceeded if the annual mean concentration is below 28 $\mu g/m^3$, gravimetric.

Table 5.5 shows the 2004 predictions that may be compared against the objectives. For 2004, the method predicts annual average concentrations of PM_{10} less than 28$\mu g/m^3$ at all of the locations modelled. Therefore no exceedances of the PM_{10} objective are predicted.

Table 5.5: Predicted PM_{10} concentrations at kerbside locations in the ABC region.

Link Ref	Link	Distance to centre of road (from receptor) (m)	distance to kerbside (from receptor) (m)	Annual Average Vehicle Flow (veh/hr)	% HDV	Average Speed (km/hr)	Background PM10 (µg/m3) 2004	PM10 Annual mean (µg/m3) 2004
A	Dereham Rd / Norwich Rd	22.7	15.5	1595	8.4	35.0	20	**23.1**
D	Bracondale	12.5	6.7	1103	2.8	32.5	20	**21.8**
E	King St / Carrow Hill	4.5	1.4	1507	6.1	32.5	20	**24.0**
H	Bishops Bridge Rd	7.7	3.2	978	4.0	32.5	20	**21.8**
J	St Augustines	4.3	1.9	962	3.9	26.0	20	**22.4**
L	Cromer Rd / Heather Avenue	4.3	1.9	998	7.6	35.0	20	**23.0**
N	Boundary Rd / City View Rd	7.8	3.0	1366	11.9	35.0	20	**24.2**
O	Sweetbriar / Hellesdon Hall Rd	31.5	26.5	1046	9.6	35.0	20	**21.7**
P	Barn Rd / St Crispins	10.0	1.9	1832	4.1	35.0	20	**23.3**
R	ChapelField Rd	9.6	2.1	1476	3.4	35.0	20	**22.5**
T	St Stephens Rd	8.8	4.9	1596	3.8	28.0	20	**23.1**

5.6 IMPACT OF INDUSTRY ON PM_{10}

There are three Part B processes in the Norwich City area identified in the Stage one Review and Assessment that might have the potential to impact on PM_{10} concentrations in the area. These are:

- Anglia Lead Ltd
- LC Jay and Son Ltd
- Lefarge Redland Aggregates Ltd

The background for the sites has been calculated for 2004 from the monitoring data and has been estimated at 20 $\mu g/m^3$. This background concentration will be used as the background for all the 3 sites.

5.6.1 LC Jay and Son Ltd

LC Jay and Son Ltd have monitored stack emissions of PM_{10} and found it to be not more than 5 $\mu g/m^3$. The ambient concentration will decrease from this value as the plume disperses away from the stack. Using this value therefore will give a very conservative estimate. When combined with the background concentration the maximum concentration that will be caused by the plume is:

Background contribution		+	Plume contribution	
=	20 $\mu g/m^3$	+	5 $\mu g/m^3$	= **<u>25 $\mu g/m^3$</u>**

This concentration of 25 $\mu g/m^3$ is well below the annual mean objective of 40 $\mu g/m^3$ and is also a conservative estimate. Therefore we can be confident that this source will not cause an exceedance of the PM_{10} objective.

5.6.2 Anglia Lead Ltd

Anglia Lead Ltd have monitored stack emissions of PM_{10} and found it to be 1.8 $\mu g/m^3$. The ambient concentrations will decrease from this value as the plume disperses away from the stack. Using this value therefore will give a very conservative estimate. When combined with the background concentration the maximum concentration that will be caused by the plume is:

Background contribution		+	Plume contribution	
=	20 $\mu g/m^3$	+	1.8 $\mu g/m^3$	= **<u>21.8 $\mu g/m^3$</u>**

This concentration of 21.8 $\mu g/m^3$ is well below the annual mean objective of 40 $\mu g/m^3$ and is also a conservative estimate. Therefore we can be confident that this source will not cause an exceedance of the PM_{10} objective.

5.6.3 Lefarge Redland Aggregates Ltd

Emissions monitoring data were not available for Lefarge Redland Aggregates Ltd and therefore concentrations of PM_{10} were predicted using the screening model "Guidance for Estimating the Air Quality Impact of Stationary Sources" (GSS) as recommended in PSG. This model requires annual total emissions, stack heights, plume content and plume efflux velocity. This information was obtained from Norwich City Council. GSS is based on conservative assumptions and will tend to overpredict concentrations.
PSG advises that if the total predicted 90^{th} percentile concentration exceeds 50$\mu g/m^3$ the authority should undertake further review and assessment.
GSS predicted the 90^{th} percentile in 2004 would be **45.3 $\mu g/m^3$**.

Therefore there is no need for further assessment of this site, as it is unlikely to cause an exceedance of the PM_{10} objective.

5.7 CONCLUSIONS FOR PM10 CONCENTRATIONS IN THE CITY OF NORWICH

There are no predicted exceedances of the objective either by traffic or industrial sources. Therefore there is no need for further review and assessment of this pollutant.

6 Review and Assessment of Sulphur Dioxide

6.1 INTRODUCTION

Sulphur dioxide is a corrosive acid gas, which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry depositions have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses. SO_2 in ambient air is also associated with asthma and chronic bronchitis.

The principal source of this gas is power stations burning fossil fuels, which contain sulphur. Episodes of high concentrations of SO_2 now only tend to occur in cities in which coal is still widely used for domestic heating, in industry and in power stations. As some power stations are now located away from urban areas, SO_2 emissions may affect air quality in both rural and urban areas. Since the decline in domestic coal burning in cities and in power stations overall, SO_2 emissions have diminished steadily and, in most European countries, they are no longer considered to pose a significant threat to health.

6.1.1 Standards and objectives for sulphur dioxide

Two new objectives have been introduced for SO_2 in the AQS based on the limit values in the Air Quality Daughter Directive, and the three objectives are:

- 266 $\mu g\ m^{-3}$ as a 15 minute mean (maximum of 35 exceedences a year or equivalent to the 99.9th percentile) to be achieved by the 31st December 2005
- 350 $\mu g\ m^{-3}$ as a 1 hour mean (maximum of 24 exceedences a year or equivalent to the 99.7th percentile) to be achieved by the 31st December 2004
- 125 $\mu g\ m^{-3}$ as a 24 hour mean (maximum of 3 exceedences a year or equivalent to the 99th percentile) to be achieved by the 31st December 2004

The 15-minute mean objective is the most stringent; the other two objectives will not be exceeded if this objective is not exceeded.

6.1.2 The National Perspective

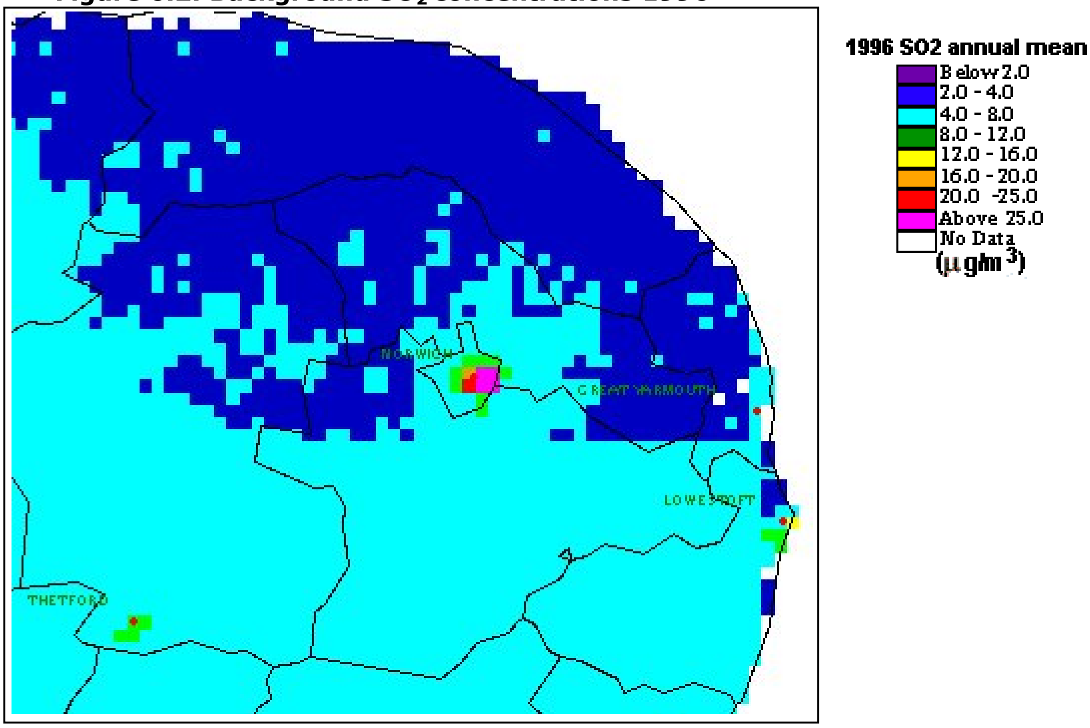
Sulphur dioxide is emitted in the combustion of coal and oil. Emissions today are dominated by fossil-fuelled power stations which in 1997 accounted for 62% of the national total emission. Emissions from road transport are a very small fraction of the national total: 2%.

Exceedences of the 15-minute air quality standard currently occur near industrial processes for which the stack heights were designed to meet previous air quality standards and downwind of large combustion plant such as power stations. Exceedences are also possible in areas where significant quantities of coal are used for space heating. These large combustion plant are currently regulated under BATNEEC and the EPA 1990, and will come under the provisions of the IPPC. The government considers that bearing in mind the envisaged change in fuel use, it does not expect exceedences of the 15-minute objective by 2005 from these sources. Sulphur dioxide concentrations are elevated at the kerbside but not sufficiently to exceed the air quality standard in the absence of other sources.

6.2 BACKGROUND CONCENTRATIONS OF SULPHUR DIOXIDE

Estimates of background concentrations of Sulphur Dioxide were obtained for the Norwich City area using the maps on the UK National Air Quality Information Archive web site http://www.aeat.co.uk/netcen/airqual/home.html. Figure 6.2 shows the most recent estimates available, for 1996. The maximum estimated annual average concentration for 1996 in the Norwich City area was 35.1 $\mu g/m^3$ and average 11.6 $\mu g\ m^{-3}$ across the Authority. Guidance TG4(00) assumes that the annual mean at the end of 2004 and 2005 will be half the 1996 annual mean. Here we are using the maximum value as a worst case scenario thus the estimated annual mean background concentration in the Norwich City area in 2004 will be no more than 17.6 $\mu g\ m^{-3}$. For each individual source assessment the value at the nearest grid reference will be used.

Figure 6.2: Background SO_2 concentrations 1996



6.3 MONITORING OF SULPHUR DIOXIDE

There is automatic monitoring of sulphur dioxide in Norwich City. The monitoring station is located within a central Norwich public garden (OS Grid Reference: TG230089). The nearest road is located approximately 12 metres away at St George's Street although traffic flow is free flowing and very light. The surrounding area is generally open and comprises of residential and light industrial premises. It is an Urban Centre Site, which is defined as 'Non-kerbside sites located in an area representative of typical population exposure in town or city centre areas e.g. pedestrian precincts and shopping areas'. Monitoring results obtained from the Air Quality Archive (http://www.airquality.co.uk/archive/index.php) for 2001 are shown below in table 6.3.

Table 6.3: Monitored SO_2 concentrations ($\mu g/m^3$) in Norwich Centre, 2001

SO2 15 minute average	4.9
SO2 Hourly annual average	5.1

6.4 IMPACT OF INDUSTRY ON CONCENTRATIONS OF SULPHUR DIOXIDE

There is one site that has been identified as a potentially significant source of SO_2 and it is likely to be in existence in 2005:

- Lefarge Redland Associates

Therefore Lefarge Redland Associates has been assessed using GSS (Guidance for Estimating the Air Quality Impact of Stationary Sources) as advised by pollutant specific guidance. To be applicable to the GSS model the sources must have:
- Stacks between 20metres and 200metres tall
- Stack exit velocities between 10m/s and 25 m/s
- Releasing buoyant plumes, i.e. temperature slightly above or greater than ambient.

As Lefarge Redland Associates fits this criteria it can be entered into GSS. The 15 minute objective is the most stringent of the sulphur dioxide objectives and so if this objective is predicted to be met it can be assumed that the other objectives, the hourly and the 24 hourly, will be met. GSS predicts15-minute and hourly objective relationships based on conservative assumptions and will tend to overpredict concentrations.

6.4.1 Lefarge Redland Associates

A background SO_2 concentration was taken from the netcen maps for the specific grid reference location (624439,307189) and halved to predict forward from 1996 to 2004/2005 as advised in PSG. This gave a background contribution of 3.75 $\mu g/m^3$ (this contribution is multiplied by two when estimating the total 15 min mean contribution).

GSS predicted that for Lefarge Redland Associates the air quality impact of the stack for the 2005 15 minute objective (inclusive of background SO2) would be 201.8 $\mu g/m^3$. The objective for the 15 minute mean is 266 $\mu g/m^3$. Therefore GSS predicts that this source will not cause an exceedance of the 15 minute mean Sulphur dioxide objective, the most stringent of the 3 SO_2 objectives.

It is concluded then that this site does not need to be investigated further.

6.5 CONCLUSIONS FOR SULPHUR DIOXIDE CONCENTRATIONS IN THE CITY OF NORWICH

There were no sources predicted to cause exceedances of sulphur dioxide in the region. It is therefore concluded that there is no need to proceed to a Stage 3 Review and Assessment.

7 Review and assessment of Lead

7.1 BACKGROUND CONCENTRATIONS OF LEAD

The background for Lead is no longer mapped on the **netcen** website as the background concentration is considered to be 0 $\mu g/m^3$ now as a result of reductions in lead sources.

7.2 IMPACT OF INDUSTRY ON CONCENTRATIONS OF LEAD

There are two sites that have been identified as potentially significant sources of lead and are likely to be in existence in 2005:

- LC Jay and Son Ltd
- Anglia Lead Ltd

7.2.1 LC Jay and Son Ltd

LC Jay and Son Ltd have monitored stack emissions of Lead and found it to emit 0.2 $\mu g/m^3$. The ambient concentration will decrease from this value as the plume disperses away from the stack. Using this value therefore will give an overestimate.
This is well below the annual mean objective of 0.5 $\mu g/m^3$ in 2004 and below the 0.25 $\mu g/m^3$ objective in 2008, therefore we can be confident that this source will not cause an exceedance of the lead objective.

7.2.2 Anglia Lead Ltd

Anglia Lead Ltd has monitored stack emissions of lead and found concentrations of 0.4 $\mu g/m^3$. This is the measurement actually at the stack which will decrease significantly as the plume disperses away from the stack.
This is below the annual mean objective of 0.5 $\mu g/m^3$ in 2004. However this is above the objective of 0.25 $\mu g/m^3$ in 2008. In order to determine if an exceedance of the 2008 objective is likely at a relevant receptor the nomograms in the Pollutant Specific Guidance (LAQM.TG.4(00)) have been used. To use these nomograms the temporal emission has been calculated (see table 7.3)

Table 7.3: Anglia Lead Emissions of Lead calculation

3.142	π
0.4	$\mu g/m^3$
8	stack flow rate (m/s)
0.76	Stack diameter (m)
0.38	Stack radius (m)
0.4537048	Stack cross-sectional area (m)
3.6296384	flow m^3/sec
1.45185536	μg/sec lead emission
1.45186E-06	g/sec lead emission
4.57857E-05	tonnes/annum lead Emission

The annual emission from this process plant of lead is 45 grams/annum, which is below the limits of range on the guidance nomogram. It is therefore unlikely that an exceedance of the 2008 objective will occur.

7.3 CONCLUSIONS FOR LEAD CONCENTRATIONS IN THE CITY OF NORWICH

There is no need to carry out any further review and assessment of the industrial processes studied here as it is very unlikely that either of them could cause an exceedance of the Lead objectives in 2004.

8 Other pollutants

8.1 BENZENE

The main sources of benzene in the United Kingdom are petrol-engine vehicle exhaust, petrol refining, distribution and uncontrolled emissions from petrol station forecourts without vapour recovery systems. Measurements at UK national network monitoring sites are already below the 2003 objective, even close to heavily trafficked roads. The increasing numbers of vehicles equipped with three way catalysts will significantly reduce emissions of benzene in future years. Recently agreed additional reductions in vehicle emissions as part of the Auto-Oil programme are expected to further reduce emissions of benzene from vehicle exhausts, and proposals to control emissions from petrol station forecourts during vehicle refuelling are expected to lead to significant reductions in uncontrolled emissions. These existing and proposed measures are expected to deliver the revised air quality objective by the end of 2003, and no further measures are thought to be needed (DETR, 2000).

Only those authorities with major industrial processes in the near vicinity which handle, store or emit benzene are expected to be at risk of exceeding the objective for benzene. There were no major industrial processes which either handled, stored or emitted benzene, which had the potential, in conjunction with other sources, to result in elevated concentrations of benzene in relevant locations in the Norwich area. Therefore, it is likely that national policies will deliver the prescribed air quality objective for benzene by the end of 2005.

8.2 1,3 BUTADIENE

The main source of 1,3 butadiene in the United Kingdom is from motor vehicle exhausts. 1,3-butadiene is also an important industrial chemical and is handled in bulk at a small number of industrial premises. Measurements at UK national network monitoring sites are already well below the 2003 objective at all urban background/centre and roadside locations. The increasing numbers of vehicles equipped with three way catalysts will significantly reduce emissions of 1,3-butadiene in future years. Recently agreed additional reductions in vehicle emissions as part of the Auto-Oil programme are expected to further reduce emissions of 1,3-butadiene from vehicle exhausts. These measures are expected to deliver the revised air quality objective by the end of 2003, and no further measures are thought to be needed (DETR, 1999).

Only those authorities with major industrial processes in the near vicinity which handle, store or emit 1,3-butadiene are expected to be at risk of exceeding the revised objective. There are no major industrial processes which either handle, store or emit 1,3-butadiene, which have the potential, in conjunction with other sources, to result in elevated concentrations of 1,3-butadiene in relevant locations in the Norwich area. Therefore, it is likely that national policies will deliver the prescribed air quality objective for 1,3 butadiene by the end of 2005.

8.3 CARBON MONOXIDE

The main source of carbon monoxide in the United Kingdom is currently road transport, in particular petrol-engine vehicles. The contribution from major roads to carbon monoxide concentrations was assessed in the Stage 1 Review: exceedence of the objective for 2005 was considered unlikely. Recently agreed reductions in vehicle emissions as part of the

Auto-Oil programme are expected to deliver the revised air quality objective by the end of 2003, even at roadside locations, and no further measures are considered necessary (DETR, 1999).

The Stage 1 Review did not identify any significant industrial sources of carbon monoxide in the City or nearby.

9 Conclusions

NO_2 concentrations In the City of Norwich

Modelling has predicted that there could be an exceedance of the nitrogen dioxide objectives as a result of traffic sources. Declaration of an AQMA(s) was recommended. Norwich City Council have considered the likelihood of receptor exposure to exceedances based on the modelling and decided the appropriate locations of AQMAs in the city. Three AQMAs have been proposed, Castle, Grapes Hill and St Augustines.

PM_{10} concentrations In the City of Norwich

There are no predicted exceedances of the PM_{10} objective either by traffic or industrial sources. Therefore there is no need for further review and assessment of this pollutant.

SO_2 concentrations In the City of Norwich

There are no sources predicted exceedances of the SO_2 objective by industrial sources. Therefore there is no need for further review and assessment of this pollutant.

Lead concentrations In the City of Norwich

There are no sources predicted exceedances of the lead objective by industrial sources. Therefore there is no need for further review and assessment of this pollutant.

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