Air Quality Review and Assessment

A report for Castlereagh Borough Council

July 2004

Executive Summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality. The NI Environment Order came into operation in January 2003 and implements both the European Air Framework Directive 96/62EC and the UK Air Quality Strategy. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality objectives.

Under the Air Quality Strategy all Local Authorities are required to undertake an air quality review. In areas where air quality objectives are not anticipated to be met by the specified date, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

Local Air Quality Management Policy Guidance (LAQM.PGNI (03)) is designed to help relevant authorities with their Local Air Quality Management (LAQM) duties under Part III of the Environment (NI) Order 2002. The Environment (NI) Order 2002 provides the framework for LAQM across Northern Ireland. The Air Quality Objectives set out in the Air Quality Regulations (NI) 2003 provide the statutory basis for the system of LAQM.

This report forms the Stage 3 Air Quality Review for road emissions and domestic fuel combustion by Castlereagh Borough Council. This report investigates current and potential future PM_{10} and NO_2 levels due road emissions at two major links/roads and PM_{10} and SO_2 levels due to domestic fuel combustion emissions in one 5 km^2 grid. This assessment has been undertaken by means of modelling and monitoring.

netcen's LADSUrban model has been used to assessed road traffic emissions while **netcen**'s DISP model has been used to assessed domestic fuel combustion emissions. Ambient air quality data was obtained from two automatic monitoring stations located in Castlereagh: Espie Way (Suburban - PM_{10} and SO_2) and Lough View Drive (Roadside – PM_{10} and NO_2).

The conclusions of the report are:

Nitrogen Dioxide (NO_2)

The modelling shows that levels of NO_2 are likely to be below the annual mean objective for 2005 at relevant receptors at the assessed major links/roads. Therefore, an Air Quality Management Area (AMQA) should not be declared on NO_2.

Particulate Matter (PM_{10} gravimetric)

The modelling shows that an exceedence of the PM_{10} annual mean objective for 2004 is unlikely at relevant receptors on the assessed major links/roads. The daily mean objective will not be exceeded. Therefore, an *Air Quality Management Area (AMQA) should not be declared* on PM_{10}.

Sulphur dioxide (SO_2)

The detailed modelling has shown that SO_2 emissions arising from domestic fuel combustion in Castlereagh Borough Council are not predicted to cause an exceedence of the air quality objectives. Therefore, an *Air Quality Management Area (AMQA) should not be declared* on SO_2.

Acronyms and definitions

AADTF	Annual Average Daily Traffic Flow
ADMS	atmospheric dispersion modelling system
AQDD	Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
BC	Borough Council
defra	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions (now defra)
DoE NI	Department of Environment Northern Ireland
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
GIS	Geographical Information System
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
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
ppb	parts per billion
r	the correlation coefficient
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
$\mu g\ m^{-3}$	micrograms per cubic meter

Contents

1 Introduction

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality. The NI Environment Order came into operation in January 2003 and implements both the European Air Framework Directive 96/62EC and the UK Air Quality Strategy. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality objectives.

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1.1 PURPOSE OF THE STUDY

The assessment investigates whether emissions from roads and domestic fuel combustion are likely to contribute to exceedences of the UK Air Quality Objectives for NO_2, PM_{10} and SO_2. This study:

- Assesses the air quality in 2004 and 2005 (PM_{10} and NO_2 respectively) in Castlereagh BC due to road emissions,
- Assesses the air quality in 2004 and 2005 (PM_{10} and SO_2) in Castlereagh BC due to domestic fuel combustion and
- Identifies any actions that are likely to be required by Castlereagh BC under the Environment (NI) Order 2002.

1.2 FINDINGS FROM THE FIRST STAGE REVIEW

Castlereagh Borough Council agreed in the absence of statute to assess air quality by 30 June 2000. The commitment to this air quality review was agreed on 13 January 1999 at a meeting to discuss local quality air assessment by attending Committee members of Castlereagh Borough Council and subsequently approved by Council.

The first stage review involves the assessment of eight pre-determined pollutants:

- Benzene; 1.3-Butadiene;
- Carbon Monoxide; Lead;
- Nitrogen Dioxide; PM_{10} (Particulates)
- Sulphur Dioxide; Ozone.

1.2.1 <u>Conclusion for Castlereagh First Stage Review and Assessment</u>

In Castlereagh, the first stage review and assessment has found that the air quality objectives for 3 of the 7 specified parameters namely benzene, 1,3-butadiene and lead are all likely to be achieved by 2003-2005. However, the possibility of carbon monoxide, nitrogen dioxide, PM_{10} and sulphur dioxide meeting the approved standards by the target dates is unlikely and therefore Castlereagh will require to progress to a second stage review and assessment for these pollutants namely carbon monoxide, nitrogen dioxide, PM_{10} and sulphur dioxide.

1.2.2 Recommendations

- It is recommended that a second stage review and assessment be undertaken for carbon monoxide, nitrogen dioxide, PM_{10} and sulphur dioxide.

- It is recommended that the current air quality monitoring work in Castlereagh be continually reviewed, monitored and updated with the introduction of new monitoring sites to enable Castlereagh Borough Council Environmental Health Department to assess the air quality and to enable the above pollutants to meet future standards. This will provide data to indicate compliance with the objectives and will be useful in the next review and assessment to be undertaken between 2003-2005.

1.3 GENERAL APPROACH TAKEN

The approach taken in this report is summarised below. The assessment of both road emissions and domestic fuel combustion has been carried out in a similar manner. However these are covered separately. The general approach taken to assess road emissions has been to:

- Collect traffic information for the two junctions/roads to be assessed;
- Compile emission inventories for the links;
- Use monitoring data to assess the ambient concentrations produced by road emissions and to verify the output of the modelling study;
- Model the concentrations of PM_{10} and NO_2 on each link including local background concentration using **netcen**'s LADSUrban model;
- Present the predicted concentrations as contour plots, directly comparable to the relevant objectives, overlaid onto a map of local housing;
- Comment on the uncertainty in the predicted concentrations.

The general approach taken in this Stage 3 Assessment for domestic fuel combustion has been to:

- Collate fuel use survey data for Castlereagh BC;
- Compile emission inventory for each surveyed house;
- Compile emission inventory for the whole area;
- Use monitoring data to assess the ambient concentrations produced by domestic fuel combustion and to verify the output of the modelling study;
- Model the concentrations of PM_{10} and SO_2 in the selected area including local background concentration using **netcen**'s DISP model;
- Present the concentrations as contour plots, directly comparable to the relevant objectives, overlaid onto a map of local housing;
- Comment on the uncertainty in the predicted concentrations.

1.4 VERSION OF THE LAQM TECHNICAL GUIDANCE USED IN THIS ASSESSMENT

In preparing this report the latest version of the Government Guidance has been used LAQM.TG(03) in conjunction with the previous 'Pollutant Specific Guidance' (2000).

1.5 NUMBERING OF FIGURES AND TABLES

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

1.6 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g\ m^{-3}$ and the PM_{10} levels are gravimetric equivalent (which is consistent with the presentation of the AQS objectives), unless otherwise noted.

1.7 STRUCTURE OF THE REPORT

This document is the completion of the Stage 3 review and assessment for road emissions and domestic fuel combustion for Castlereagh Borough Council. 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 UK's Air Quality Strategy (AQS).

Chapter 3 contains details of the information used to conduct this review and assessment for Castlereagh Borough Council.

Chapter 4 gives a description of the pollutants assessed in this report (PM_{10}, SO_2 and NO_2).

Chapter 5 covers the Stage 3 Assessment of road emissions including the results of the modelling

Chapter 6 describes the Stage 3 Assessment on domestic fuel combustion including the results of the modelling

Chapter 7 summarises the finding of this report.

Chapter 8 concludes the finding of this report and makes recommendations.

2 The Updated Air Quality Strategy

2.1 THE NEED FOR AN AIR QUALITY STRATEGY

After agreement, in June 1998 at the European Union Environment Council, of a Common Position on the First Air Quality Daughter Directive (AQDD), the UK government published its proposals for review of the National Air Quality Strategy. Subsequent to this review, the Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in January 2000.

The Environment Order (NI) 2002 came into operation in January 2003 and implements both the European Air Framework Directive 96/62/EC, Daughter Directives and the UK Air Quality Strategy.

The Environment Order (NI) 2002 provides the framework for LAs to review air quality in Northern Ireland and for implementation of any AQMAs. It is issued by the Department of the Environment in Northern Ireland under Article 16 of the Environment (NI) Order 2002. Under the Order, all Councils and other relevant authorities are required to have regard to published guidance when carrying out any of their duties under, or by virtue of, Part III of the order. The published guidance is outlined in Table 2.1 below.

Table 2.1 Environment Order (NI) 2002 Key Guidance:

- The statutory background and the legislative framework within which relevant authorities have to work
- The principles behind reviews and assessments of air quality up to 2010 and the recommended steps that relevant authorities should take
- The timetable for reviews and assessments up to 2010
- How councils should handle the designation of AQMAs
- How relevant authorities should handle the drawing up and implementation of action plans
- Recommendations and suggestions on taking forward the development of local and regional air quality strategies
- Suggestions of how relevant authorities should consult and liase with others
- Local transport measures which Roads Service might wish to consider
- The general principles behind air quality and land use planning; and
- How enforcing authorities should use powers of entry under Article 19 of the Order

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

The UK Government intention is that the AQS provides a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles which include:

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

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

2.2.1 Air Quality Strategy

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

Table 2.2. Objectives included in the Air Quality Regulations (NI) 2003 for the purpose of Local Air Quality Management.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 μgm^{-3}	Running annual mean	31.12.2003
	3.25 μgm^{-3}	Running annual mean	31.12.2010
1,3 Butadiene	2.25 μgm^{-3}	Running annual mean	31.12.2003
Carbon Monoxide	10.0 mgm^{-3}	Maximum daily running 8-hour mean	31.12.2003
Lead	0.5 μgm^{-3}	Annual mean	31.12.2004
	0.25 μgm^{-3}	Annual mean	31.12.2008
Nitrogen Dioxide[1]	200 μgm^{-3} not to be exceeded more than 18 times a year	1 hour mean	31.12.2005
	40 μgm^{-3}	annual mean	31.12.2005
Particles (PM_{10})[2] **Gravimetric**[3]	50 μgm^{-3} not to be exceeded more than 35 times a year	24 hour mean	31.12.2004
	40 μgm^{-3}	annual mean	31.12.2004
Sulphur Dioxide	350 μgm^{-3} not to be exceeded more than 24 times per year	1 hour mean	31.12.2004
	125 μgm^{-3} not to be exceeded more than 3 times per year	24 hour mean	31.12.2004
	266 μgm^{-3} not to be exceeded more than 35 times per year	15 minute mean	31.12.2005

Notes
1. The objectives for nitrogen dioxide are provisional.
2. Likely to be new particles objective for 2010, not in regulation at present, expected after the review of the EU's first Air Quality Daughter Directive (2005)
3. Measured using the European Gravimetric reference standard or equivalent.

2.2.2 Relationship between the UK 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 four EU ambient air quality directives that the UK has transposed into 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).

- **2002/03/EC** Directive of the European Parliament and the Council of 12 Feb 2002 relating to ozone in ambient air (the third Daughter Directive).

The first, second and third daughter directives contain air quality Limit Values for the pollutants that are listed in the framework directive. The United Kingdom must comply as a minimum with these Limit Values. The UK Air Quality Strategy must comply with the limit values set out in the EU Air Quality Daughter Directives but the UK Air Quality Strategy also includes stricter objectives for some pollutants, for example, sulphur dioxide.

The UK 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 the relevant EU Directives.

2.2.3 Policies in place to allow these objectives to be achieved

The policy framework to allow these objectives to be achieved is one 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 2010. 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 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 station emissions will result in ambient concentrations that meet the air quality standards set out in the AQS.

Northern Ireland now has in place the Air Quality Regulation (NI) 2002. The Government has recognised the problems associated with achieving the AQS standard for ozone, 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. For this reason Ozone is specifically excluded from the LAQM regime.

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.

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 area. 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.

2.2.4 Timescales to achieve the objectives

Objectives are to be met within the timescales shown in Table 2.2. Note: the objectives for NO_2 remain provisional.

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 LAQM.TG(03), and the previous version LAQM.TG4(00) May 2000, on 'Review and Assessment: Pollutant Specific Guidance'. This review and assessment has considered the procedures set out in these guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet 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.

At present Councils in Northern Ireland are engaged in the 3 staged approach to review and assessment as set out in the original technical guidance. The Stages are briefly described in Table 2.3. The latest technical guidance LAQM.TG(03) is based on a revised '2 step' approach. The revised steps are briefly described in Table 2.4. In this process a Stage 1 equates to an 'updating and Screening assessment, and a stage 2 and 3 equates to a 'detailed assessment'.

The department recommends that councils should use the latest technical guidance LAQM.TG(03) to complete their first rounds of review and assessment. Where councils have commenced using the old technical guidance (LAQM. TG (00)) they may continue using the old guidance. However the methodology should be cross-referenced with the new guidance.

The latest technical guidance LAQM.TG (03) has been used as the guidance document for both the road emissions and domestic fuel combustion modelling methodology. Road emissions have been modelled at a resolution of 10m while the domestic at 25m. This is consistent with recommendations within the latest technical guidance.

Table 2.3 Brief details of Stages in the Air Quality Review and Assessment process (LAQM.TG4(00))

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 first 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 2.4 Brief details of Steps in the revised Air Quality Review and Assessment process (LAQM.TG(03))

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

2.4 LOCATIONS THAT THE REVIEW AND ASSESSMENT MUST CONCENTRATE ON

For the purpose of review and assessment, the authority should focus on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 2.5 summarises the locations where the objectives should and should not apply.

Table 2.5 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 2.5 (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, locations should represent non-occupational exposure.

AQS Key Points

- The Environment (Northern Ireland) Order 2002 has implemented 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 factors and agencies involved.

- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2010.

- A number of air quality reviews are required in order to assess compliance with air quality objectives. The detail necessary depends on the likelihood of achieving the objectives

3 Information and tools used to support this assessment

This chapter presents the information and tools used to support the review and assessment of road emissions and domestic fuel combustion.

3.1 ROAD TRAFFIC DATA

Castlereagh BC provided information necessary for the road emissions modelling. The following data was provided:

- GIS shape files containing the road links details,
- Traffic information for the roads/links including AADT, Percentage HGV flows and average road link speeds (projected for 2004/2005) and
- Traffic information for the surrounding links.

3.2 FUEL COMBUSTION DATA

Castlereagh BC provided information necessary domestic fuel combustion modelling. The following data was provided:

- Fuel Use Survey 2002 (including type of fuel, consumption, XY variables etc.),
- Average cost of different fuel types from local suppliers,
- GIS shape files with and
- COMPASS data file for Castlereagh BC which contains information for all the houses across the Borough.

3.3 EMISSION FACTORS

Emissions factors for road and household emissions where obtained from the NAEI website (www.naei.org.uk). Vehicle emissions factors have recently been revised by defra[1]. The most recent emission factors have been used in this Stage 3.

3.4 BACKGROUND AIR QUALITY DATA

Background concentration of oxides of nitrogen (NOx), nitrogen dioxide (NO_2), particulates (PM_{10}) and sulphur dioxide (SO_2) have been taken from the Local Air Quality Management section in the UK Air Quality Archive (http://www.airquality.co.uk/archive/laqm/laqm.php) and scaled to the year of interest where necessary following the recommended procedure in LAQM. TG(03).

[1] 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. This is based on review and assessment of new factors for Euro I and II vehicles given in TRL Database of Emission Factors, September 2001 (Barlow, Hickman and Boulter) and reconsideration of scaling factors for Euro III, IV vehicles by netcen

3.5 INDUSTRIAL SOURCES

The first Stage Review and Assessment identified 5 industrial sources that could be significant sources of pollution in Castlereagh Borough Council

PREMISES NAME	PREMISES ADDRESS
Hydebank	Hospital Road, Belvoir
Knockbracken Health Care Park	Saintfield Road, Belfast
Ulster Hosipital	Upper Newtownards Road, Dundonald
Cashel Quarries	Ballynahinch Road, Carryduff
Stevensons Quarries	Ballynahinch Road, Carryduff

Since the completion of the First Stage Review Knockbracken Health Care Park and the Ulster Hospital incinerators are no longer operational, and the boilers at Knockbracken Health Care Park have been reduced to a thermal rating below 5MW, while the boilers at Hydebank have been converted to gas as a fuel source. The 2 quarries are at a considerable distance from receptors and therefore there are no significant industrial sources within the Castlereagh Borough Council area.

3.6 LOCAL AIR QUALITY MONITORING DATA

3.6.1 Extent of data available

Castlereagh Borough Council has carried out automatic air quality monitoring since September 2002. Monitoring is carried out at two different locations: a roadside station measuring NO_2 and PM_{10} (Castlereagh Lough View Drive – 335749, 370711) and a suburban background station measuring SO_2 and PM_{10} (Castlereagh Espie Way – 337347, 371991). The instrumentation employed uses UV fluorescence for the measurement of SO_2, the TEOM technique for PM_{10}, and chemiluminescence for the measurement of NO_2 these methods are appropriate for Stage 3 Assessment under LAQM (LAQM TG(03)). All TEOM data are quoted as gravimetric equivalent in accordance with the guidance. Appendix 1 provides more details about the local air quality monitoring programme.

netcen has undertaken data management of the Castelreagh air monitoring stations since November 2003. **netcen** has managed data from the stations start dates retrospectively, and it is these data that are used in the verification and adjustment of the modelled output. **netcen** has undertaken a review of the data comparing the trends of the pollutants to other nearby National Network monitoring stations. The Castlereagh datasets follows the same temporal variation as seen at the AURN station at Belfast Centre and Belfast East, providing a degree of confidence in the dataset.

3.7 MAPS

Castlereagh Borough Council provided Ordnance Survey tiles for the council maps in the form of GIS shape files.

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3.8 MET DATA USED IN THE DISPERSION MODELLING

Hourly sequential data was obtained for 2003 for the Aldergrove site for input into the dispersion model. This Met Office station is located *circa* 23km away from Castlereagh (see figure 3.1). More information is attached in Appendix 2.

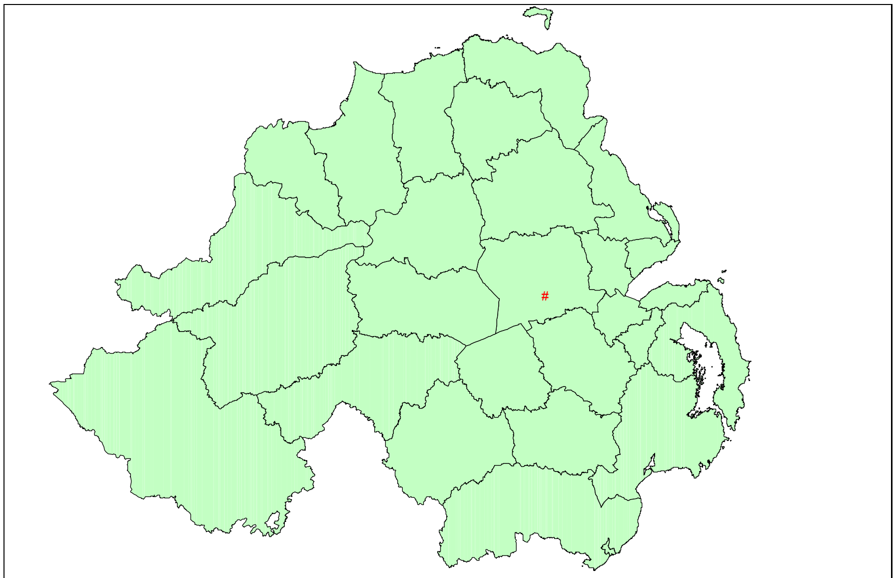

Figure 3.1 Location of Aldergrove Meteorological Station

3.9 OVERVIEW OF THE MODELLING APPROACH

netcen's LADSUrban model has been used to assess road traffic emissions of NO_2 and PM_{10} while **netcen**'s DISP model has been used to assess domestic fuel combustion emissions of SO_2 and PM_{10}.

Concentrations of NO_2 and PM_{10} from road traffic emissions have been assessed using a high-resolution approach, with concentrations being modelled at 10 m intervals along the roads assessed. This high spatial resolution is recommended in Technical Guidance LAQM.TG(03). The model has been run for the relevant objective years. Existing monitoring data has been used to verify and adjust the model result if necessary.

Domestic fuel combustion has been carried out using DISP model to predict PM_{10} and SO_2 concentrations arising from domestic fuel burning in the area. It has been specially developed for Review and Assessments by **netcen**. The model uses ADMS-3.1 to provide dispersion kernels over a grid. ADMS could not be used on its own as there is a limit of 100 point sources that can be modelled. In this assessment, emissions from around 5,000 houses have been modelled.

3.9.1 Model verification and adjustment

The two monitoring sites in Castlereagh (Espie Way and Lough View Drive) have been used as a reference to verify the model results. The monitoring data was ratified by **netcen** as explained in section 3.5.1.

The purpose of this verification and adjustment has been to ensure that the modelled concentrations equalled the measured values at the monitoring locations. The same modelling methodology has been used at other Local Authorities to maintain consistency in the modelling approach and thus minimise the uncertainty of applying a generic bias correction.

More details of model verification and adjustments are given in Appendix 4.

3.9.2 Model uncertainties

The modelling approach has not taken account of:

- Uncertainties in road emissions and domestic fuel burning data;
- Uncertainties in how the burning of domestic fuel might change in future years;
- Uncertainty resulting from year to year variations in atmospheric conditions;
- Uncertainty in emission factors

- Uncertainty in monitoring data

The above uncertainties are dealt with as fully as possible but it is important to remember that the modelling depends highly on the accuracy of the fuel use survey, which is a sample survey. It is assumed that the fuel use survey is representative and will remain representative of the fuel use at the time of the objectives. As we are assuming the fuel use profile will remain the same there is no need to correct the fuel use survey to the year of the objective. Predicted future background concentrations have been applied.

The dispersion modelling is based upon the meteorology and emissions for 2003, clearly meteorological conditions will vary from year to year but overall would be expected to be broadly representative of local conditions for the year of the objectives.

Emissions Factors are average emission factors and do not take into account , for example natural variation in coal and its sulphur content variability.

3.9.3 Relationship between annual means and short term concentrations

Both LADSUrban and DISP models calculate the annual mean contribution of road emissions and domestic fuel combustion, respectively. In order to predict short term AQ objectives, we have followed recommendations in LAQM.TG(03) and elsewhere.

3.9.3.1 Relationship between NO_2 annual average and means and short term concentrations

Laxen and Marner (2003) suggest that "local authorities could reliably base decisions on likely exceedences of the 1-hour objective for nitrogen dioxide alongside busy streets using an annual mean of 60 ug/m3 and above". As can be seen in figure 3.2, exceedences of the 1 hour objective are unlikely below 40 ug/m3. Therefore, if there is no exceedence of the annual mean objective of 40 ug/m3, it is considered unlikely that an exceedence of the hourly objective will occur.

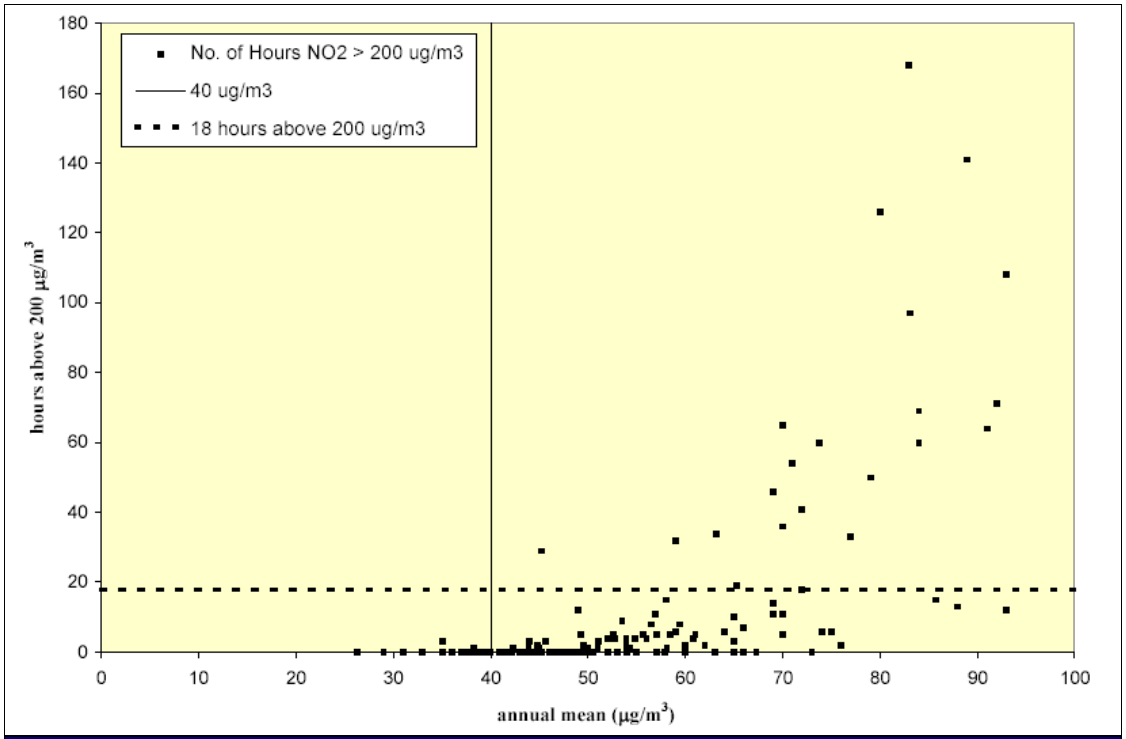

Figure 3.2 Number of Hours per Year With > 200 mg/m3 of Nitrogen Dioxide as a Functionof the Annual Mean Concentration at all Roadside/Kerbside Sites, 1980-2001. (*from Laxen and Marner, 2003*)

3.9.3.2 Relationship between annual mean PM_{10} and number of 24-hour exceedences of 50 μgm^{-3}

The relationship between PM_{10} annual mean and number of daily exceedences of 50 μgm^{-3} from LAQM.TG(03) has been used. As can be seen in figure 3.3, the daily mean objective is likely to be exceeded more than 35 times when PM_{10} annual mean is above 30 μgm^{-3}

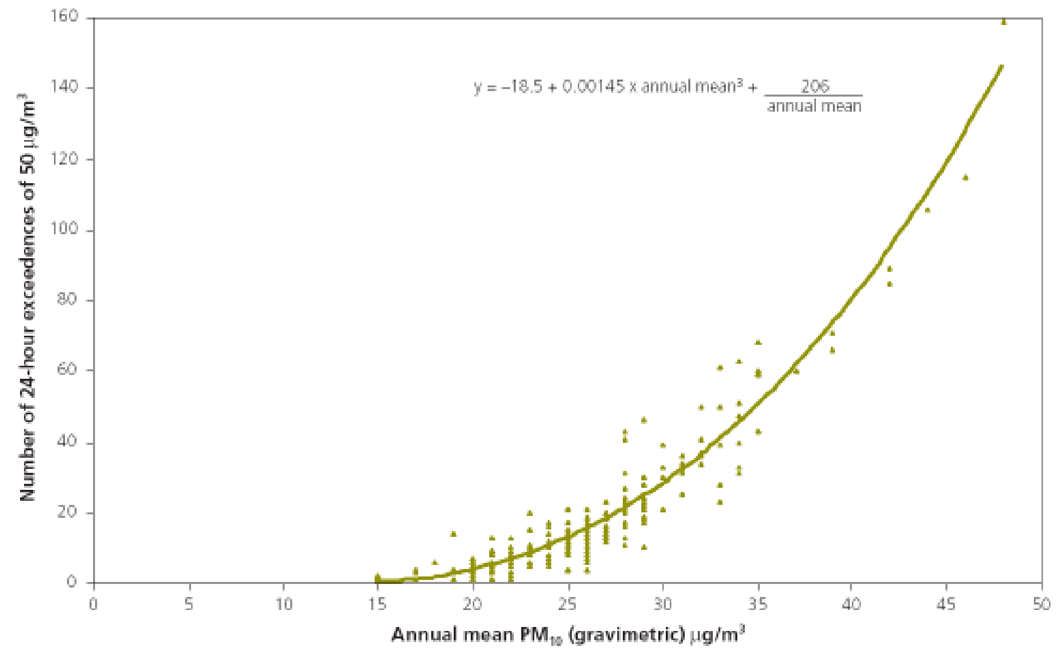

Figure 6.2 Relationship between the number of 24-hour exceedences of 50 μgm^{-3} and the annual mean concentration (derived from UK Automatic Network Sites 1997-2001) (*from LAQM.TG(03)*)

3.9.3.3 Relationship between annual mean and short term sulphur dioxide concentrations

Pye and Vincent (2003) published a report "*Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland*". This report includes a relationship between annual mean and short term sulphur dioxide concentrations in Northern Ireland. When the annual mean concentrations for all years (between 1990 to 2002) and for each site (Belfast Centre, Belfast East and Derry) are plotted against each of the short term average concentrations, strong associations are observed. Table 4.6 show the regression equations that will be applied to a map of annual mean concentrations to produce the respective map of short term mean sulphur dioxide concentrations.

Table 4.6: Regression equations used to predict sulphur dioxide concentrations over short term averaging times (from Pye and Vicent, 2003)

Short term mean (Y) Averaging period	**Regression equation**	**R^2**
15 minute (99.9 %ile)	Y = 15.6 × Annual mean concentration – 23.6	0.91
Hourly (99.73 %ile)	Y = 11.9 × Annual mean concentration – 18.7	0.87
Daily (99.18 %ile)	Y = 5.87 × Annual mean concentration – 17.8	0.95

4 Pollutants Assessed

This chapter gives information about the three pollutants assessed in this report.

4.1 NO_2 (NITROGEN DIOXIDE)

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

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

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

4.1.1 Objectives for nitrogen dioxide

The Air Quality Strategy objectives to be achieved by 31st December 2005 are:

- An annual average concentration of 40 $\mu g\ m^{-3}$;
- 200 $\mu g\ m^{-3}$ as an hourly average with a maximum of 18 exceedences in a year.

4.1.2 The National Perspective

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, 1999; 2000) included 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 objective will also be achieved.

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

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

4.2 PM_{10} (PARTICULATE MATTER)

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 particles in air size <10 µm aerodynamic equivalent 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 1 μm 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, $PM_{2.5}$, and even smaller size fractions or total particle numbers.

4.2.1 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.

4.2.2 The National Perspective

National UK emissions of primary PM_{10} have been estimated as totalling 182,000 tonnes in 2001. Of this total, around 18% was derived from road transport sources, 11% from power stations and 21% from combustion in commercial and residential. 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)[5]. 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.

4.3 SO_2 (SULPHUR DIOXIDE)

Sulphur dioxide is a corrosive acid gas which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition 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 areas affected by heavy industry and in footprints of power stations. As power stations are now generally 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.

4.3.1 Objectives for sulphur dioxide

The Air Quality Strategy Objectives to be achieved 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 are unlikely to be exceeded if this objective is not exceeded.

4.3.2 The National Perspective

Sulphur dioxide is emitted in the combustion of coal and oil. Emissions today are dominated by fossil fuelled power stations. Combustion in energy production accounted for 73% of the national total emission. Emissions from road transport are a very small fraction of the national total: less than 1% and combustion in Commercial, institutional and residential combustion accounted for 18% of the national total.

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 plants 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.

4.4 CO (CARBON MONOXIDE)

Carbon monoxide (CO) is produced by the incomplete combustion of organic material or materials that are essentially just carbon such as coke.

In the indoor environment, individuals are exposed to carbon monoxide from sources such as domestic fuel burning heaters and gas cooking appliances. Cigarette smoke can be a significant source.

The main source of outdoor exposure to carbon monoxide is general pollution of the atmosphere by vehicle exhaust gases. Proportionately higher levels of carbon monoxide are contained in exhaust gases when the engine is cold or badly tuned, or while the engine is idling or moving slowly. Thus it might be expected that levels of the gas in the ambient air would be highest close to busy roads in towns where traffic flow is reduced as in rush hours.

Carbon monoxide emitted by motor vehicles in urban areas is normally rapidly dispersed away from roads and then is destroyed by photochemical reaction over a period of months.

Unlike many toxic gases, carbon monoxide is both colourless and odourless and life-threatening concentrations can be breathed without giving any warning to the individual. Exposure to high levels results in unconsciousness with further exposure causing death.

Health effects are caused by carbon monoxide interfering with the transport of oxygen by the red blood cells by the formation of carboxyhaemoglobin and also by blocking essential biochemical reactions in cells.

Varying levels of brain damage can result from carbon monoxide poisoning.

Carbon Monoxide is an atmospheric pollutant emitted during combustion. It is also formed by the oxidation of hydrocarbon and other organic compounds. Carbon Monoxide survives in the atmosphere for about one month before it is eventually oxidised to Carbon Dioxide.

4.4.1 Standard and Objective for Carbon Monoxide

The Government has adopted an Air Quality standard for running 8 hour mean of ten parts per million for Carbon Monoxide. The objective is for this standard is to be achieved by the end of 2003.

4.4.2 The National Perspective

In the UK road transport accounts for 70% of the total emissions of Carbon Monoxide. How this value has been decreasing as a result of reduced Carbon Monoxide emissions from vehicles. These include the induction of three-way catalysts and a reduction of Carbon Monoxide limit in exhaust gases.

Existing national policies are expected to deliver the national air quality standard by the end of 2003 with the possible exception of heavily trafficked roads or in the vicinity of certain stationary resources.

4.4.3 Conclusion for Carbon Monoxide

There are no significant industrial sources of Carbon Monoxide within the Castlereagh area. There had been 2 processes identified in the 1st Stage Review, namely, Knockbracken Healthcare Park and the Ulster Hospital, however, both of these incinerators are no longer operational. There are no significant Part A processes of neighbouring local authorities. Transport levels are not lively to exceed the vehicle threshold of 80,000.

The background levels are beneath the threshold of 1ug/m^3. There is no need to continue with a further assessment of this pollutant.

5 Review and assessment of PM_{10} and NO_2 from Road Emissions

Road emission modelling has been carried out at two major roads/links in Castlereagh BC. Saintfield Road (A24) and Upper Knockbreda Road (A55) junction and the Upper Newtownards Road (A20). These are shown in figure 5.1 below. These are the roads identified in the Castlereagh Stage 1/2 as required further assessment at stage 3.

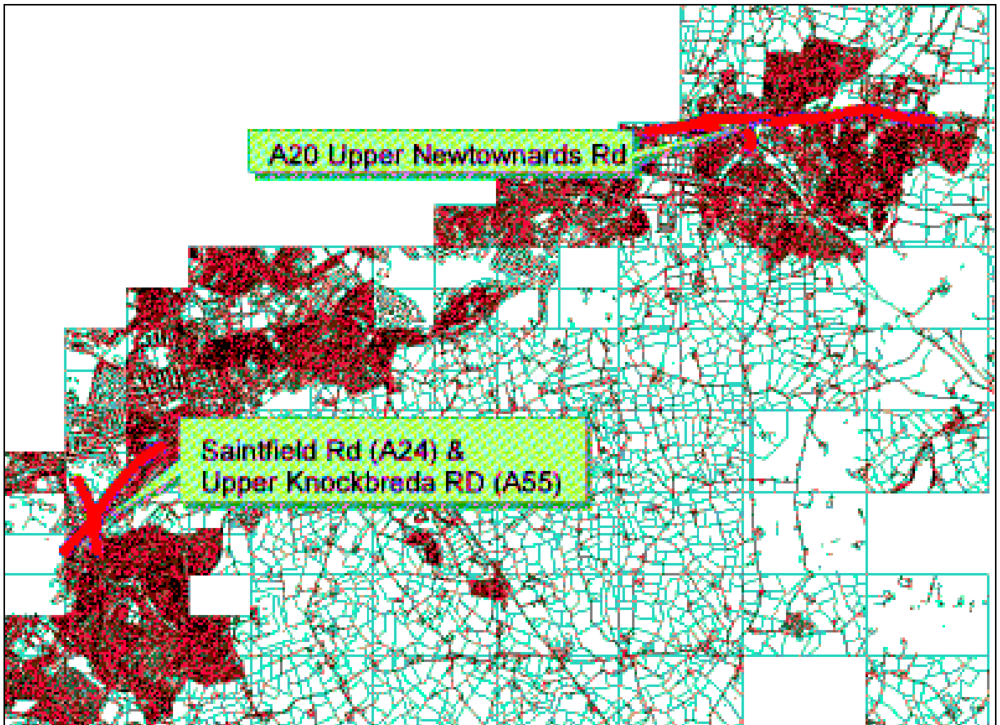

Figure 5.1 Road/links modelled as part of this report

5.1 ROAD EMISSIONS DATA

In order to carry out this assessment, a variety of input data has been necessary.

5.1.1 Traffic Data

Castlereagh BC supplied traffic information for the roads/links to be modelled. This included the following (see table 5.1):

- AADT traffic flows (Annual Average Daily Traffic Flows);
- Percentage HDV flows (HDV = HGV + Buses)
- Average road link speeds

Castlereagh BC also provided traffic flows for links around and outside the junctions to be modelled (see appendix 3)

Table 5.1 AADT, HDV% and average speed across for different link/roads

	AADT Projected 2004/05	% HDVs	Average Speed (Km/h)*
A20	28764	8	45
A24	33912	8	45
A55	43248	8	45

*note that at junctions the average speed has been decreased to 20-30 km/h to take into account for idling traffic

5.1.2 Emissions rates

Emissions factors for road emissions were obtained from the NAEI website (www.naei.org.uk). Vehicle emission factors have recently been revised by defra[2]. The most recent emission factors have been used in this Stage 3.

5.1.3 Background data

Background concentration of oxides of nitrogen (NOx), nitrogen dioxide (NO_2) and particulates (PM_{10}) have been taken from Local Air Quality Management section in the UK Air Quality Archive (http://www.airquality.co.uk/archive/laqm/laqm.php) and scaled to the year of interest where necessary following the recommended procedure in LAQM. TG(03). In order to avoid double counting, rural background levels south of the modelled grid have been used. The values estimated are:

Table 5.2 Background concentrations

Pollutant	2003	2004	2005
PM_{10} gravimetric	18 μgm^{-3}	17 μgm^{-3}	**17 μgm^{-3}**
NO_2	20 μgm^{-3}	19 μgm^{-3}	**18 μgm^{-3}**
NOx	25 μgm^{-3}	25 μgm^{-3}	**24 μgm^{-3}**

5.2 MODEL RESULTS

The traffic data supplied by Castlereagh Borough Council has been used within **netcen**'s LADSUrban model to determine whether road emissions are likely to cause exceedences of the 2004 PM_{10} and 2005 NO_2 objectives. Contour plots show the results for both links assessed in terms of annual means for both NO_2 (2005) and PM_{10} (2004). Annual means are used to indicate likely exceedences of short term concentrations for NO_2 and PM_{10} (see Section 3.8.3).

[2] 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. This is based on review and assessment of new factors for Euro I and II vehicles given in TRL Database of Emission Factors, September 2001 (Barlow, Hickman and Boulter) and reconsideration of scaling factors for Euro III, IV vehicles by netcen

5.2.1 Predicted NO_2 Concentration

Figure 5.2 and 5.3 show the NO_2 annual mean concentrations in the A42-A55 junction and the A20 link. Exceedences of the NO_2 Annual Mean Objective have only been predicted in the centre of the junction and links. Levels at nearby receptors (dwellings) are predicted to be below 40 μgm^{-3}.

In relation to the 1-hour mean objecitive, the levels at the kerbside of the junction and roads are well below the threshold of 60 μgm^{-3} recommended by Laxen and Marner (2003).

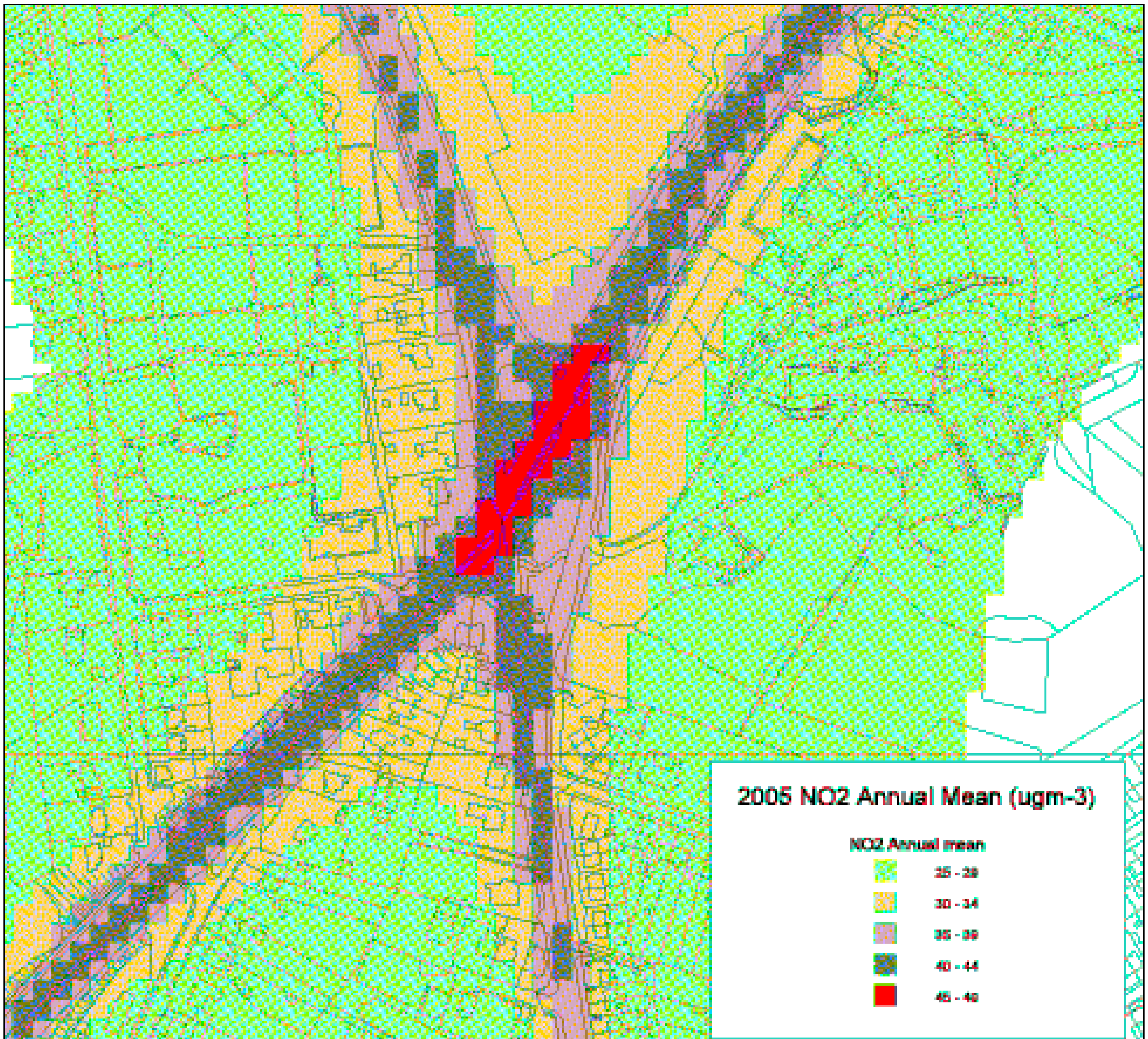

Figure 5.2 2005 NO_2 Annual Mean modelled for A42-A55 junction

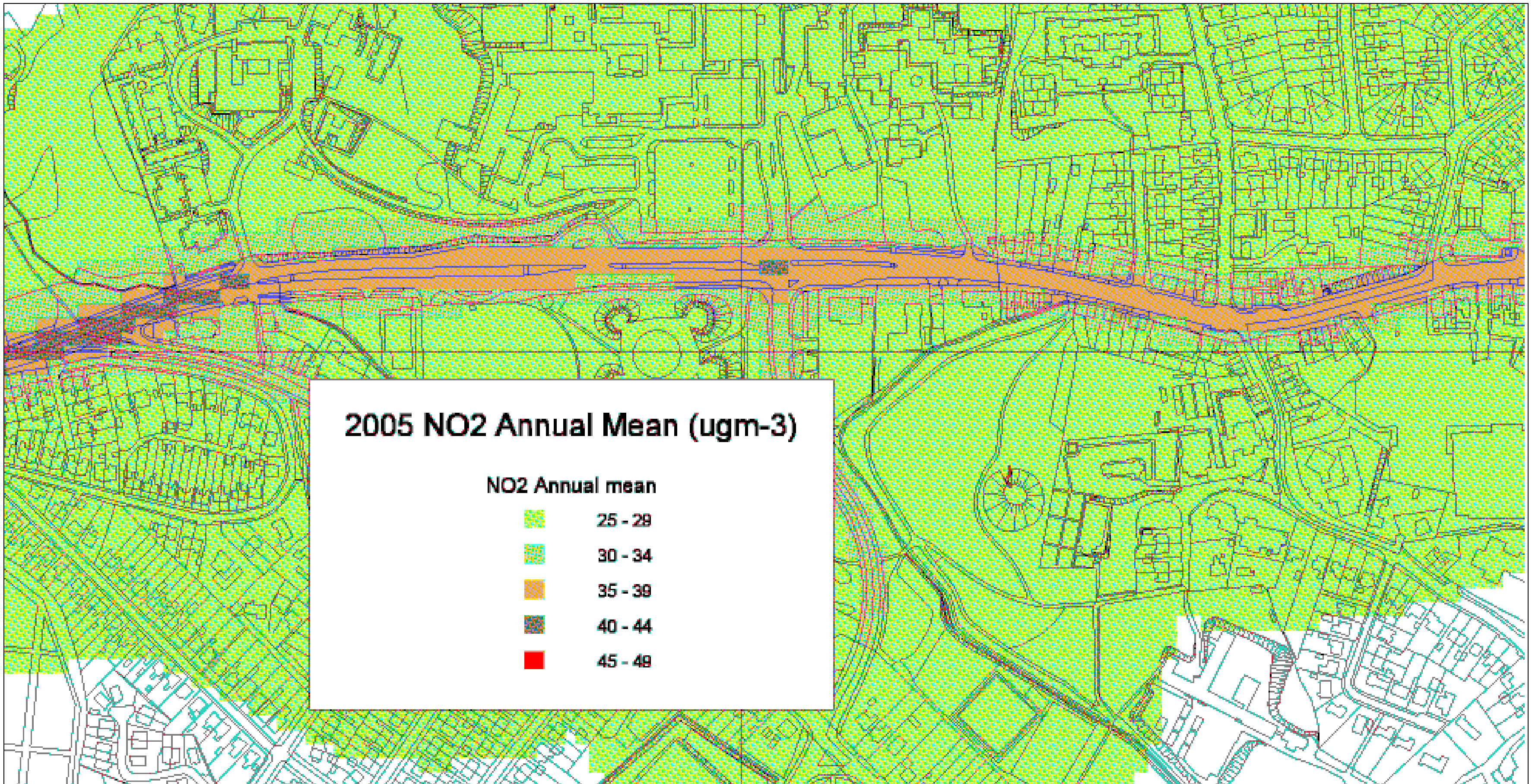

Figure 5.3 2005 NO_2 Annual Mean modelled for the A20 (Upper Newtonwnards Rd)

5.2.2 Predicted PM_{10} Concentrations.

Figure 5.4 and 5.5 show the PM_{10} annual mean concentrations for the A42-A55 junction and the A20 link. Exceedences of the PM_{10} Annual Mean Objective have not been predicted. A maximum concentration between 28 and 34 μgm^{-3} is predicted at the centre of the A42-A55 junction. Levels at nearby receptors (dwellings) are predicted to be between 22-24 μgm^{-3} at the A42-A55 junction and between 20-22μgm^{-3} along the A20 link.

In relation to the daily mean objecitive, the levels at the kerbside of the junction and roads, and at the closest receptors are well below the threshold of 30 μgm^{-3} in LAQM.TG(03).

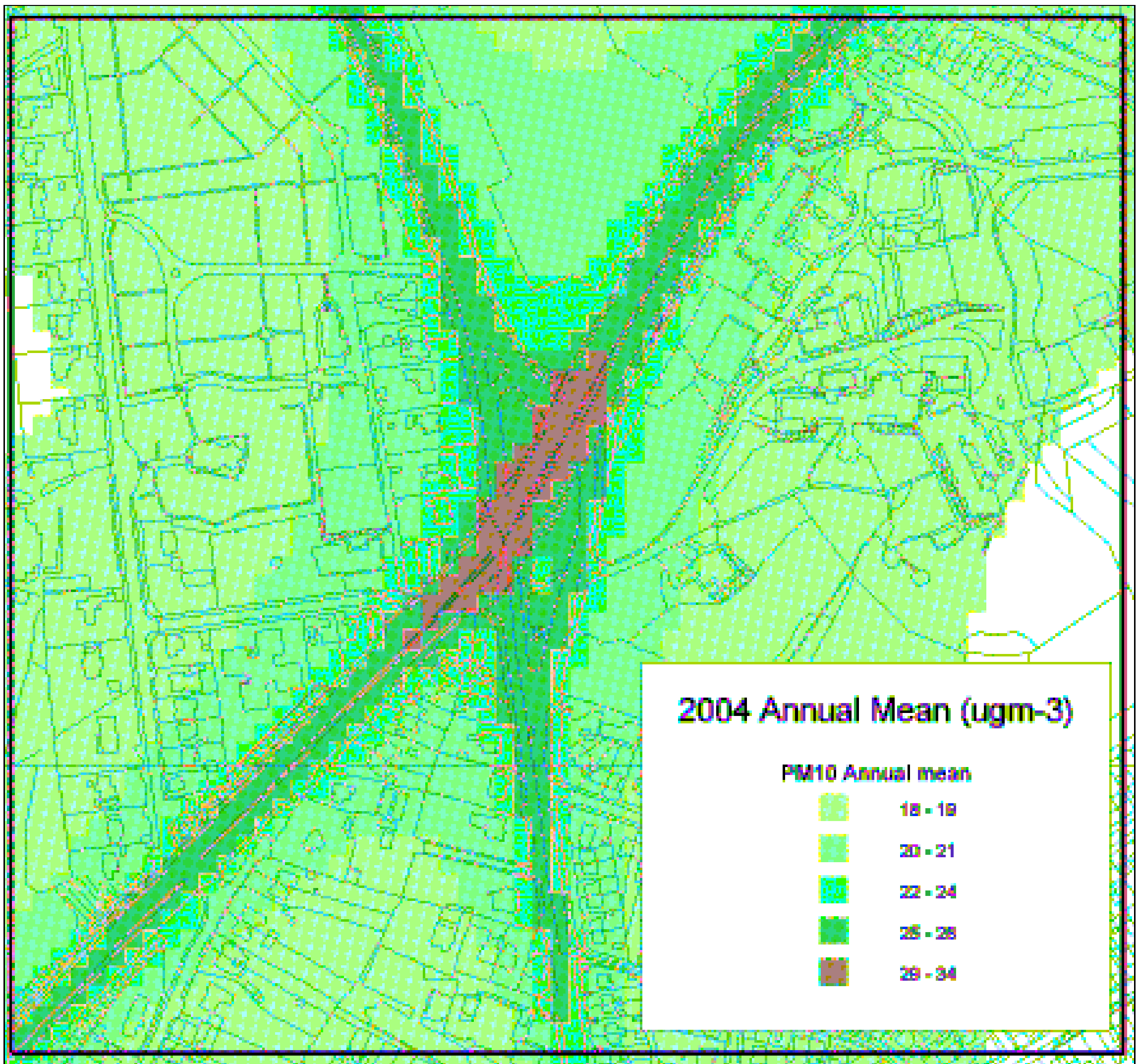

Figure 5.4 2004 PM_{10} Annual Mean modelled for A42-A55 junction

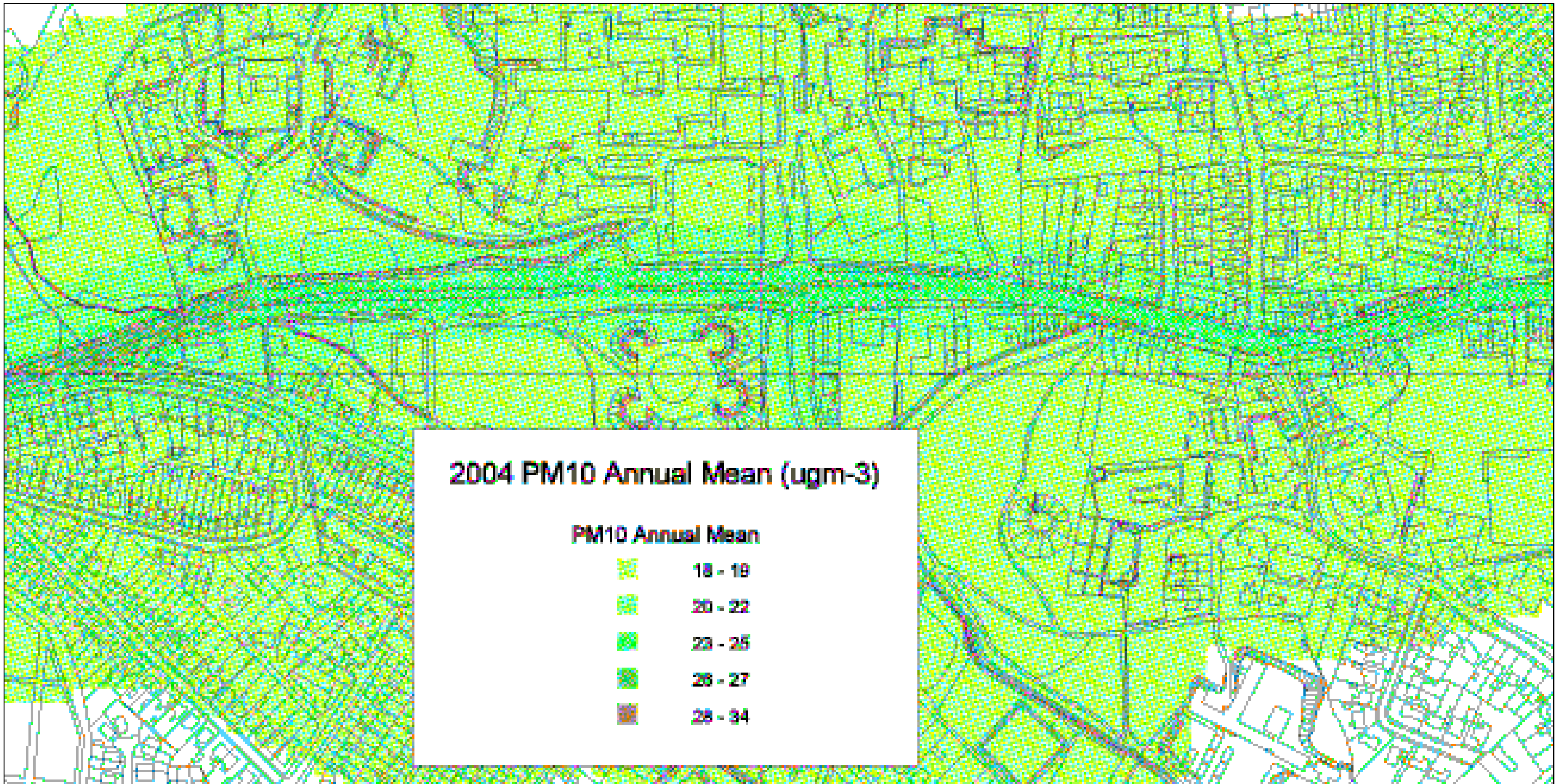

Figure 5.5 2004 PM_{10} Annual Mean modelled for the A20 (Upper Newtonwnards Rd)

6 Review and assessment of PM_{10} and SO_2 from Domestic Fuel combustion

6.1 DOMESTIC FUEL COMBUSTION

Solid fuel burning for domestic heating is still relatively common in parts of Northern Ireland. Where solid fuel burning is predominant it may have the potential to cause exceedences of the objectives. According to the guidance, "the risk of exceedence within an area can be considered significant where the density of coal burning (or solid smokeless fuel burning) houses exceeds 300 properties per $1km^2$". In such cases the guidance recommends an authority proceed to a second or third stage review and assessment.

6.2 CASTLEREAGH BOROUGH COUNCIL FUEL USE SURVEY

Castlereagh Borough Council undertook a fuel use survey in 2002. This consisted of 1390 interviews across residents in Castlereagh. As can be seen in table 6.1, more than ¾ of the households use oil as their main fuel for heating. The remaining ¼ is equally divided between gas, electricity and solid fuel. Solid fuel, mainly consists of Smokeless Solid Fuel (SSF).

Table 6.1 Main fuel type across Castlereagh BC

	Number Households	% of Properties
Oil	1071	77
Gas	111	8
Electricity	97	7
Solid Fuel (90%SSF)	111	8
Total	1390	100

6.2.1 Modelled grid

A 2km by 2.5km grid has been modelled in order to assess the contribution of domestic fuel combustion. This has been modelled at a resolution of 25m. This $5km^2$ grid contains 5,000 households of which 10% where represented in the fuel use survey. Table 6.2 shows the percentage of the different fuel types used for heating. Oil is used at more that ¾ of the households while SSF is used in 12% of the households followed by electricity (6%) and gas (4%). The percentage of SSF users in the grid is greater than the overall average across the borough. However oil usage dominates.

Table 6.2 Main fuel type across Modelled grid

	Number Households	% of Properties
Oil	367	78
Gas	19	4
Electricity	28	6
Solid Fuel (90%SSF)	56	12
Total	470	100

Backup fuel is considered to be negligible as 98% of the households do not have backup facility. Moreover, only 50% who have backup use SSF (an overall of 1%).

Figure 6.1 shows the location of surveyed dwellings and their main fuel type. As shown in table 6.2, the predominant fuel used is oil (in pink) followed by coal (SSF) in grey.

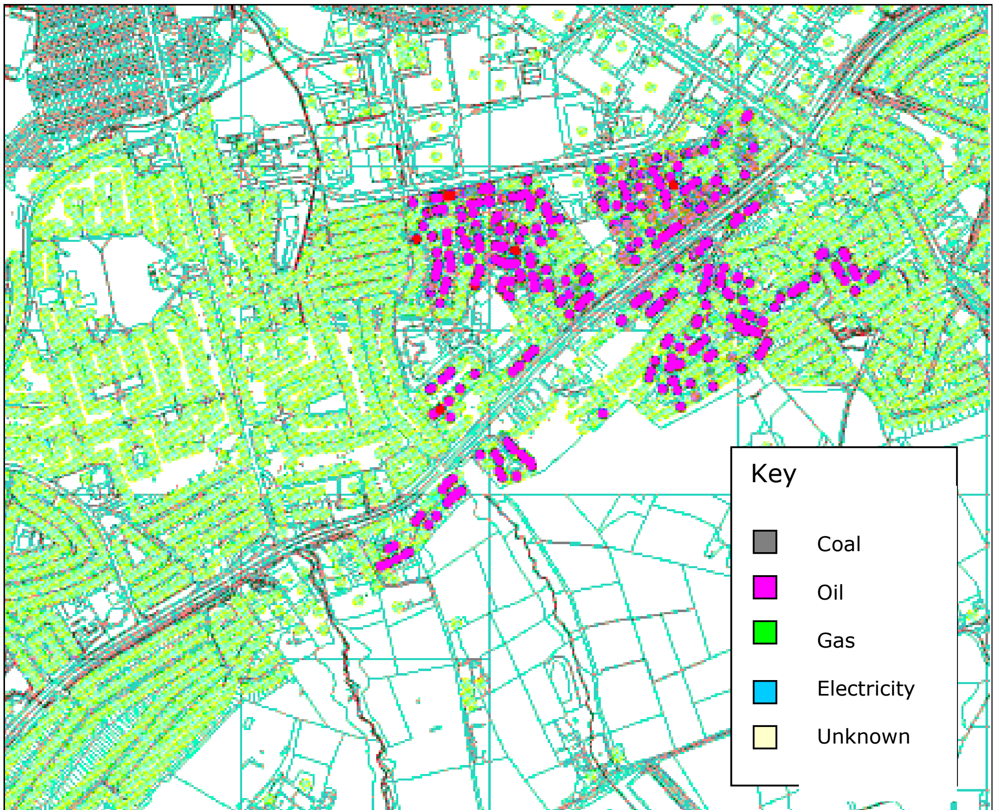

Figure 6.1 Fuel Use in Modelled Grid

6.3 DOMESTIC SOURCES REVIEW AND ASSESSMENT

The fuel use survey undertaken by Castlereagh Borough Council has been used within **netcen**'s DISP model to determine whether domestic fuel combustion is likely to cause exceedences of the 2004 SO_2 and PM_{10} objectives. The DISP model calculates the annual contribution to SO_2 and PM_{10}. Pye and Vincent (2003) conversion factors have been used to calculate 99.9 percentile of 15 minute means, the 99.73 percentile of hourly means and the 99.18 percentile of daily means for SO_2.

The relationship between the number of daily exceedences of 50μgm^{-3} and the annual mean concentration of PM_{10} in LAQM.TG (03) has been used calculate likely exceedences of the daily PM_{10} objective.

6.3.1 Emissions rates

The PM_{10} and SO_2 emission rate for each dwelling has been calculated using information from the fuel use survey (annual expenditure and fuel use type). Oil and Solid fuel annual expenditure was converted into litres and kilograms, respectively using an average cost from different providers in the Castlereagh area (One litre of heating oil costs 22.2p and a 50kg bag of SSF costs £9.50).

Using the emissions rates in table 6.3, an annual emission rate for each dwelling was calculated (see table 6.4). This average annual emissions rate per dwelling was then applied to dwellings not included in the fuel use survey.

Table 6.3 Emissions rates for different fuel type

Fuel Type	SO_2	PM_{10}	Units
Oil	0.42	0.01	Kt/mt fuel
Gas	-	-	Kt/mt fuel
Electricity	-	-	Kt/mt fuel
Coal	10	10	Kt/mt fuel
SSF	16	5.6	Kt/mt fuel

Table 6.4 Emission rates resulting from domestic fuel combustion

	SO_2 (g/s)	PM_{10} (g/s)
Total emission from Surveyed houses	0.16765246	0.05546935
Average emission from Surveyed houses	3.54E-04	1.17E-04
Total emission from grid*	1.383072	0.457488

*Assuming average SO_2 and PM_{10} for dwellings not covered in the survey

6.3.2 Point source characteristics (Domestic Heating)

The assumptions in the modelling exercise are:

- Chimney height 10m.
- Chimney diameter of 0.2m
- Exit velocity of 4 m/s and temperature of 60 °C.
- Surface Roughness 1m
- The fuel use survey is representative of the grid population.
- Meteorological data from Aldergrove 2003.
- Concentrations calculated to a resolution of 25m.
- Monitoring data is correct

6.3.3 Background concentrations

The background concentrations have been added to the modelled concentrations. The background concentrations have been estimated for the grid from the **netcen** background concentration maps. In order to avoid double counting, rural background levels south of the modelled grid have been used. The values estimated are:

Table 6.5 Background concentrations

	2001	2003	2004
PM_{10}	19 μgm^{-3}	18 μgm^{-3}	17 μgm^{-3}
SO_2	4 μgm^{-3}	4 μgm^{-3}	4 μgm^{-3}

6.4 MODEL RESULTS

The model results form **netcen**'s DISP model are presented below.

6.4.1 PM_{10} Predicted Concentration

Figure 6.2 PM_{10} annual mean concentrations in the modelled area. The contribution from domestic fuel combustion is very low (1μgm^{-3} maximum). Exceedences of the PM_{10} have not been predicted. Based on the relationship between daily means and annual means the daily mean objective will not be exceeded within the grid.

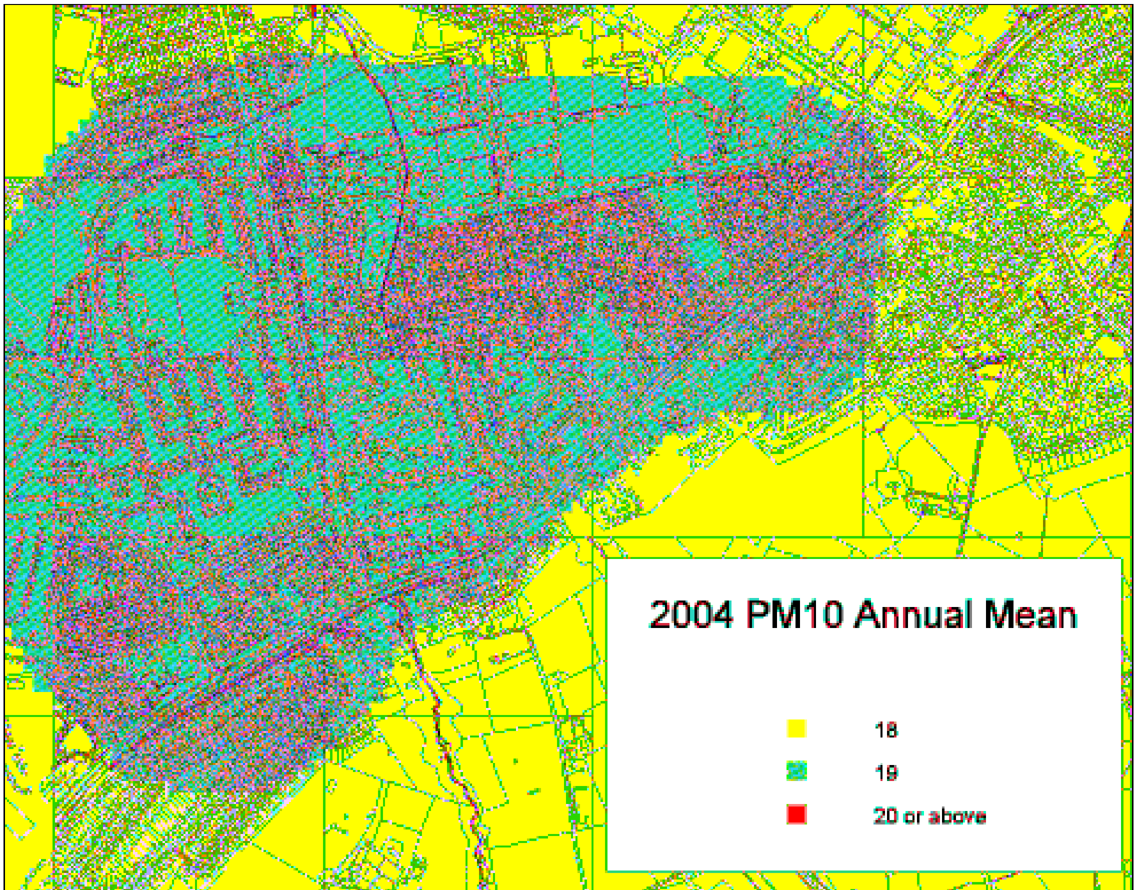

Figure 6.2 2004 PM_{10} Annual mean corrected modelled results
Contour units are in $\mu g\ m^{-3}$

6.4.2 SO_2 Predicted Concentration

Figures 6.3 – 6.5 show the predicted short term concentrations for SO_2. None of the following AQ Objectives will be exceeded within the grid:

- 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 (see figure 6.3)
- 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 (see figure 6.4)
- 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 (see figure 6.5)

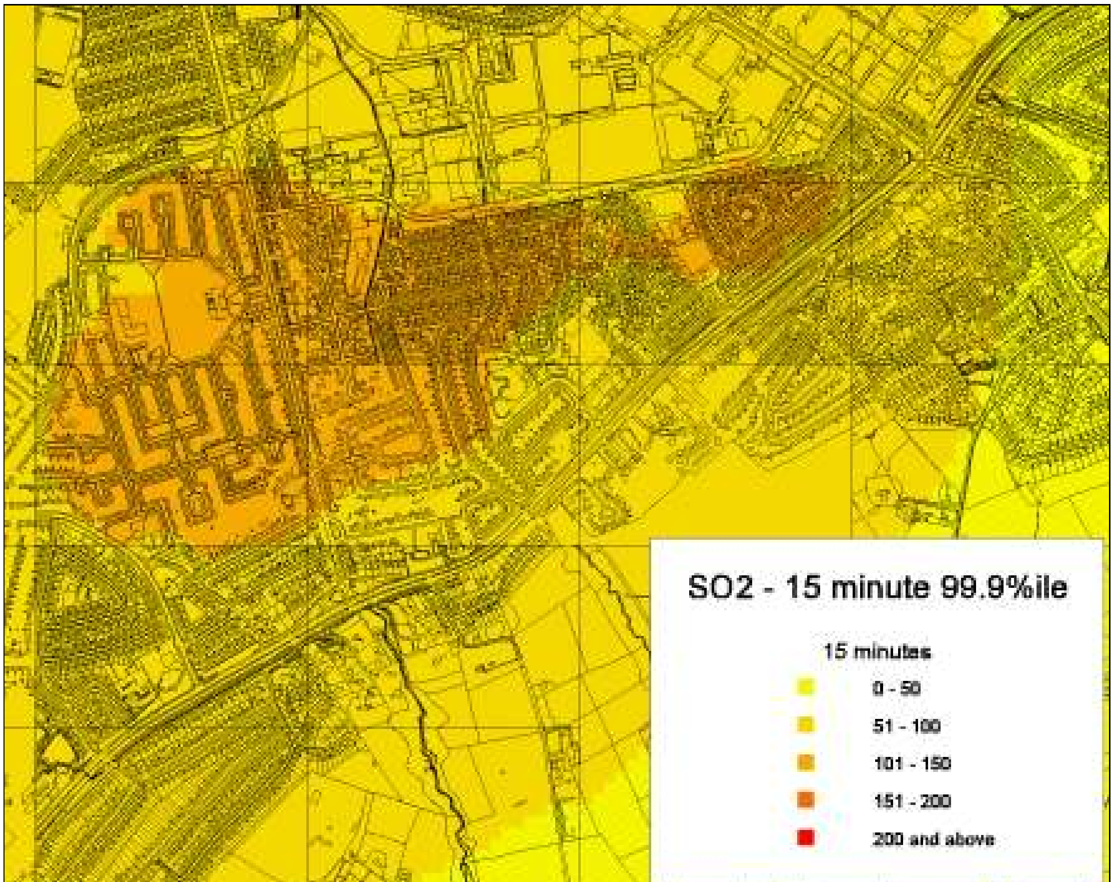

Figure 6.3 - 2005 SO_2 15 minute mean (99.9%ile)
Contour units are in $\mu g\ m^{-3}$

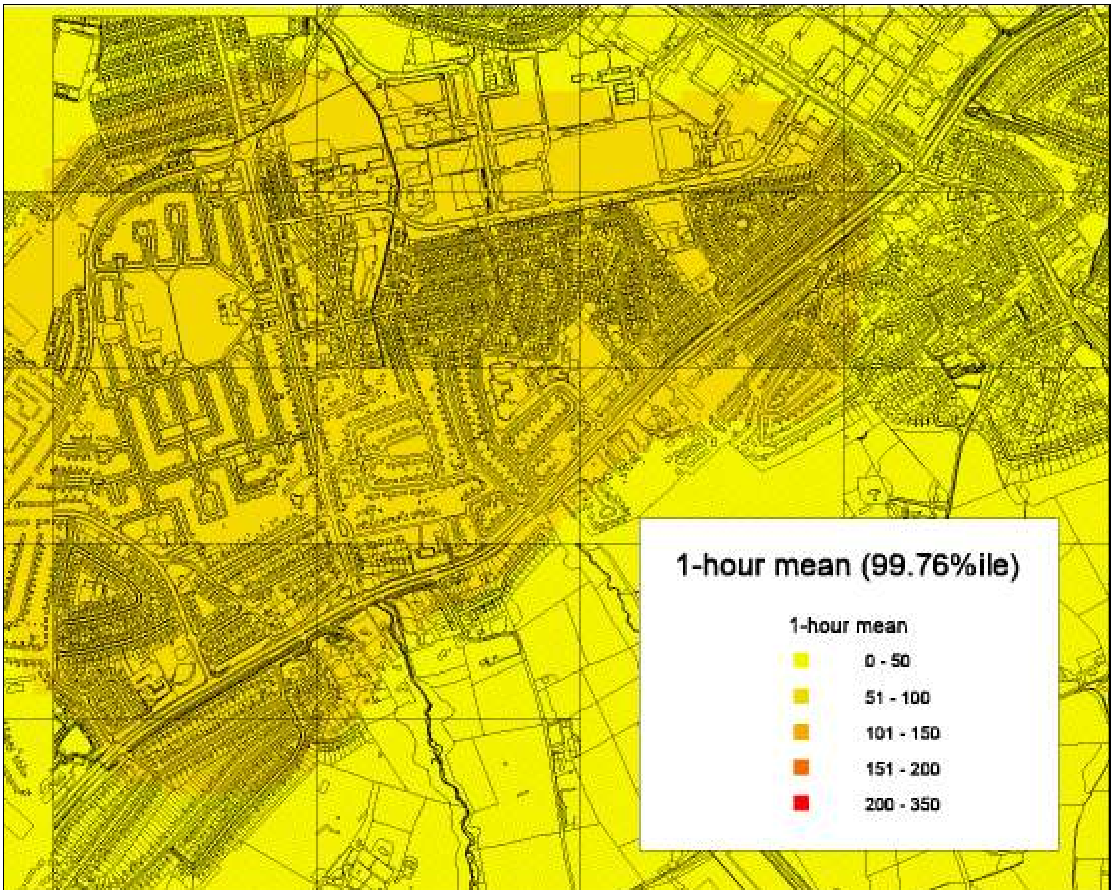

Figure 6.4 - 2004 SO_2 1 hour mean (99.73%ile)
Contour units are in $\mu g\ m^{-3}$

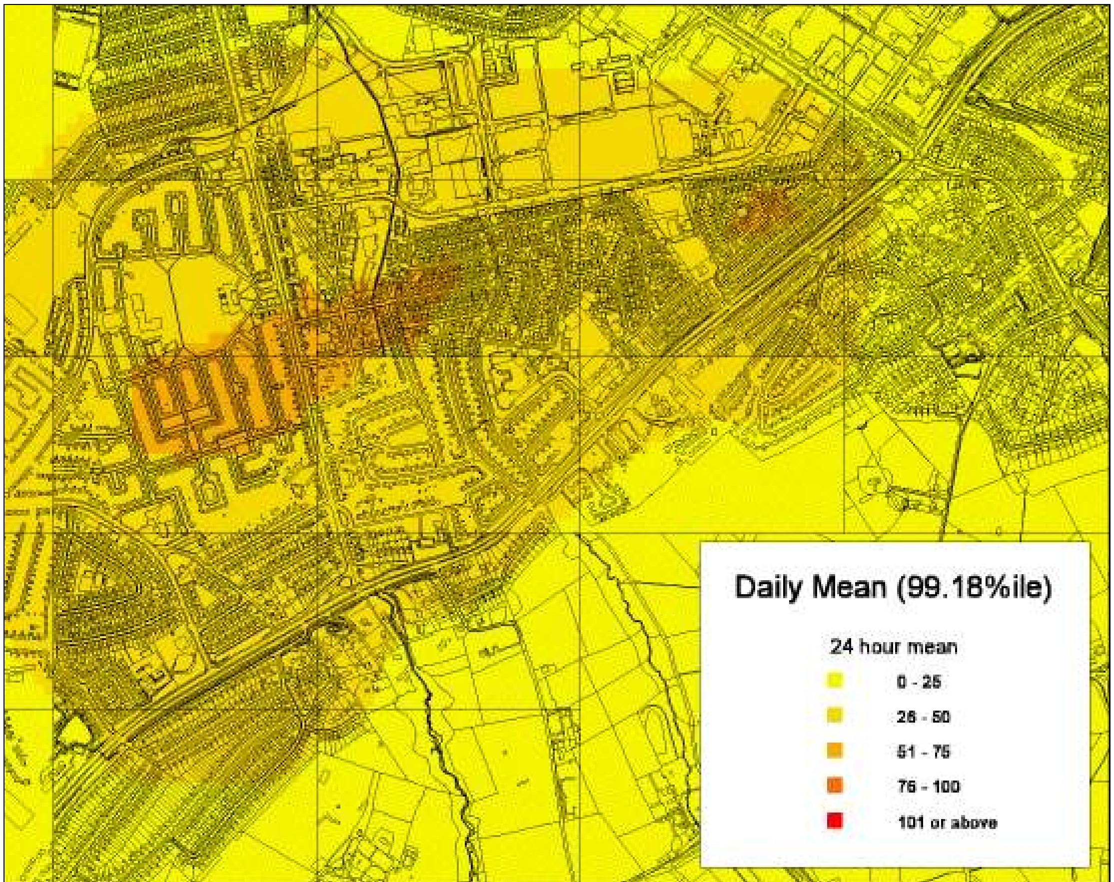

Figure 6.5 - 2004 SO_2 24 hours mean (99.18%ile)
Contour units are in $\mu g\ m^{-3}$

7 Discussion

7.1.1 NO_2

NO2 Annual mean and 1-hour concentrations are not predicted to be exceed the 2005 Air Quality Objectives. The levels at dwellings close to the junctions and links modelled, are predicted to be below 40ugm-3.

7.1.2 PM_{10}

PM10 levels are unlikely to exceed 2004 AQ Objectives. The levels at dwellings close to the junctions and links modelled, are predicted to be well below 50ugm-3.. Even if the maximum contribution from domestic fuel combustion (1.5μgm^{-3}) is added to the road emissions contribution, the PM_{10} 2004 objective would not be exceeded.

7.1.3 SO_2

Levels of SO2 are predicted to remain well below 2004/2005 AQ Objectives across the modelled grid. The levels at all the dwellings across the modelled grid, are predicted to be below AQS Objectives. This is probably due to low usage of Smokeless Solid Fuel which is only 12%.

7.1.4 CO

Carbon Monoxide levels are predicted to be well below the AQ Objective and was disregarded at the start of this investigation.

8 Conclusions and Recommendations

The modelling shows that there will be no exceedences of NO_2, PM_{10} and SO_2 objectives in Castlereagh in 2004/05. The low number of vehicles (compared to busier roads elsewhere) and the low percentage of dwellings using Smokeless Solid Fuel are such that the objectives will not be threatened.

No exceedences of NO_2, PM_{10} or SO_2 objectives have been predicted. Therefore no further assessment of these sources is required.

It is recommended that any existing monitoring be continued in order to provide data to prove this modelling in any future rounds of review and assessment.

Assuming acceptance of these conclusions by DoE NI, the next formal R&A reporting requirement will be production of a progress report in April 2005.

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Pye, S and Vincent, K (2003) Determing the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland. AEAT/ED47047 http://www.airquality.co.uk/archive/reports/cat05/0401151142_NI_PAH_draftv4.pdf

Appendices

CONTENTS

Appendix 1
Automatic Monitoring Station Data

CASTLEREAGH AMBIENT AIR MONITORING PROGRAMME

Castlereagh Borough Council has undertaken automatic ambient air monitoring of NO_2, SO_2 and PM_{10} since September 2002. Monitoring is carried out at two different locations: a roadside station measuring NO_2 and PM_{10} (Castlereagh Lough View Drive – 335749, 370711) and a suburban background station measuring SO_2 and PM_{10} (Castlereagh Espie Way – 337347, 371991). The instrumentation employed uses UV fluorescence for the measurement of SO_2, the TEOM technique for PM_{10}, and chemiluminescence for the measurement of NO_2 these methods are appropriate for Detailed Assessment under LAQM (LAQM TG(03)). All TEOM data are quoted as gravimetric equivalent in accordance with the guidance.

Location of the Automatic Monitoring Stations in Castlereagh

Some data uncertainties and gaps have been overcome by comparing the data with AURN stations located in Northern Ireland (Belfast Centre, Belfast East and Derry) or by using an early period. Table A1.1 summarises the different cases:

Table A1.1 Summary of data verification and amendment

Data	**Reason**	**Solution**
Espie Way PM_{10}	Low data capture (66.8%)	Follow LAQM guidelines to obtain annual average from a period of estimated mean
Espie Way SO_2	Uncertainty on data	Data from Sept 02 to August 03 used as representative of 2003 data.
Lough View Drive PM_{10} and NO_2	Low data capture (75 and 63%)	Follow LAQM guidelines to obtain annual average from a period mean

Castlereagh Espie Way Air Monitoring

Table A1.2 Air Quality Summary Statistics, Espie Way in 2003

POLLUTANT	$PM_{10\ teom}$	PM_{10} gravimetric	SO_2
Number Very High	0		0
Number High	0		0
Number Moderate	0		0
Number Low	5840		32877
Maximum 15-minute mean	165 µg m^{-3}		112 µg m^{-3}
Maximum hourly mean	68 µg m^{-3}		93 µg m^{-3}
Maximum running 8-hour mean	57 µg m^{-3}		60 µg m^{-3}
Maximum running 24-hour mean	44 µg m^{-3}		44 µg m^{-3}
Maximum daily mean	41 µg m^{-3}		43 µg m^{-3}
Average	14.5 µg m^{-3}	19 µg m^{-3}	4 µg m^{-3}
Data capture	66.8 %		95.8 %

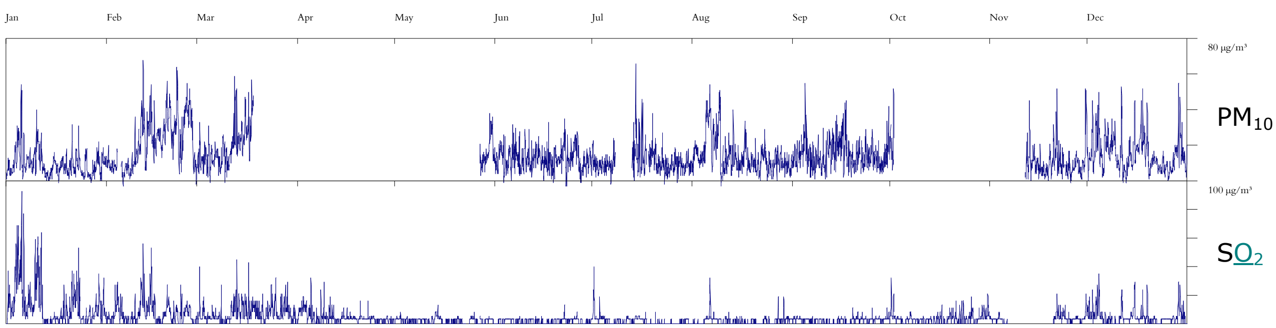
Note: A factor of 1.3 has been used to correct TEOM PM_{10} to gravimetric equivalent PM_{10} All mass units are at 20'C and 1013mb

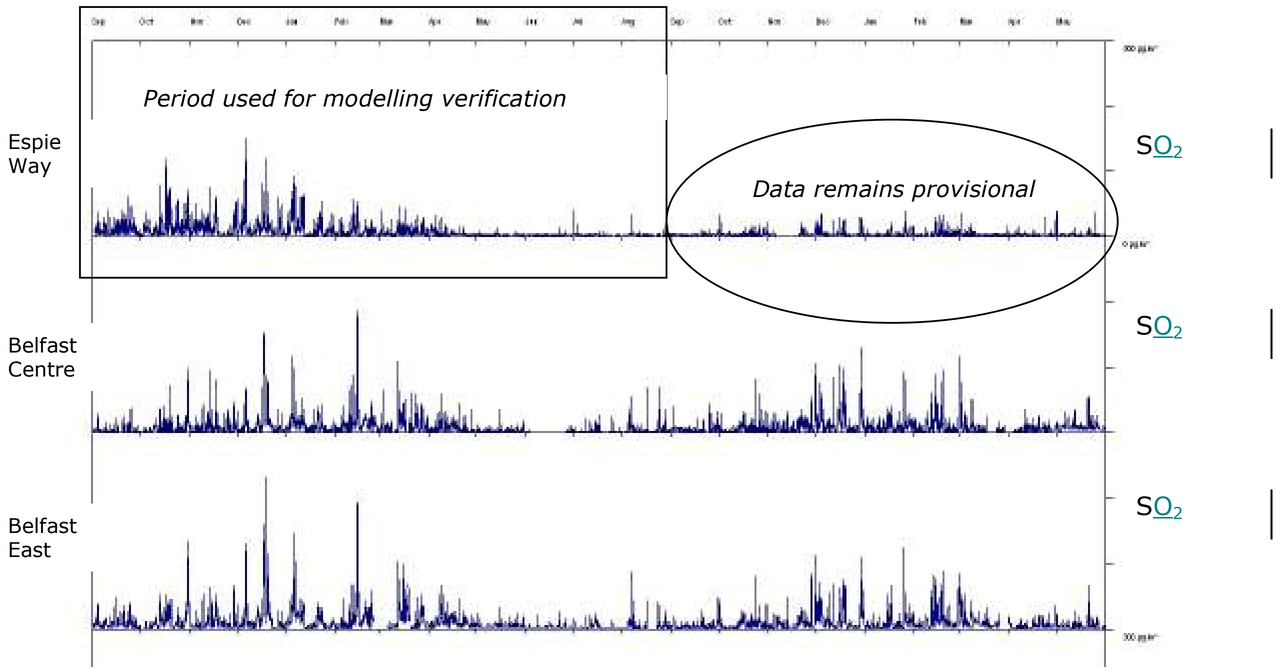
Table A1.3: Air Quality Exceedence Statistics, Espie Way in 2003

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µg m^{-3}	4	4
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µg m^{-3}	0	-
Sulphur Dioxide	15-minute mean > 266 µg m^{-3}	0	0
Sulphur Dioxide	Hourly mean > 350 µg m^{-3}	0	0
Sulphur Dioxide	Daily mean > 125 µg m^{-3}	0	0
Sulphur Dioxide	Annual mean > 20 µg m^{-3}	0	-

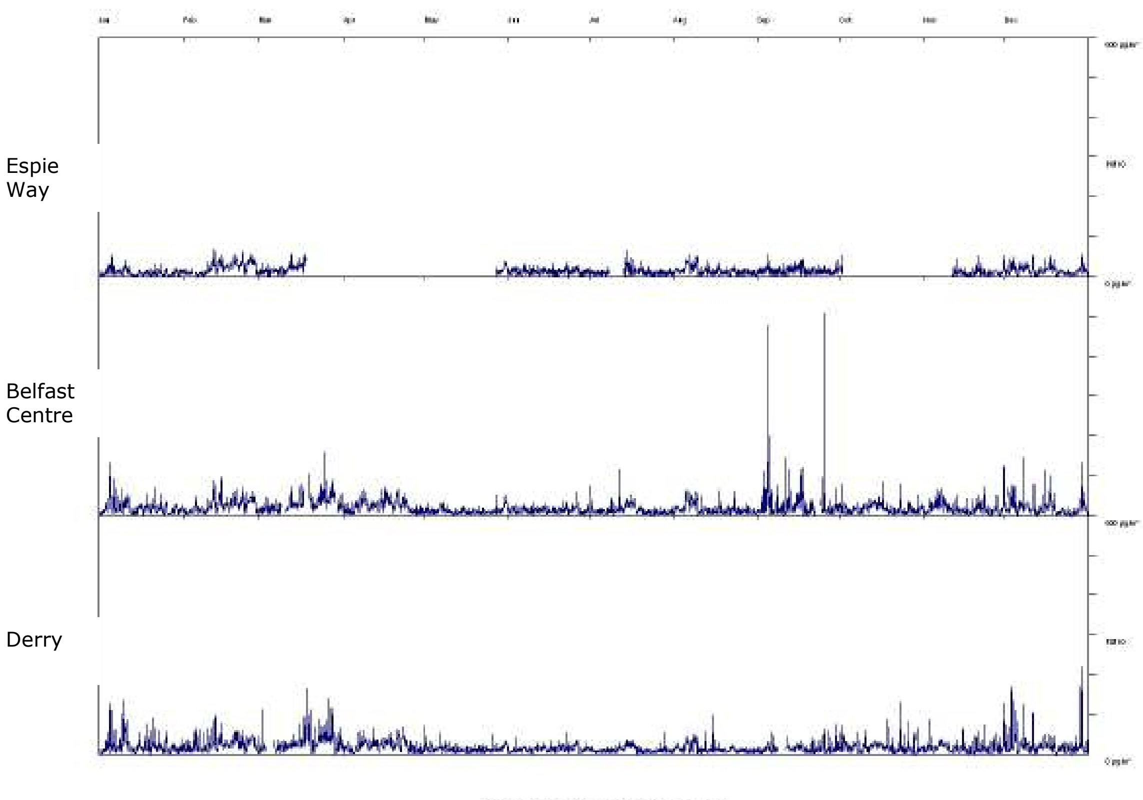
Note: A factor of 1.3 has been used to correct TEOM PM_{10} to gravimetric equivalent PM_{10} (GR_{10} in Table A1.2)

Hourly Mean Data for 01 January to 31 December 2003





SO_2 data from Espie Way compared to AURN Stations in Belfast



PM_{10} data from Espie Way compared to AURN Station in Belfast and Derry

Castlereagh Lough View Drive Air Monitoring

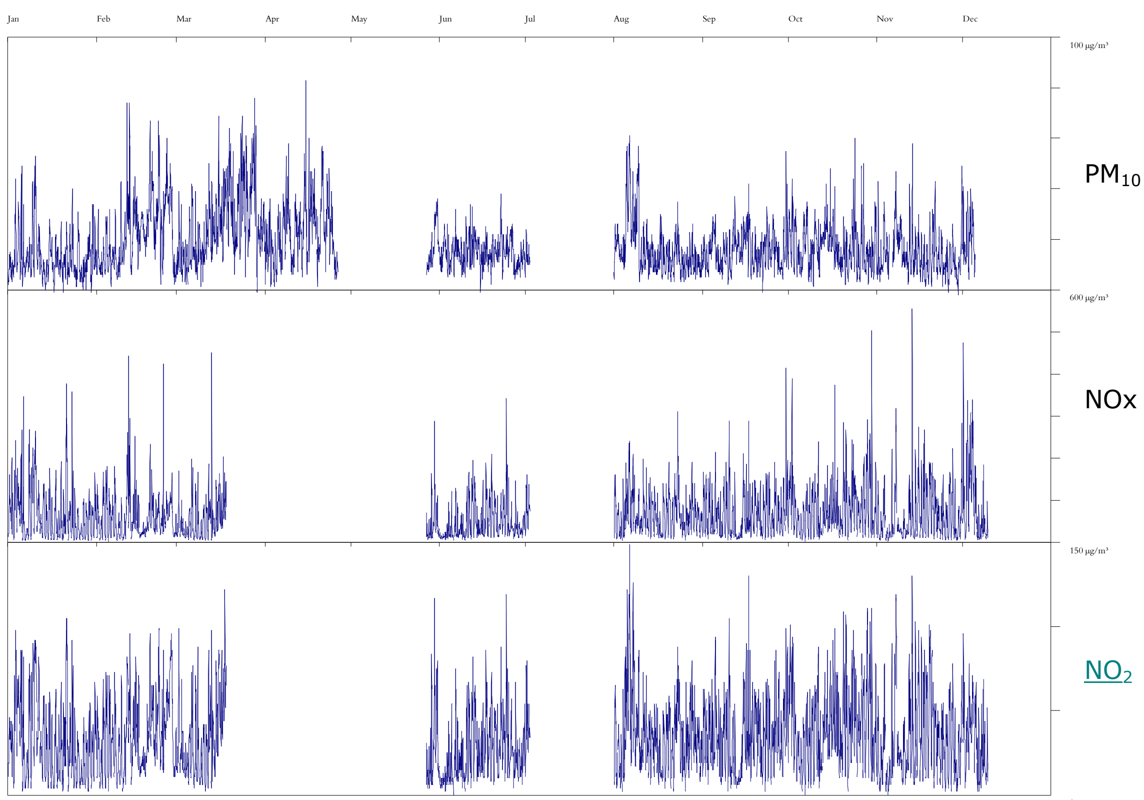
Table A1.4 Air Quality Summary Statistics, Lough View Drive in 2003

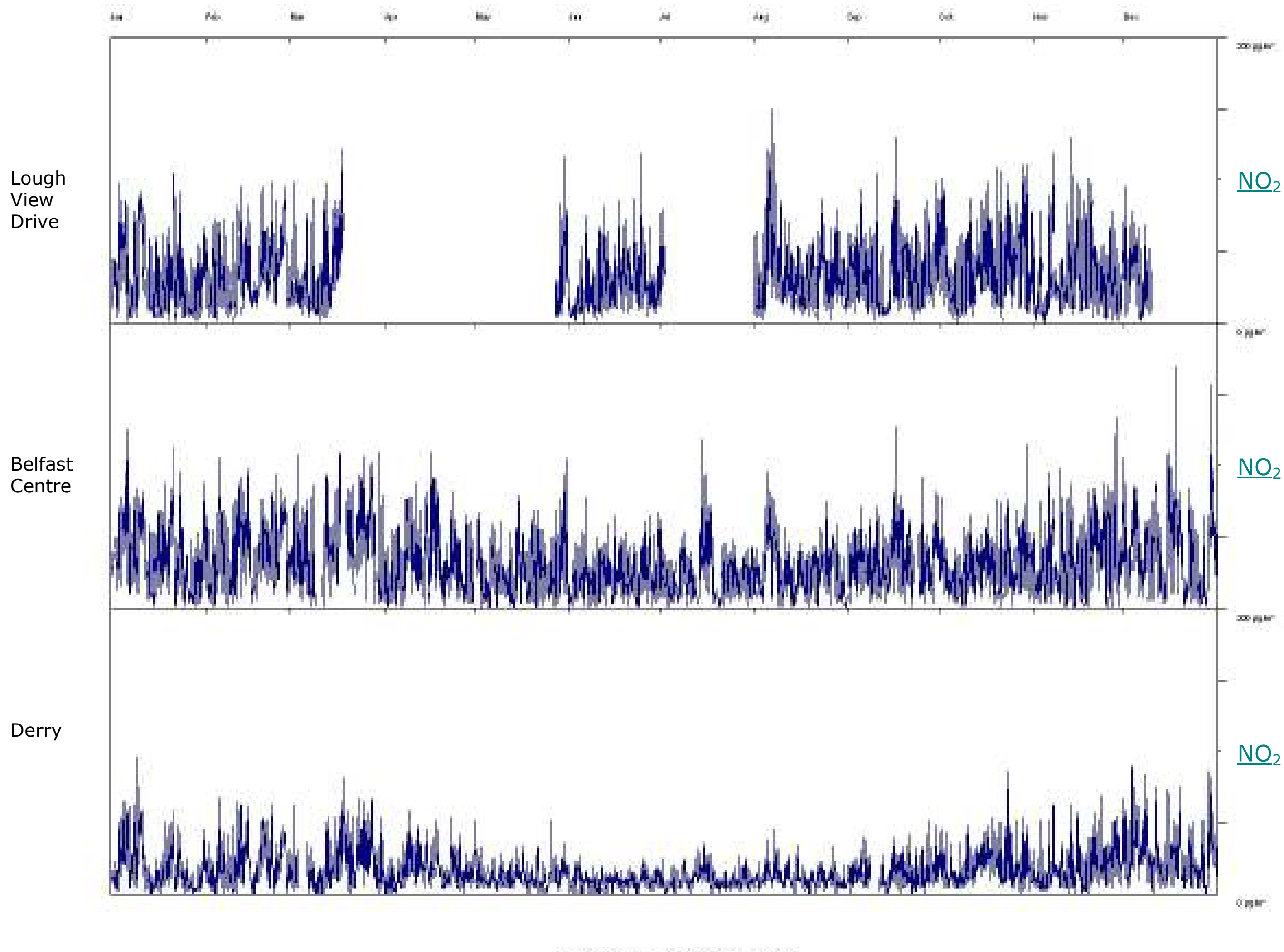
POLLUTANT	PM_{10}	NO_X	NO_2
Number Very High	0	-	0
Number High	0	-	0
Number Moderate	4	-	0
Number Low	6619	-	5507
Maximum 15-minute mean	144 µg m^{-3}	651 µg m^{-3}	163 µg m^{-3}
Maximum hourly mean	83 µg m^{-3}	556 µg m^{-3}	149 µg m^{-3}
Maximum running 8-hour mean	57 µg m^{-3}	273 µg m^{-3}	119 µg m^{-3}
Maximum running 24-hour mean	51 µg m^{-3}	225 µg m^{-3}	92 µg m^{-3}
Maximum daily mean	47 µg m^{-3}	205 µg m^{-3}	80 µg m^{-3}
Average	18 µg m^{-3}	64 µg m^{-3}	34 µg m^{-3}
Data capture	75.7 %	62.9 %	62.9 %

Note: A factor of 1.3 should be used to correct TEOM PM_{10} to gravimetric equivalent PM_{10}
All mass units are at 20'C and 1013mb

Table A1.5: Air Quality Exceedence Statistics, Lough View Drive in 2003

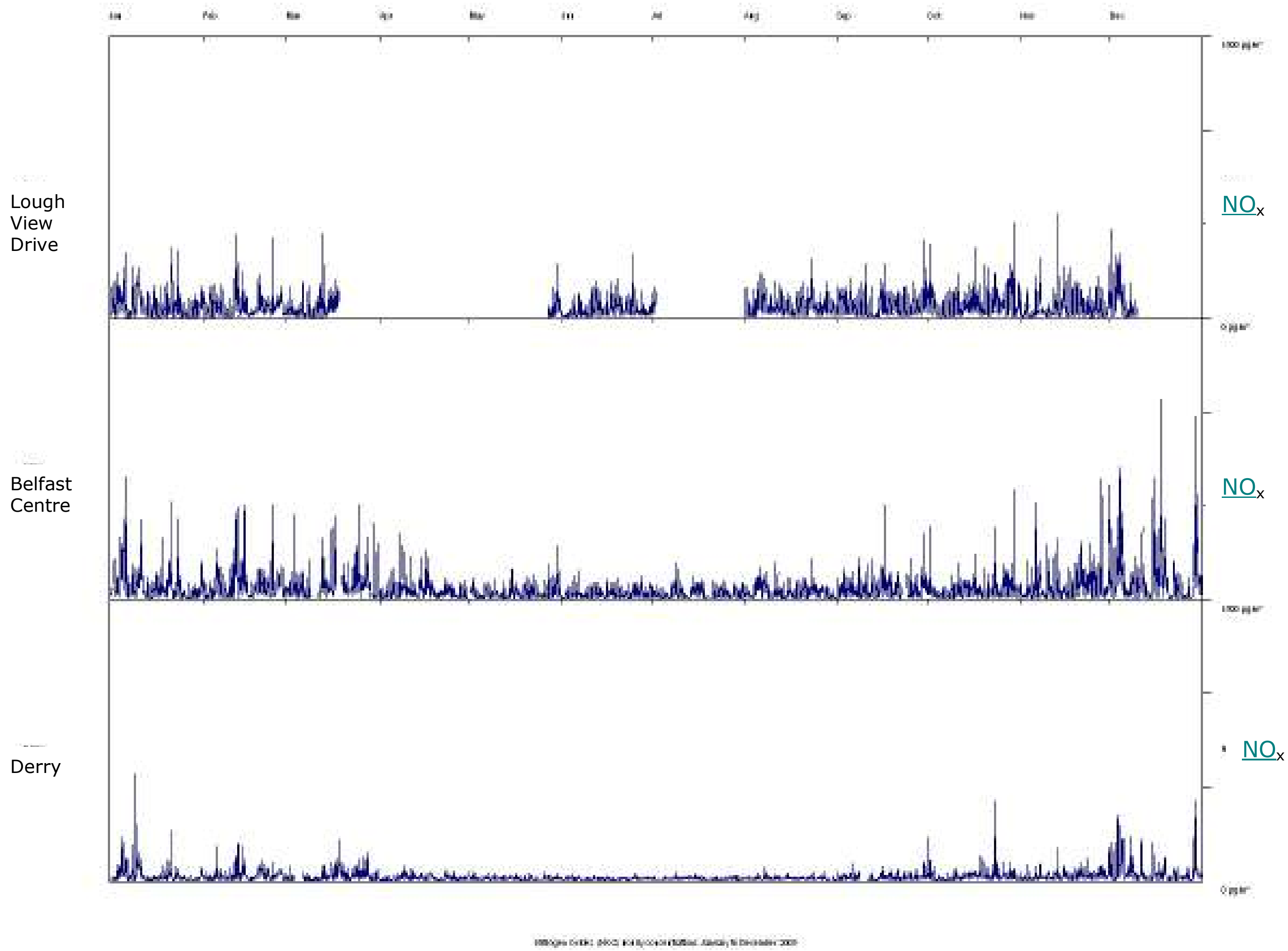
Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µg m^{-3}	9	9
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µg m^{-3}	0	-
Nitrogen Oxides (NO_2)	Annual mean > 30 µg m^{-3}	1	-
Nitrogen Dioxide	Annual mean > 40 µg m^{-3}	0	-
Nitrogen Dioxide	Hourly mean > 200 µg m^{-3}	0	0



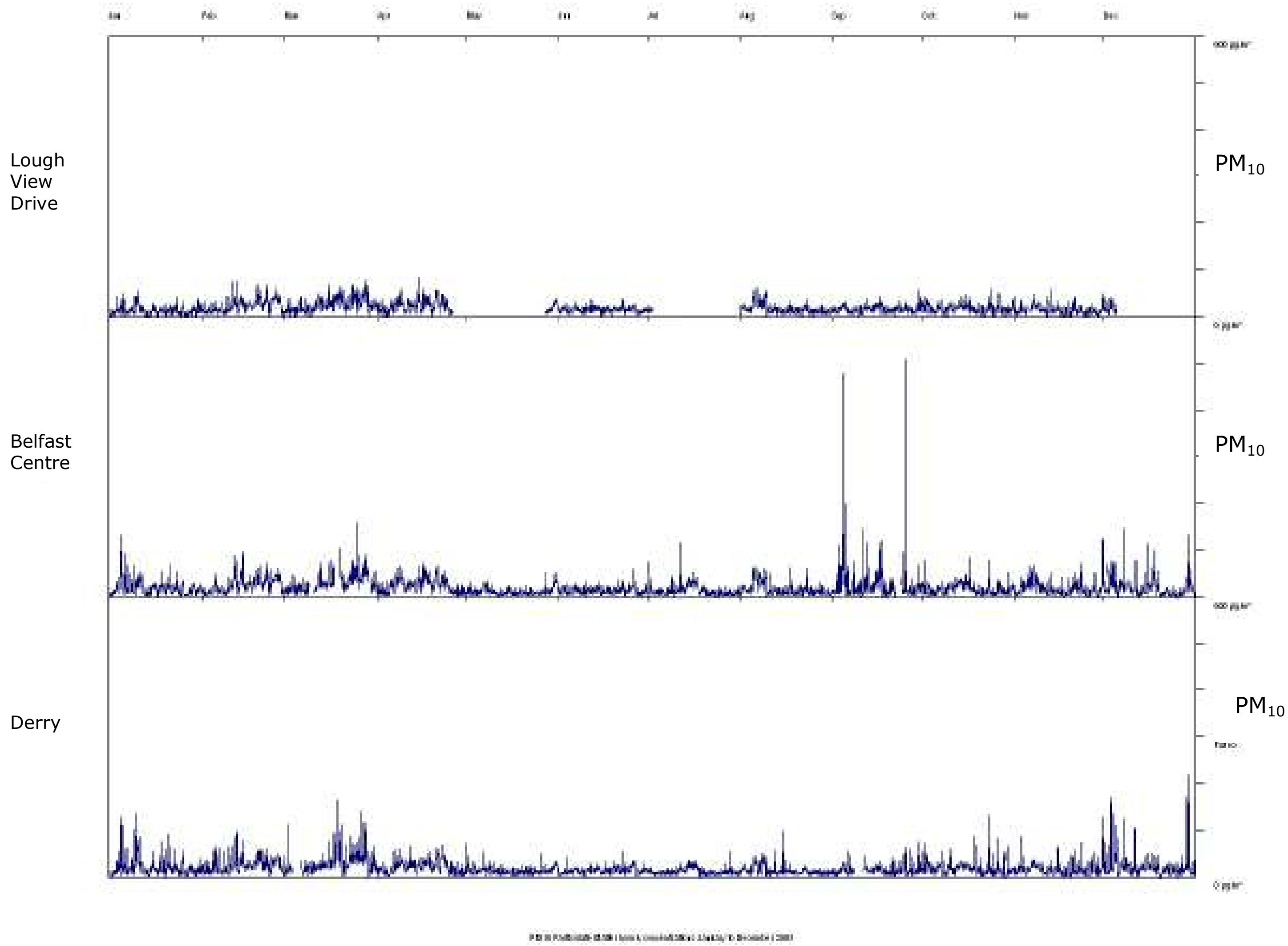


NO_2 Data at Lough View Drive compared to data at Belfast Centre and Derry

netcen



NO_x Data at Lough View Drive compared to data at Belfast Centre and Derry



PM$_{10}$ Data at Lough View Drive compared to data at Belfast Centre and Derry

Appendix 2
Aldergrove Met Station Data

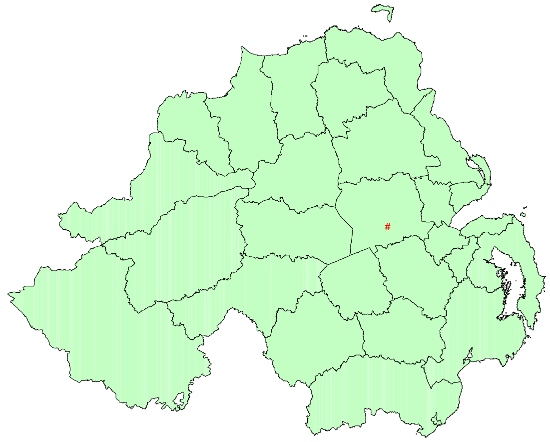
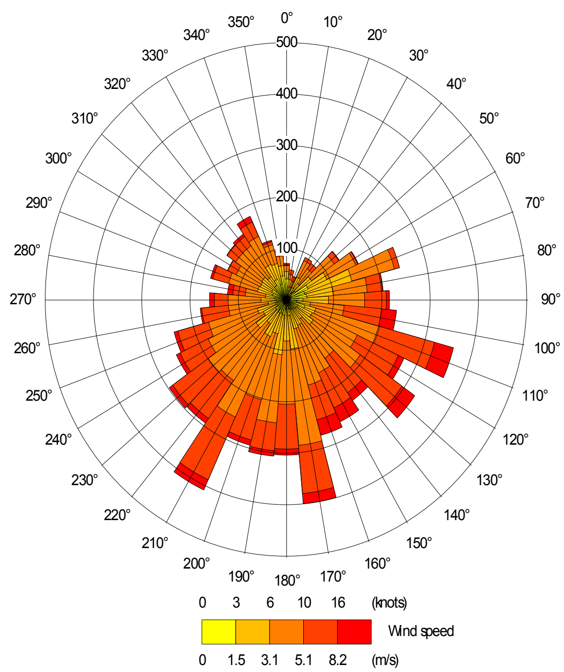


Figure A2- Location of Aldergrove Station

Table A2 - Characteristics of Aldergrove Station

Description – Aldergrove International airport.	
DCNN	9142
Eastings	314700
Northings	379800
Latitude Deg Min	54 39 N
Longtitude Deg Min	06 13 W
Station height AMSL (m)	68
Effective height of anemograph (m)	10



Wind rose for the Aldergrove 2003 met data

Appendix 3
Traffic Data from other Links/Roads in Castlereagh and Belfast

Grid Ref No.	Road	Location	Direction	24 Hr 2-Way Flow	Year
32973697	M1	Blacks Road On Slip	To Belfast	15065	2002
32983696	M1	Blacks Road Off Slip	To Blacks Road	14119	2003
33083713	M1	At Stockmans Lane Bridge	To Belfast	52390	2001
33173725	M1	Stockmans Lane to Broadway	To Belfast	65152	2002
33263735	Westlink	At Roden Street	To City Centre	60308	2001
33353751	Westlink	At Clifton Street (Southbound)	Towards M1	33894	2002
33353752	Westlink	At Clifton Street (Northbound)	Towards M2	41140	2002
33153708	Lisburn Road	At Kings Hall	To City Centre	12381	2002
33733756	Sydenham By-Pass	East of Airport Entrance	To Belfast	53956	2002
33823726	Knock Road	At Shell Service Station	To Upper Knockbreda	38812	2002
33893743	Hawthornden Way	At Campbell College	To Parkway	27772	2002
33503725	Ravenhill Rd	South of Broughton Gardens	To Belfast	20717	2003
33333732	Donegall Road	West of Sandy Row	To City Centre	12371	2002
33723741	Upper Newtownards Rd	Opposite Fire Station	To City Centre	22275	2001
33443726	Ormeau Road	North of Ormeau Bridge	To City Centre	29602	2000
33443743	Oxford Street	Opposite Court House	To East Bridge Street	33998	2000
33423744	Victoria Street	At Marlborough Street	To Dunbar Link	38401	2000
33413739	May Street	West of Montgomery Street	To City Hall	21820	1999
33453744	Queen's Bridge	Bridge End (In)	To City Centre	18225	2000
33453744	Station Street Flyover	Bridge End	To Bridge End	10380	2000
33473739	East Bridge Street	Albert Bridge	To City Centre	29844	2002
33413741	Chichester Street	At Multi Storey Car park	To Victoria Street	14009	2000
33293738	Grosvenor Road	West of Westlink	To City Centre	17655	2002
33323744	Westlink	At Divis Street (To M2)	Towards M1	42111	2000
33323744	Westlink	At Divis Street (To M1)	Towards M2	45547	2000
33693744	Holywood Road	West of Pomona Avenue	To City Centre	17449	2002
33413750	Nelson Street	At Little Patrick Street	To City Centre	6655	2001
33453755	Garmoyle Street	North of Dock Street	To Corporation Street	14366	2001
33563744	Newtownards Road	At Belvoir Street	To City Centre	18483	2002
33593740	Albertbridge Road	East of Templemore Street	To City Centre	22163	2002
33423711	Annadale Embankment	At Deramore High School	To Kings Bridge	14820	2002
33543689	Saintfield Road	South of Lenaghan Avenue	To City Centre	24885	2002
33503706	Saintfield Road	North of Church Drive	To City Centre	23831	2001
33913739	Upper Newtownards Rd	Near Cabinhill Park	To City Centre	34468	2000
33153708	Lisburn Road	At Kings Hall South Slip	To Balmoral Avenue	12664	2002
33163709	Lisburn Road	At Kings Hall North Slip	To City Centre	12730	2002
34073739	Upper Newtownards Rd	At Dundonald Cemetery	To Belfast	37530	2002
32803675	Queensway	At Derriaghy Cricket Club	To Belfast	11128	2002
33443759	Duncrue Street	South of Milewater Road	To Garmoyle Street	5212	2002
33733737	North Road	South of Kirkliston Drive	To Grand Parade	14603	2002
33403723	Stranmillis Embankment	Kings Bridge to Ormeau Bridge	To Ormeau Bridge	7701	2002
33413721	Annadale Embankment	Kings Bridge to Ormeau Bridge	To Ormeau Bridge	10257	2002
33463729	Ormeau Embankment	Ravenhill Road to Ormeau Road	To Ormeau Road	12111	2002
33423754	York Street	South of Brougham Street	To York Road	18861	2002
33063696	Finaghy Road South	-	To Upper Malone Road	12918	2002
33023703	Finaghy Road North	-	To Upper Lisburn Road	11208	2001
33643680	Knockbracken Road	-	To Saintfield Road	3297	2002
33503743	Short Strand	South of Mountpottinger Link	To City Centre	27054	2002
33503743	Mountpottinger Link	At Bus Depot	To City Centre	7600	1999
33,423,753	York Street	(Off)	To Nelson Street	47158	2002
33423753	M3	M2 ONSLIP	-	63453	2003
33623674	Saintfield Road	At Ivanhoe Inn	To City Centre	32886	2002

Appendix 4
Model Verification and Adjustment

Data from the two monitoring stations in Castlereagh BC has been used to verify and adjust the output results from DISP and LADSUrban models. The data used are:

- Castlereagh Espie Way (PM10 and SO2)
- Castlereagh Lough View Drive (PM10 and NO2)

NOx/NO2 verification and adjustment

NOx-NO2 data from Lough View Drive roadside has been use to verify and adjust the model results at Castlereagh Lough View Drive. As covered in Appendix 1, the NOx-NO2 data capture for 2003 in Lough View Drive was of 60%. In order to verify whether this result could be applied as representative of the full dataset for 2003, the data was compared to Belfast Centre and Derry. As specified in LAQM.TG(03), NOx-NO2 period averages from the two AURN station have been compared to NOx-NO2 annual averages. Table A4.1 shows the corrected NOx-NO2 annual average (NOx annual = 61 and NO2 annual = 33).

Table A4.1 Corrected NO_x-NO_2 Annual Averages at Lough View Drive

Perid/Annual	Belfast Centre	Am/Pm	Derry	Am/Pm	Lough View Drive	Ra	Lough View Drive Annual 2003
NO2 period (Pm)	33		17		34		
NO2 2003 (Am)	32	0.970	17	1.000		**0.985**	**33**
NOx period (Pm)	61		27		64		
NOx 2003 (Am)	59	0.967	25	0.0926		**0.946**	**61**

(see LAQM.TG(03))

NOX

Rural background NOx levels of 25ugm-3 has been added to a modelled NOx (38ugm-3) given a value of total NOx of 63ugm-3. This is very close result compared to the annual measured result at Lough View Drive of 61 ugm-3.

NO2

NO2 road contribution has been calculated from the modelled NOx (38umg-3) road contribution following recommendations in LAQM.TG(03). NO2 road contribution is of 9 umg-3. This added to a background annual mean of 20ugm-3 gives a total modelled NO2 result of 29ugm-3. Therefore, the following correction factor has been used:

$$NO_{2\ monitoring\ data}\ [Annual\ mean] = background_{NO2} + Modelled\ result + 4$$

SO2 verification and adjustment

Annual average rural SO2 background was obtained from 1kmx1km maps (4 ugm-3). The modelled contribution at the Espie Way monitoring station was of 3 ugm-3. Therefore, the modelled results at Espie Way was of 7 ugm-3[3].

Table A4.2 SO_2 Model Verification

Background		Modelled contribution		Final modelled
4	**+**	**3**	**=**	**7**

$$SO_{2\ monitoring\ data}\ [Annual\ mean] = background_{SO2} + Modelled\ result$$

[3] Please note that the monitoring data of SO2 for 2003 runs from September 2002 to August 2003. This is due to the 2003 data remains provisional pending engineers reports on the data compared to other SO2 concentrations across Northern Ireland

Pye and Vincent (2003) relationships from short-term concentration and annual mean were obtained (see table A4.3). These following multipliers have been applied to adjust modelled concentrations 15 minutes, hourly and daily with monitoring results

$$SO_{2\ monitoring\ data} = \text{Modelled result} \times 1.18$$
[15min 99.9%ile]

$$SO_{2\ monitoring\ data} = \text{Modelled result} \times 1.07$$
[1-hour 99.7%ile]

$$SO_{2\ monitoring\ data} = \text{Modelled result} \times 1.80$$
[24-hour 99.189%ile]

:

Table A4.3 SO_2 Model Verification for short term concentrations

Short term concentration	**Modelled** (using Pye and Vincent, 2003)	**Measured at Espie Way**	**Multiplier**
15 minute mean - 99.9th percentile	**85.6**	**101**	**1.18**
1 hour mean - 99.7th percentile	**64.6**	**69**	**1.07**
24 hour mean – 99.18th percentile	**23.3**	**42**	**1.80**

PM10

PM_{10} data from both monitoring stations have been used to verify and adjust model results. As the data capture was below 90%, the data obtained from a period of monitoring, has been converted to full 2003 following recommendations in the LAQM.TG(03). Table Table A2.1 show the results obtained at both monitoring stations. The PM10 results from DISP do not have to be adjusted as background plus DISP is equal to the monitoring data. However, the LADSUrban results have to be adjusted by a factor of 2.25. This factor of 2.25 is probably due to resuspention of dust which is not taken into account in LADSUrban.

Table A4.1 Corrected NO_x-NO_2 Annual Averages at Lough View Drive

Perid/Annual	Belfast Centre	Am/Pm	Derry	Am/Pm	Lough View Drive	Ra	Lough View Drive Annual 2003
PM_{10} period (Pm)	19.0		19.1		17.7		
PM_{10} 2003 (Am)	18.5	0.974	18.1	0.948	-	0.961	17 (*22.1 in grav*)
Perid/Annual	Belfast Centre	Am/Pm	Derry	Am/Pm	Espie Way	Ra	Lough View Drive Annual 2003
PM_{10} period (Pm)	18		17.3		14.2		
PM_{10} 2003 (Am)	18.5	1.027	18.1	1.046		1.036	14.7 (*19.1 in grav*)

*Teom data (need to multiply it by a factor of 1.3 to obtain gravimetric)

Table 3.1 Summary of model bias correction

	Monitoring data 2003	**Background** (from NAEI)	**DISP** (Domestic Fuel)	**LADSUrban** (Road emissions)	**Adjustment factor**
Espie Way background	19.1 $\mu g\ m^{-3}$	18 $\mu g\ m^{-3}$	1.1 $\mu g\ m^{-3}$	0 $\mu g\ m^{-3}$	*No factor necessary*
Lough View Drive roadside	22.1 $\mu g\ m^{-3}$	18 $\mu g\ m^{-3}$	0.5 $\mu g\ m^{-3}$	1.6 $\mu g\ m^{-3}$	21.3=18+0.5+(1.6***2.25**)