Air Quality Review and Assessment
Stages II and III
for Arun District

as required by
Environment Act 1995 Part IV

Prepared by:

Environmental Health
Arun District Council
in conjunction with
Sussex Air Quality Steering Group

May 2000

Air Quality Review and Assessment Stage II and III for Arun District

1. Introduction

Arun District Council has undertaken a review of local air quality in order to fulfil its obligations under the Environment Act 1995 Part IV. The Act requires Arun District Council to review the sources of pollution in its own and neighbouring areas, and to assess likely future concentrations of a number of pollutants.

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The work began in April 1998 and was completed in May 2000.

There are two main objectives of a review and assessment of air quality:

- to identify those areas at a local level where national policies and measures appear unlikely to deliver the air quality objectives by the year 2005

- to ensure that air quality considerations are integrated into a local authority's decision making process

1.1 National Targets

In its National Air Quality Strategy (1999) the Government set a series of revised targets for concentrations of harmful pollutants in air, these are listed in Table 1.1.

Table 1.1: National Air Quality Standards and Objectives

Substance	*Air quality objective levels*	*Air quality objective levels*
Benzene	16.25 micrograms per cubic metre or less, when expressed as a running annual mean	31st December 2003
1,3 -Butadiene	2.25 micrograms per cubic metre or less, when expressed as a running annual mean	31st December 2003
Carbon monoxide	11.6 milligrams per cubic metre or less, when expressed as a running 8 hour mean	31st December 2003
Lead	0.5 micrograms per cubic metre or less, when expressed as an annual mean 0.25 micrograms per cubic metre or less, when expressed as an annual mean	31st December 2004 31st December 2008
Nitrogen dioxide	200 micrograms per cubic metre, when expressed as an hourly mean, not to be exceeded more than 18 times a year 40 micrograms per cubic metre or less, when expressed as an annual mean	31st December 2005 31st December 2005
PM_{10}	50 micrograms per cubic metre or less, when expressed as a 24 hour mean, not to be exceeded more than 35 times a year 40 micrograms per cubic metre or less, when expressed as an annual mean	31st December 2004 31st December 2004
Sulphur dioxide	125 micrograms per cubic metre or less, when expressed as a 24 hour mean, not to be exceeded more than 3 times a year 350 micrograms per cubic metre or less, when expressed as an hourly mean, not to be exceeded more than 24 times a year 266 micrograms per cubic metre or less, when expressed as a 15 minute mean, not to be exceeded more than 35 times a year	31st December 2004 31st December 2004 31st December 2005

Stage II assessments are only required for those pollutants shown to be significant by Stage I. The aim of Stage II is to provide further screening of pollutant concentrations in local authority areas. Stage II is not intended to provide an accurate prediction of levels of current or future air quality across the whole of the authority's area. The second stage does not require a local authority to estimate every area of exceedence within its locality for each pollutant in question or to estimate the geographical extent of potential exceedence areas.

The Air Quality Regulations 1997 made a statutory duty on local authorities to ensure that, by the year 2005, air pollutant concentrations, both in Arun and nationally, comply with the specific objectives.

Ozone was not included in the list of pollutants for local authority control, and is not therefore covered in the Air Quality Regulations. Due to the nature of ozone pollution, action at the local authority level will not be effective in tackling high concentrations. Action is therefore being taken by the National Government at International level to combat high concentrations of ozone.

The review and assessment has regard to the air quality objectives as laid down in the Regulations rather than the air quality standards. The recommended air quality **standards** from the Strategy are set as benchmarks or reference points for setting the objectives and are based on the assessment of the effects of each pollutant on human health. The air quality **objectives** however, represent the Government's present judgement of achievable air quality within a specified timescale.

1.2 Review and Assessment Process

In order to determine compliance with these objectives, a process of air quality review and assessment has been recommended. To ensure that there is some consistency between local authorities, the Government has issued Guidance on how local authorities should carry out their reviews and assessments. The guidance notes issued are as follows:

General Guidance
- Framework for Review and Assessment of Air Quality
- Developing Local Air Quality Action Plans and Strategies: The Main Considerations
- Air Quality and Transport
- Air Quality and Land-Use Planning

Technical Guidance
- Monitoring for Air Quality Reviews and Assessments
- Preparation and Use of Atmospheric Emission Inventories
- Selection and Use of Dispersion Models
- Review and Assessment: Pollutant Specific Guidance

This review and assessment has been undertaken with regard to these guidance notes, most notably "Review and Assessment: Pollutant Specific Guidance".
This Guidance note breaks the process down into three stages:

- **Stage I –** gather information about current and likely future sources of air pollution. This includes levels of traffic on the road, industrial processes (large and small) and an examination of current air pollution monitoring data for the area. The sources of pollution are then examined to determine whether the general public are likely to be exposed to any pollution over the timescales of the air quality objectives, and to determine if either the operation (road or industry) will close before 2005, or whether new operations are planned. If significant sources of any of the pollutants named in Table 1 above are identified then the authority must progress to Stage II.

- **Stage II –** This Stage involves the application of screening techniques to determine both current and future levels of air pollution. A further examination of any current monitoring data should be carried out. If air quality in 2005 is predicted to be above any of the objectives above then a Stage III assessment will be required.

- **Stage III –** In Stage III more complex techniques (dispersion modelling, real-time monitoring and emission inventories) are required, in order to determine the nature and size of any areas where the objectives are exceeded.

If at the end of Stage III air pollutant concentrations are predicted to be above any of the specific objectives (see Table 1.1) then an Air Quality Management Area must be declared, and wider consultation is then required. Following from this, an Air Quality Action Plan should then be prepared, detailing how the local authority proposes to introduce measures to reduce the concentrations of air pollutants in line with the Government objectives.

This report forms the second and third stage of the statutory air quality review and assessment process for Arun District Council and is based on the findings of the Stage I report published in December 1998.

In Stage I those activities which may represent significant sources of the relevant pollutants were identified as follows:

Road Sections -	A27; A259; B2166; Aldwick Road, Barrack Lane and Hawthorn Road in Bognor Regis.
Pollutants of concern:	Particulate Matter (PM_{10}) and Nitrogen dioxide (NO_2).
Part B Processes -	Lafarge Redland Aggregates Limited operating a roadstone coating process.
Pollutants of concern:	PM_{10} and SO_2

2. Particulate Matter (PM_{10} - particles less than 10mm in diameter)

PM_{10} is of major concern, as it has been linked with both increased morbidity and premature mortality, estimates have placed the figure as high as 10,000 excess premature deaths per year for the whole of the UK.

The major source of particulate matter is the motor vehicle, which nationally accounts for 24% of emissions, with other major sources being industrial emissions (38%) and power stations (16%) and domestic and other low power combustion (17%). These are only the primary PM_{10} emissions, and additional contributions in the atmosphere arise from secondary particles (formed through chemical reactions involving nitrogen dioxide and sulphur dioxide in the atmosphere), and particles such as sea salt, road dust and wind blown soil.

During the Stage I air quality review and assessments all Sussex local authorities identified the pollutant PM_{10} for further consideration. In specific cases this was due to the level of local PM_{10} emissions in the area, but in the majority of cases this was due to the background levels of PM_{10} reported across the south east of England. Since the Stage I assessments were completed, the Department of the Environment, Transport and the Regions (DETR) has completed its Review of the National Air Quality Strategy (NAQS), May 2000, to update the 1997 version, with important new developments, including the EC Air Quality Framework and Daughter Directives. One of the main changes within the Strategy Review was to revise the PM_{10} air quality objective to:

- Annual Mean of 40 $\mu g/m^3$; and
- 24-hour running mean of 50 $\mu g/m^3$, not to be excceded more than 35 times a year (approximately equivalent to a 90th percentile of 50 $\mu g/m^3$)

Both are to be achieved by 31st December 2004.

The European Union 'Daughter Directive' gives the following limit value for PM_{10}

- Stage 1, to be achieved by 1 January 2005: 24-hour limit value of 50 $\mu g/m^3$, not to be exceeded more than 35 times a year (approximately equivalent to a 90th percentile of 50 $\mu g/m^3$).

Projected concentrations in 2004 are expected to be lower than the EU 'Daughter Directive' Stage 1 limit values at most urban background locations, with the possible exception of central London. Concentrations at the roadside are expected to be higher than at nearby background locations. Concentrations higher than the EU Stage 1 limit value are therefore expected at the roadside of heavily trafficked roads in urban areas in 2004. Concentrations at sites with significant industrial source contributions to measured ambient PM_{10} concentrations are also expected to be at risk of exceeding this limit value.

It is unfortunate that there are no sites in Sussex with PM_{10} monitors on the national pollution monitoring network. The nearest national network sites are those in

Southampton Centre and Rochester (in the Medway Towns in Kent). A NETCEN report produced alongside the review of the NAQS concludes that the Stage I EC Limit value is likely to be met in all but the busiest of city centres, and in particularly heavily influenced industrial areas. Both the Southampton Centre (42 $\mu g/m^3$) and Rochester (41 $\mu g/m^3$) sites comply with the proposed EC Stage I limit value, suggesting that Arun District Council will also comply with this revised target value.

This report presents assessments of PM_{10} concentrations in the local area from potentially significant sources. The revised local air quality management technical guidance document (LAQM.TG4, 2000) advises that an annual mean PM_{10} concentration of 28 $\mu g/m^3$ is equivalent to the EC Stage I limit value. For assessments close to roads the Highways Agency's Design Manual for Roads and Bridges has been used. For industrial locations various models have been used to make an assessment, and details are specified for individual cases. Background concentrations of PM_{10} are then added to these calculations, and have been taken from national mapping work prepared by AEA NETCEN, detailed in the Stage I report.

3. Nitrogen dioxide

Nitrogen dioxide is a respiratory irritant, and is also thought to be a sensitiser, which may worsen other conditions such as hayfever. There are a number of oxides of nitrogen present in the atmosphere, but it is nitrogen dioxide which gives rise to health concerns.

The updated NAQS included the following changes to the NO_2 air quality objective:

- Annual Mean of 40 $\mu g/m^3$; and
- 1-hour mean of 200 $\mu g/m^3$, not to be exceeded more than 18 times a year

Both are to be achieved by 31st December 2005.

The assessment of concentrations of nitrogen dioxide (NO_2) is a difficult process. Nitrogen dioxide is a secondary pollutant, that is it is not emitted directly as nitrogen dioxide but it formed through a series of chemical reactions from emissions of nitric oxide (NO) largely due to incomplete combustion of fossil fuels. For example in motor vehicle exhaust, roughly 95% of the emissions are NO with only 5% direct NO_2.

For this reason, for the purpose of review and assessment, a more reliable estimate of future concentrations may be available for oxides of nitrogen (NOx) rather than NO_2. Government Guidance [10] therefore suggests as an interim approach that air quality objectives be compared with the following concentrations of NOx (which, due to the atmospheric chemistry involved, vary with increasing distance from the road source):

Distance from kerb	NOx (ug/m3)
0 – 5 metres	108
5 – 10 metres	102
10 – 15 metres	97
15 – 20 metres	93
20 – 25 metres	90
25 – 30 metres	87
30 metres	85

Again, close to roads these concentrations will be assessed using the Highway Agency's Design Manual for Roads and Bridges.

4. Sulphur dioxide (SO_2)

Sulphur dioxide is an acute respiratory irritant, hence the short averaging time for the standard. Sulphur dioxide may also be converted through chemical reactions in the atmosphere to secondary sulphate particulate matter.

Nationally, the major source of sulphur dioxide is power stations, which account for 65% of emissions, with other major sources being industrial emissions (24%) and commercial and domestic heating (6%).

The updated NAQS included the following changes to the SO_2 air quality objective:

- 1-hour mean of 350 $\mu g/m^3$ (not to be exceeded more than 24 times a year);
- 24-hour mean of 125 $\mu g/m^3$ (not to be excceded more than 3 times a year); and
- 15-minute mean of 266 $\mu g/m^3$ (not to be excceded more than 3 times a year).

The 1-hour and 24-hour means are to be achieved by 31st December 2004, and the 15-minute mean by 31st December 2005.

Some monitoring of sulphur dioxide is undertaken in Sussex by Crawley, Eastbourne and Adur Local Authorities, as part of the national survey of smoke and sulphur dioxide. This method uses wet chemical techniques, and is only capable of giving daily average sulphur dioxide concentrations. A continuous automatic ultra violet monitoring system is in operation at Lullington Heath (DETR) site in East Sussex.

National sulphur dioxide monitoring data shows that recorded concentrations have exceeded the 15-minute mean of 266 $\mu g/m^3$ (not to be excceded more than 3 times a year), especially in the vicinity of large point sources of sulphur dioxide, such as power stations.

5. The Techniques used in the Stage II/III Review and Assessment

5.1 The use of Dispersion Modelling in Air Quality Management

Dispersion models describe how pollutants are spread and mixed in the atmosphere. Mathematical procedures are used to calculate pollutant concentrations based on emission rate (mass of pollutant emitted over time) and dilution rate (the volume of surrounding air into which the pollutant is being mixed per unit time). In this way, dispersion models link measured air quality with emissions data, they can be used to improve emission inventories and monitoring programmes, and assist in planning control measures.

Dispersion models are one of the tools available during the management of air quality, and are particularly useful in the following areas:

- Air Pollution monitoring is a very effective tool for assessing changes in air quality over time and in ensuring that policy objectives are met. It is an expensive tool, with coverage of all sites of interest in a local authority by automatic monitors being prohibited by cost. Dispersion models are useful for ‘filling in the gaps’ of a monitoring programme since it is clearly impractical to monitor at every point of interest. Models therefore allow an assessment to be made of air quality in locations where no monitoring is undertaken.

- Monitoring clearly also has little or no predictive capabilities, tools are therefore needed to evaluate future policies, and make predictions of concentrations into the future. Such scenario analysis is a vital part of the air quality management process, especially in the development of air quality action plans. Stage III of the review and assessment process and further stages require the use of comprehensive validated models.

- Dispersion modelling can also be used in source attribution work. Emission inventories can show the percentage of emissions for a particular pollutant which arise from different sectors, but these may not correspond with ground level exposure to pollution. This is because road transport emissions are emitted at ground level nearest to where people are exposed, whereas emissions from tall chimney stacks are significantly diluted before they reach ground level. The important point is that in terms of ground level *concentrations* ground level sources are more important than high level sources. Again, the only way to make an assessment of this kind is through dispersion modelling.

- Another predictive use of dispersion models is in pollution forecasting, where weather forecasts can be used as an input to dispersion models. In this way it is possible to give advance warning of any possible exceedences of air quality guidelines and standards to the public.

Models therefore have many roles in air quality management and should be seen as essential for testing new policies or developments that affect air quality.

5.2 Distribution of Pollutants

Before considering different modelling approaches it is useful to consider the character of air pollution. There can be many thousands of individual sources in an area which can be stationary or mobile. The pattern of emissions can be very complex both spatially and temporally. Vehicle emissions in particular can be very difficult to predict given the range of different vehicle types and driving patterns. The concentration of a pollutant at any point is made up from very local sources, other sources throughout the region, other sources from around the UK and also an element which is transboundary in origin.

For the purposes of modelling, sources are often split into three categories:

- Line sources - such as roads, railways, runways etc
- Point sources - such as chimney stacks
- Area sources - such as domestic emissions, fugitive dust emissions

Some models are able to model each of these types of source and combine the output, whilst others deal specifically with one source type.

Nowadays most models come in the form of computer programs, although there are some which are paper based. This has simplified the undertaking of calculations, and has allowed the production of visually more appealing output. One disadvantage of this is that non-specialists could now easily use models, but not be entirely sure of what they are producing. The "Garbage in/Garbage out" principle still holds.

5.3 Meteorology

Meteorology determines how quickly emissions are diluted, hence an essential input to dispersion models is meteorological data which must be representative of the area of interest. Models differ significantly in both their meteorological input requirements and the way in which they interpret the data to predict dispersion. Traditional dispersion models used a stability class approach to describe the state of the atmosphere. More recent models aim to calculate variables which better represent the state of the atmosphere. These variables are not routinely measured but need to be calculated from more basic parameters. Several models therefore use “meteorological pre-processors” to estimate these variables for direct input to the models.

For ground level sources such as roads, the conditions which lead to the highest concentrations are those where the wind speed is low and the atmosphere is stable. Conversely, for an elevated source (e.g. a chimney stack) the conditions which typically lead to high ground level concentrations are unstable conditions, where the plume is rapidly mixed downwards. Peak concentrations are therefore determined by very different meteorological conditions depending on the nature of the source. The source of emission is clearly important, but meteorology determines the final concentration of a pollutant.

From the point of view of air quality management it is often those situations that are most difficult to model about which information is required. Examples include busy town and city centre streets where dispersion is complex, or areas where the terrain is complex and may affect pollutant dispersion.

Particular models have been recommended for use in Stage II air quality assessments by the DETR guidance notes and are discussed below.

5.4 **DMRB** (Design Manual for Roads and Bridges, Volume 11)

The model was developed by the Transport Research Laboratory for the initial assessment of the air quality impact of existing or planned road schemes, and it includes a method for estimating vehicle emissions from light and heavy duty vehicles up to the year 2020. In its simplest form the model comprises a series of look up tables based on outputs from a Gaussian dispersion model. The latest revision was issued in May 1999, when the model was adapted to predict National Air Quality Objectives, and to take account of background pollutant concentrations separately.

The model uses the following as input data:

- hourly vehicle flow
- proportion of light and heavy goods vehicles
- Vehicle speeds,
- Year
- Distance to receptor
- Background Concentration

The model initially gives annual mean concentrations of carbon monoxide, oxides of nitrogen, hydrocarbons and PM_{10}, but converts these to National Air Quality Strategy objectives.

A spreadsheet version of the model has been provided free of charge by the operators of the Modelling Helpline for local authorities (Stanger Science and Environment) and this version (January 2000) has been used in this assessment.

5.5 GSS (Environment Agency Guidance for Estimating the Air Quality Impact of Stationary Sources)

This paper based manual developed by the Environment Agency allows calculation of concentrations in the vicinity of point sources of pollution (i.e. chimney stacks). The method is based on a series of runs of a more advanced dispersion model (UK ADMS 2.2), with these results for a variety of conditions being translated into look-up charts. The model requires geographical and engineering data (for each stack) as inputs:

Geographical Inputs

- Stack numbers/names and positions
- Extent of study area
- Surface roughness (from manual)
- Types and positions of any sensitive receptors
- Meteorological type (from manual)

Engineering Inputs

- Stack height
- Operational mode
- Flues
- Pollutants
- Release temperature
- Release velocity

The model is capable of making predictions for all NAQS pollutants, and using the relevant conversion factors over the correct averaging periods. The model predicts the maximum ground level concentration arising from the source in question, as well as the distance from the point of release to this maximum.

Outputs from both of these models, and possibly from other sources are required in Stage II assessments.

Modelling is a valuable tool in air quality management, allowing the prediction of future concentrations of pollution which might not otherwise be possible. Specific models have been recommended for use in Stage II of the review and assessment process for investigation of point sources and roads. These models are simplifications of the dispersion process, and can provide an indication of the need for more advanced dispersion modelling. It is clear however that modellers need detailed knowledge of input parameters and model processes in order to fully understand results.

6. Investigation of Sources Identified in Stage 1

Each of the individual sources of concern identified in the Stage I assessment are reviewed here, and an assessment of whether or not concentrations will meet the National Air Quality Strategy objectives is given.

6.1 Road Sections

6.1.1 DMRB

Explanation of information used in DMRB modelling

Nearest receptor
The receptors' identified in this assessment are taken as being those non-occupational properties closest to the road in the section being assessed. Using Ordnance Survey Data via Fastmap GIS it is possible to estimate the distances from the building facade to both the kerb and centre of the road.

Year
To estimate annual mean concentrations for both PM_{10} and NO_2 using DMRB the appropriate year must be used, relating to the target date for each objective. All road traffic modelling has been carried out for 2004 (PM_{10}) and 2005 (NO_2).

Vehicle speeds
Using information obtained from the emissions inventory (UKRAPID) database prepared by CES Ltd on behalf of Sussex Authorities, the average speed (Km/h) of each section has been estimated.

Hourly vehicle flow
West Sussex County Council's (WSCC) Surveyors Department has provided traffic flow data for each of the relevant sections of road. In most cases the data is for actual counted Annual Average Daily Traffic Flows (AADT) from 1998. Where actual flow counts were not available the traffic flow was estimated using the WSCC Model.

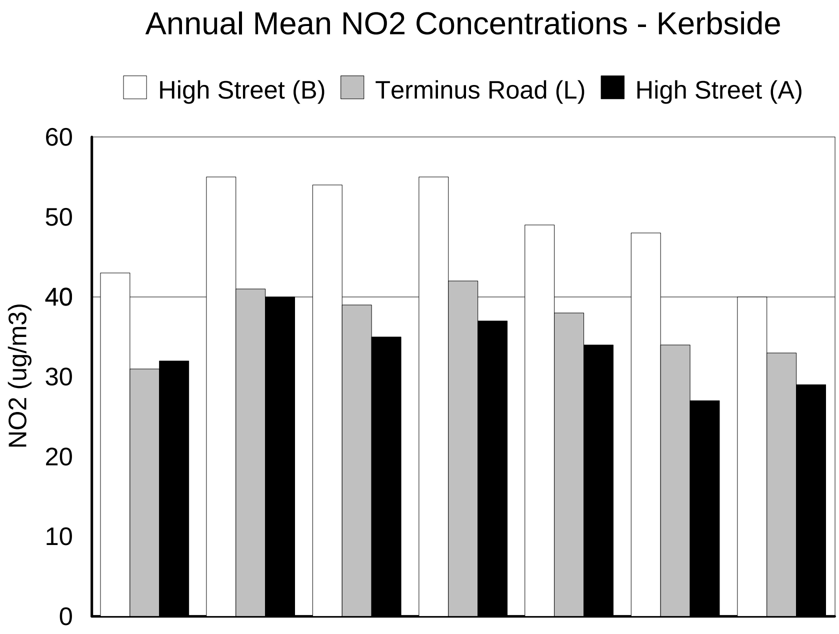
To obtain the value for vehicles per hour (vph) used in the DMRB model the daily flow data has been divided by 24.

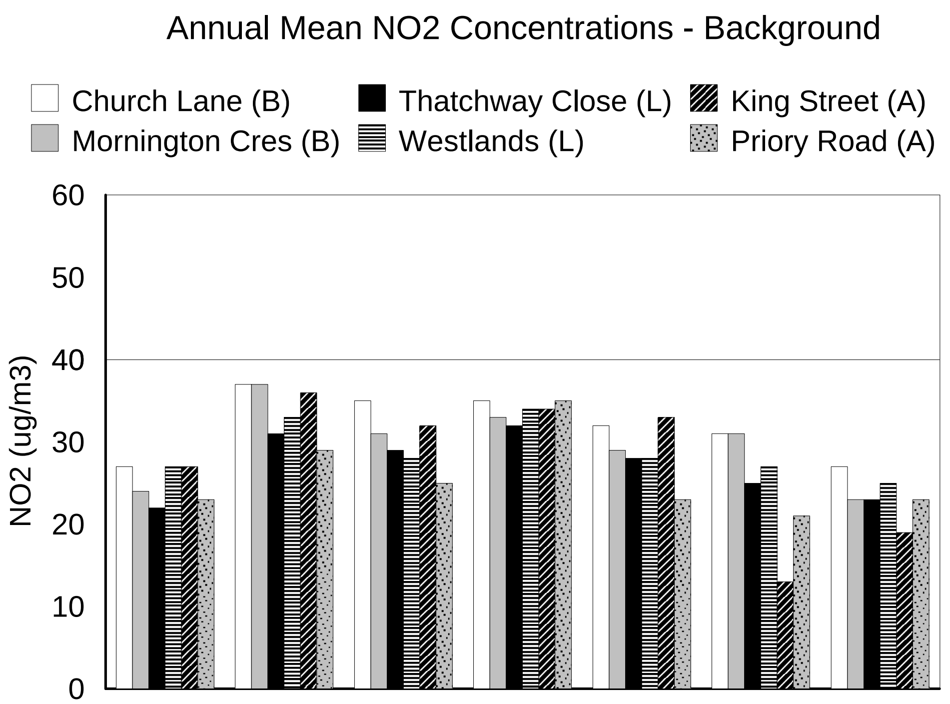
To convert the 1998 flow data into 2004 and 2005 flow data for use within the model, WSCC have provided high growth factors of 1.15 and 1.171 respectively for Arun District, to produce worst case estimates for all flows.

Proportion of light and heavy goods vehicles
All % HGV values used in the the assessment were obtained from WSCC surveyors Department.

Background Pollutant Concentrations

Estimated annual mean background concentrations mapped by NETCEN for both 2004 (PM_{10}) and 2005 (NOx) were obtained from the internet at the following address: www.aeat.co.uk/netcen/airqual.





<u>Worked example of DMRB - A27 Lyminster Rd/ Station Rd/ The Causeway</u>

Description of Road Section The section of road lies along the A27 west of the junction with Lyminster Road (A284) and east of the roundabout where The Causeway meets the Arundel Bypass (heading towards Fontwell). It is a single carriageway main road.

Description of receptors
The nearest receptors are the residential properties, 1-4 Causeway Villas, which are located approximately 100m south-east of the roundabout. Using Fastmap GIS it is estimated that the distances from the building facade to the kerbside and centre of the road are ***8m*** and ***12m*** respectively.

Vehicle speed
The average speed taken from UKRAPID is estimated at ***45Km/h.***

Proportion of light and heavy goods vehicles
The % HGV figure supplied by WSCC Surveyors Department is estimated at ***5%***

Hourly vehicle flow
The 1998 AADT for this section of the A27 is 34 375 vpd. Dividing by 24 will give an hourly vehicle flow of 1432 vehicles. Applying growth factors for 2004 and 2005:
2004 hourly flow = 1432 x 1.15 = 1647 vehicles
2005 hourly flow = 1432 x 1.171 = 1677 vehicles

Background Pollutant Concentrations
NETCEN estimated background concentrations at receptor NGR (502325, 106556):
PM_{10}(2004) = 23.6 ug/m3 and NOx (2005) = 18.7 mg/m^3.

Model Outputs

PM_{10} contribution from all roads	= 2.91 µg/m^3
PM_{10} background concentration	= 23.60 µg/m^3
TOTAL PM_{10} contribution	= 26.51 µg/m^3

PM_{10} (2004) ANNUAL MEAN CONCENTRATION	**= 27 mg/m^3**
AIR QUALITY OBJECTIVE CONCENTRATION	**= 40 mg/m^3**

NOx contribution from all roads	= 67.66 µg/m^3
NOx background concentration	= 18.70 µg/m^3
TOTAL NOx contribution	= 86.47 µg/m^3
(NOx converted to NO_2):	= 39.69 µg/m^3

NO_2 (2005) ANNUAL MEAN CONCENTRATION	**= 40 mg/m^3**
AIR QUALITY OBJECTIVE CONCENTRATION	**= 40 mg/m^3**

Comparisons between the air quality objective concentration and the predicted annual mean concentation for each pollutant shows that for this particular section of road, the objective will be met for PM_{10} in 2004 but a stage III assessment will be necessary for NO_2, as the model predicted concentration is equal to the Air Quality Objective.

6.1.2 Diffusion Tube Monitoring of NO_2

Nitrogen dioxide is the pollutant for which the most monitoring has been carried out in Arun District, through participation in the national nitrogen dioxide diffusion tube survey. This survey has provided results over a number of years. There is also additional local monitoring, conducting by the Council, of nitrogen dioxide using diffusion tubes in addition to the national survey.

The diffusion tube sampler consists of an acrylic tube, 7cm long with a 1cm internal diameter. Triethanolamine, an extremely effective absorbent of nitrogen dioxide is used to coat a stainless steel grid fixed at one end of the tube by an airtight cap. The tube is then fixed vertically with the capped end uppermost. Nitrogen dioxide diffuses up the tube and is trapped by the absorbent coating. After exposure, the tubes are then sent for analysis at a laboratory where sulphanilamide in orthophosphoric acid and napthyl ethylene diamine dihydrochloride are added. The resultant colour change is monitored using colour spectrometric techniques at 540nm. By measuring the total amount of nitrogen dioxide absorbed, and knowing the exposure time of the tube and the rate at which the gas diffuses up the tube, the mean concentration of nitrogen dioxide in the air over the exposed period can be determined. The tubes are generally exposed for 4 weeks. Thus they only provide an estimate of long-term concentrations, and cannot measure short-term (e.g. daily) peaks in concentration.

Paragraph 6.37 of technical guidance note LAQM.TG4 states that local authorities should be confident in the performance of their analytical laboratory. During 1997 analytical laboratory performance testing was carried out by AEA/NETCEN who run the national nitrogen dioxide diffusion tube survey. For each of the twelve months of the survey, a solution of known strength and a solution doped diffusion tube were also sent to each participating laboratory for analysis. Performance scores based around process control statistics were then assigned to each analysis. During 1997 there was a problem with February's analysis across all laboratories, and hence these were removed from the overall results. Those laboratories not performing satisfactorily were notified of their poor performance. The performance by Rotherham Metropolitan Borough Council's Laboratory, responsible for analysing Arun District Council's diffusion tubes, was rated as good throughout 1999. This means that we can be confident that the results of the tube analysis are accurate.

Figure 6.1 shows recorded annual mean background NO_2 concentrations in Bognor Regis (B), Littlehampton (L) and Arundel (A) from 1993 to 1999.

It can be seen that all recorded annual mean background concentrations within the Arun District between 1993 and 1999 were consistently less than the annual mean air quality objective of 40 $\mu g/m^3$.

Although no roads were identified for a Stage II assessment in the town centres of Bognor Regis, Littlehampton and Arundel on the basis of number of vehicles per day, the kerbside NO_2 results for each town centre have been analysed and can be seen below.

It can be seen that from 1993 to 1999, kerbside results for each town centre have consistently been below the annual mean objective of 40 $\mu g/m^3$ (with the exception of Bognor Regis) and are continuing to decrease. In 1998 Bognor Regis High Street was partially pedestrianised. This accounts for the decreased concentration recorded in 1999 and it is expected that the annual mean concentration will continue to decrease in the future. LAQM TG4 (00) section 6.40 states:

"if it is determined that the annual mean objective is not at risk of being exceeded, it is unlikely that there will be a breach of the 1-hour objective".

Therefore no additional assessment has been carried out for these sites.

The local air quality management technical guidance note on pollution monitoring LAQM. TG1 (00) states that where diffusion tube data are used in a Stage 2 review and assessment to make a decision about whether or not to proceed further, details should be given of a number of influencing factors:

- Criteria for sampler location
- Record keeping for sampler locations
- Procedures for tube handling and exposure
- Timetable for sample exposure

6.1.3 Stage III Assessment for Lyminster Road/Station Road/The Causeway

BREEZE ROADS is designed to estimate carbon monoxide (CO), particulate matter (PM), nitrogen dioxide (NO2) and other inert pollutant concentrations from motor vehicles. The model includes the CALINE4, CAL3QHC and CAL3QHCR line source dispersion models and a traffic algorithm for estimating vehicular queue lengths and the contribution of emissions from idling vehicles.

BREEZE ROADS incorporates three modules: two for modelling a single hour of user-defined meteorological data (CAL3QHC and CALINE4), the second for modelling historic, hourly meteorological data (CAL3QHCR). The latter module has the capability of processing a year of hourly meteorological data, CO, PM10, or NO2 emissions, traffic and signalisation data. In addition, the CAL3QHCR module incorporates the Industrial Source Complex (ISC) mixing height algorithm.

When using the model for review and assessment a two tier approach has been used. In this approach a full year of hourly meteorological data are entered into CAL3QHCR in place of the single hour of artificial meteorological data that are commonly entered into the CAL3QHC and CALINE4 modules. Emissions traffic volume (ETS) data however, are more detailed and reflect traffic conditions for each hour of a week. CAL2QHCR reads the ETS data as up to 7 sets of hourly ETS data (in the form of diurnal patterns) and processes the data into a week of hourly ETS data. The weekly ETS data are synchronised to the day of the week of the meteorological data year. The weekly traffic conditions are assumed to be the same for each week throughout the modelled period.

While the CAL3QHC and CALINE4 modules only produce maximum hourly averages, CAL3QHCR is capable of producing 1-hour and running 8-hour averaged CO, 24-hour period and annual block averaged PM10 concentrations, and annual block averages for NO2. In addition, CAL3QHCR output contains : a table of calm wind durations with their respective frequencies, optional link contribution results for each printed average, and optional use of variable ambient background concentration data in calculating the various maximum concentrations.

For review and assessment use the model was set to calculate annual mean Nox averages from the road, with the annual mean background value being taken from the AEA NETCEN maps described in earlier sections and added after the model was run. Traffic flows were varied by hour of day according to local profiles, but did not differentiate between weekdays and weekends. This is likely to lead to a slight overestimate rather than an underestimate of concentrations (higher weekday traffic volumes have bee assumed at weekends).

Four years (1994 - 1997) of Trinity Consultants meteorological data for Herstmonceaux Observatory (in Rother District) were run for each case to account for year to year variations in meteorology.

The emissions factors used for this modelling work are the speed related oxides of nitrogen emission factors for 1997 and 2005 provided by the London Research Centre UK Emission Factor Database.

These break the vehicle fleet down into; petrol cars, petrol Light Goods Vehicles (LGVs), diesel cars, diesel LGVs, rigid Heavy Goods Vehicles (HGVs), articulated HGVs, buses and motorcycles. Local data collected by West Sussex County Council on the percentage of HGVs travelling along this stretch of road have been used along with the national vehicle fleet breakdown to assume petrol/diesel splits. This gave a figure of 5% HGVs, which has been used for both current and future cases.

A receptor grid was placed over the area in question with receptors at 5m, 10m, 25m, 40m and 50m back from the edge of the road at 25m intervals. The building facades of the nearest properties were 8m from the edge of the road (to the South side).

The guidance on review and assessment of air quality gives a 102 $\mu g/m^3$ Nox equivalent to the 40 $\mu g/m^3$ (21 ppb) NO2 standard for receptors at a distance of 5-10m back from the roadside. This means there are no exceedences of this nitrogen dioxide standard recorded in this area, and hence no need for an air quality management area.

6.2 Point Sources

6.2.1 Description of Source

Lafarge Redland Aggregates

The process at this plant is roadstone coating, and the plant is regulated by Arun District Council under the Local Authority Pollution Control (LAPC) regime. The plant was indicated in Stage I as being a possibly significant source of PM_{10} and sulphur dioxide.

A map of the site is shown below, and model runs of the emissions from the stack have been made, in order to determine the contribution of the plant to local air quality.

The stack at the plant is 22 metres high, and emits PM_{10} at the rate of 0.4 grammes/second (g/s) and sulphur dioxide at 0.1 g/s. The emission rates have been assumed using information from US EPA AP- 42 Manual.

The nearest properties are roughly 210 metres from the stack, to the North East. The pollutants of concern, as indicated by LAQM.TG4 (00) are PM_{10} and sulphur dioxide. The air quality objectives for PM_{10} are annual mean and a 24 hour mean, and for sulphur dioxide a 15-minute mean, 1-hour mean and 24-hour mean. This means that the housing should be included in any assessment as exposure is possible over the shorter periods.

6.2.2 The GSS Model

The process has been modelled using the Environment Agency's GSS Manual (described in Section 5.4 above) and a brief description of the modelling process can be found below.

To calculate the PM_{10} and sulphur dioxide contributions from the plant the Efflux Heat and Efflux Momentum must first be calculated as follows:

$$\text{Efflux Heat (Q)} = \frac{V_{rel}}{2.9} \cdot \left(1 - \frac{283}{T_{rel}}\right)$$

$$\text{Efflux Momentum (M)} = \frac{283}{T_{rel}} \cdot \frac{(V_{rel})^2}{\pi r^2}$$

where:

V_{rel} (m3/s) = volume of flue gas under release conditions
T_{rel} (K) = flue gas exit temperature
r (m) = radius of the stack

Using the information as described in section 5.4 the following values can be calculated for the Lafarge Redland stack:

Efflux heat (Q) = 1.59 MW
Efflux momentum (M) = 135.49 M^4/S^2

These values can then be used to obtain the near ground level concentration (NGLC) and distance from the stack by reading off the appropriate look up chart.

The ***process contribution (PC)*** from the stack can then be obtained by multiplying the NGLC by the emission rate for the specified pollutant. The resulting value can then be added to the background concentration (from NETCEN) to give the ***Predicted Environmental Concentration (PEC)***. The PEC corresponds to the maximum total ground level concentration due to the process stack (as given by the PC) and all other sources (as given by the background concentration).

6.2.3 Analysis of Model Outputs

PM_{10}

The model output results show that for PM_{10} the PEC (2004) is 24.52 $\mu g/m^3$.

LAQM.TG4 (00) section 8.09 states:

"The 24-hour mean objective (50 $\mu g/m^3$) is potentially a difficult standard against which to carry out an assessment, due to the day-to-day variations in PM_{10} concentration and composition. It is therefore recommended that the initial stages of review and assessment are carried out by calculating the annual mean PM_{10} concentration and then estimating the 90th percentile concentration. The 90th percentile of daily means in a calendar year is approximately equivalent to 35 exceedance days"

Following LAQM.TG4 (00) section 8.59, the 90th percentile annual mean can be calculated:

Background 90th percentile of daily means: *1.79 x 23.6 (annual mean background)*	*=42.24 mg/m^3*
GSS predicted annual mean ground level concentration for stack in 2004:	*= 0.92 mg/m^3*
90th percentile 2004 for stack in 2004 = 0.92 x 4:	*= 3.68 mg/m^3*

The estimated 90th percentile background contribution is higher than the 90th percentile contribution from the stack so,

(PM_{10} background concentration) + (PM_{10} stack contribution x 0.6)	*=44.49 mg/m^3*

The total 90th percentile in 2004 is therefore estimated to be 44.49 $\mu g/m^3$.

Sulphur Dioxide

LAQM.TG4 (00) section 7.35 recommends that for a Second Stage review and assessment the GSS model is used to predict the annual mean and the 99.9th percentile of the 1-hour mean, ground level concentrations of sulphur dioxide. The resulting concentrations can then be used to calculate total values equivalent to the air quality objectives for sulphur dioxide.

The model output results show that for sulphur dioxide the PEC (2004) gives an annual mean of 10.87 μg/m^3 and a 99.9th percentile of 1-hour means of 12.64 μg/m^3.

Following LAQM.TG4 (00) sections 7.36 - 7.37, the following statistics can be calculated:

99.9th percentile of 15-min means:
1.34 x 12.64 (99.9th perecntile of 1-hour means) *= 16.94 mg/m^3*

99.7th percentile of hourly means:
0.83 x 12.64 (99.9th perecntile of 1-hour means) *= 10.49 mg/m^3*

99th percentile of daily means:
10 x 10.87 (annual mean) *= 108.70 mg/m^3*

To obtain total percentile estimates for each objective:

Total 99.9th percentile of 15 min means:
16.94 x (10.64 (annual mean background) x 2) *= 38.22 mg/m^3*

Total 99.7th percentile of hourly means:
10.49 x (10.64 (annual mean background) x 2) *= 31.77 mg/m^3*

Total 99th percentile of daily means:
108.7 + 10.64 (annual mean background) *= 119.34mg/m^3*

The predictions for 2004 are therefore: 99.9th percentile of 15-min means of 38.22 μg/m^3; 99.7th percentile of hourly means of 31.77 μg/m^3 and a 99th percentile of daily means of 119.34 μg/m^3.

6.2.4 Comparison with Air Quality Criteria (AQC)

The GSS manual states that more detailed modelling and analysis is likely to be necessary if, in cases of long term averages (such as annual mean), the % PEC/AQC exceeds 70% and in cases of short term averages (15-minute mean, hourly mean, 24-hour mean), the % PEC/AQC exceeds 40%, unless there are specific reasons to the contrary.

Table 6.1 shows comparisons between predicted concentrations and relevant air quality objectives for PM_{10} and sulphur dioxide.

Table 6.1

Pollutant	Measured as:	Concentration mg/m^3	PEC mg/m^3	PEC/AQC as %
PM_{10}	Annual Mean	40	25	61
PM_{10}	24 hour mean	50	45	89
Sulphur dioxide	15 min mean	266	38	14
Sulphur dioxide	1 hour mean	350	32	9
Sulphur dioxide	24 hour mean	125	119	95

PM_{10}

Following the advice given in the GSS manual the predicted PEC for the short term 24 hour mean is over 40% of the air quality objective, suggesting further modelling and analysis is required. However, LAQM TG4 (00) section 8.60 indicates that if the predicted 90th percentile concentration (equivalent to the 24-hour mean) does not exceed 50 $\mu g/m^3$ then a Stage III assessment is not necessary.

Although the predicted 90th percentile concentration for Lafarge Redland was calculated to be less than 50 $\mu g/m^3$ (45 $\mu g/m^3$) it was felt that as the difference was only 5 $\mu g/m^3$, further advanced modelling should be undertaken to confirm that the target objective concentration would be met in 2004.

Sulphur dioxide

The PEC's for the 15-minute and 1-hour means are both well under 40% of the air quality objectives, whilst the predicted 24-hour mean concentration is 95% of the air quality objective. Following the advice from the GSS manual it would suggest that for the 24 hour mean further modelling and analysis are required.

However, LAQM TG4 (00) 7.36 states that:

"for emissions arising from elevated sources (stacks) authorities may assume that the daily and hourly objectives are unlikely to be exceeded if the 15 minute mean is complied with".

As the 15 minute mean PEC was calculated to be only 14% of the air quality objective it was decided that further modelling was not necessary.

6.2.5 Advanced Modelling of PM_{10}

The local authorities in Sussex have combined their efforts on air quality through the Sussex Air Quality Steering Group. Collectively, the Group have purchased the Trinity Consultants version of the United States Environmental Protection Agency model AERMOD. This is an advanced "new generation" model, which is described in further detail below.

The AERMOD modeling system is composed of one main model (AERMOD) and two preprocessors - a meteorological preprocessor (AERMET) and a terrain preprocessor (AERMAP). AERMET calculates hourly boundary layer parameters for use by AERMOD, including friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, convective boundary layer (CBL) height, stable boundary layer (SBL) height, and surface heat flux. In addition, AERMET passes all observed meteorological parameters to AERMOD including wind direction and speed (at multiple heights, if available), temperature, and, if available, measured turbulence. AERMOD uses this information to calculate concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology. AERMAP prepares terrain data for use by AERMOD in complex terrain situations. This allows AERMOD to account for terrain using a simplification of the procedure used in the CTDMPLUS model.

This model has also been used to assess the likelihood of exceedences of the air quality objective in the vicinity of this process. The process has been modelled using the AERMOD model, as the emissions rate for the process falls below that for which the Environment Agency GSS model can be used. The model has been run using 4 years of hourly meteorological data from the Herstmonceaux observatory in East Sussex, pre-processed by AERMET using an albedo of 0.2 and Bowen ratio of 1, and roughness length 0.5m.

The model is able to account for the effects of nearby buildings on the plume (downwash), and two buildings of 2.5 by 7.5 metres at the base of the stack have been input into the model. Terrain data have not been included in this assessment, as the area in question is a fairly flat area with no major terrain variations within the study area.

A full set of model input and output files has been compiled in a separate report and contour plots have been produced to show the predicted annual mean concentrations of PM_{10} arising from the stack are shown in Appendix 8. Under each plot a separate calculation of the likelihood of exceedence of the air quality objective is given. These calculations show that the model predicts a 90th percentile of between 43 - 45 $\mu g/m^3$. These results confirm the concentrations given in the GSS modelling and are below the objective concentration of 50 $\mu g/m^3$. Therefore, it was decided that this source would not be investigated further.

7. Results and Recommendations

The following list of receptors was identified as being of possible concern from the Stage I review and assessment:

Road Sections - A27; A259; B2166; Aldwick Road, Barrack Lane and Hawthorn Road in Bognor Regis

Part B Processes - Lafarge Redland Aggregates Limited operating a roadstone coating process.

7.1 Road Sections

Identification of the above road sections for further assessment in Stage I was based on estimated traffic flows for 2005 being over 20,000 vehicles per day for NO_2 and 25,000 for PM_{10}. Revised guidance for PM_{10} section 6.16, suggests that a Stage II and /or Stage III assessment will be necessary for road sections with traffic flows of over 20, 000 vehicles per day. Traffic flow data provided by WSCC has showed that for the following sections predicted flows for 2005 will be well below 20,000 vehicles per day and do not require a Stage II assessment.

- B2166;
- Aldwick Road;
- Barrack Lane;
- Hawthorn Road; and
- Worms Lane section of A259

The results from the DMRB modelling are summarised in Tables 7.1 and 7.2 which show that all road sections assessed in Stage II (with the exception of A27 Lyminster Road/Station Road/The Causeway) will meet the annual mean NO_2 objective in 2005.

Further assessment of the A27 Lyminster Road/Station Road/The Causeway using the advanced Breeze Road model has shown that this section of road will also meet the annual mean NO_2 objective in 2005. These findings are also in keeping with monitoring results for the Arun District.

Table 7.1

NO_2 Predictions for 2005 using DMRB

Road No.	Road Section	Annual Mean (ug/m3)	Stage III?
A27	Worthing - Patching	16	No
A27	Patching - B2225 Junction	18	No
A27	B2225 Junction - Crossbush	33	No
A27	**Lyminster Rd/Station Rd/The Causeway**	**40**	**Yes**
A27	Arundel Bypass	23	No
A27	Chichester Rd/Arundel Rd - B2132 Junction	33	No
A27	B2132 Junction - Fontwell	34	No
A27	Fontwell - Chichester Border	37	No
A259	A2032 Junction - Ferring Lane	33	No
A259	Ferring Lane - B2140 Junction	32	No
A259	Roundstone Bypass	27	No
A259	B2140 Junction - B2187 Junction	32	No
A259	B2187 Junction - Watersmead	22	No
A259	Watersmead - Toddington Lane	30	No
A259	Toddington Lane - A284 Junction (Wick)	31	No
A259	A284 Junction (Wick) - B2187 Junction	19	No
A259	B2187 Junction - Church Lane Junction	19	No
A259	Church Lane Junction - B2233 Junction	17	No
A259	Grevatts Lane	24	No
A259	Felpham Way - Summerley Lane Junction	30	No
A259	Felpham Way	32	No
A259	Upper Bognor Rd	30	No
A259	Hotham Way	28	No
A259	A29 Junction - Orchard Way	30	No
A259	Orchard Way - North Bersted	28	No
A259	North Bersted - Chichester Border	31	No

Table 7.2

PM$_{10}$ Predictions for 2004 using DMRB

Road No.	Road Section	Annual Mean (ug/m3)	Stage III?
A27	Worthing - Patching	24	No
A27	Patching - B2225 Junction	24	No
A27	B2225 Junction - Crossbush	25	No
A27	Lyminster Rd/Station Rd/The Causeway	26	No
A27	Arundel Bypass	24	No
A27	Chichester Rd/Arundel Rd - B2132 Junction	25	No
A27	B2132 Junction - Fontwell	25	No
A27	Fontwell - Chichester Border	25	No
A259	A2032 Junction - Ferring Lane	26	No
A259	Ferring Lane - B2140 Junction	25	No
A259	Roundstone Bypass	25	No
A259	B2140 Junction - B2187 Junction	25	No
A259	B2187 Junction - Watersmead	24	No
A259	Watersmead - Toddington Lane	25	No
A259	Toddington Lane -A284 Junction (Wick)	25	No
A259	A284 Junction (Wick) - B2187 Junction	24	No
A259	B2187 Junction - Church Lane Junction	24	No
A259	Church Lane Junction - B2233 Junction	24	No
A259	Grevatts Lane	24	No
A259	Felpham Way - Summerley Lane Junction	25	No
A259	Felpham Way	26	No
A259	Upper Bognor Rd	25	No
A259	Hotham Way	25	No
A259	A29 Junction - Orchard Way	25	No
A259	Orchard Way - North Bersted	25	No
A259	North Bersted - Chichester Border	25	No

7.2 Part B Processes

The results from the GSS (Environment Agency Guidance for Estimating the Air Quality Impact of Stationary Sources) modelling showed that for sulphur dioxide emissions from Lafarge Redland Aggregates, all 2004 objectives will be met and it is probable that both PM$_{10}$ 2004 objectives will be met. On further analysis of PM$_{10}$ using the advanced AERMOD method this was confirmed.

It can be summised that for all areas identified as being of possible concern from the Stage I review and assessment, all will meet the necessary air quality objectives by the target year. Therefore it is not necessary for this authority to declare any Air Quality Management Areas within the Arun District.

7.3 Recommendations

It is recommended that this draft report be submitted to the Department of the Environment, Transport and the Regions, and statutory consultees and made available for public consultation. The Review and Assessment should be repeated in line with the current guidance by the end of 2003, to take account of changed circumstances and advances in knowledge about air quality.

8. References

1. *Environment Act* (1995)

2. *United Kingdom National Air Quality Strategy (Revised)* Department of the Environment, Transport and the Regions (1999)

3. *The Air Quality Regulations 1997*, Environment Protection, SI No 3043 (1997)

4. LAQM.G1 (00) *Framework for Review and Assessment of Air Quality*
5. LAQM.G2 (00) *Developing Local Air Quality Action Plans and Strategies: The Main Considerations*
6. LAQM.G3 (00) *Air Quality and Transport*
7. LAQM.G4 (00) *Air Quality and Land-Use Planning*

8. LAQM.TG1 (00) *Monitoring Air Quality*
9. LAQM.TG2 (00) *Estimating Emissions*
10. LAQM.TG3 (00) *Selection and Use of Dispersion Models*
11. LAQM.TG4 (00) *Pollutant Specific Guidance*

12. Department of the Environment, Transport and the Regions (1999). *Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1 "Air Quality"*. The Stationery Office.

13. Environment Agency (1998). *National Centre for Risk Analysis and Options Appraisal, Guidance for Estimating the Air Quality Impact of Staionary Sources (GSS),* Report No. GN24, 1998.