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Local Air Quality Management

Technical Guidance LAQM.TG(09)

February 2009

Llywodraeth Cynulliad Cymru
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DOE

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CHAPTER 1: Introduction

Introduction

1.01 This technical guidance document replaces three earlier versions, issued as LAQM.TG4(98), LAQM.TG4(00) and LAQM.TG(03), and is designed to support local authorities in carrying out their duties under the Environment Act 1995, the Environment (Northern Ireland) Order 2002, and subsequent Regulations. These duties require local authorities to review and assess air quality in their area from time to time. These Review and Assessments form the cornerstone of the system of Local Air Quality Management (LAQM). Local Air Quality Management itself forms a key part in the UK Government's and the Devolved Administrations' strategies to achieve the air quality objectives. A general introduction to the system of LAQM is provided in the Policy Guidance documents[1].

1.02 All aspects of the technical guidance are brought together in this one document. The guidance has been completely restructured in some parts, reflecting feedback from local authorities during the previous rounds of Review and Assessment. The intent is to simplify the process, particularly in the preparation of Progress Reports and Updating and Screening Assessments. This document supersedes all previous technical guidance documents. It is supported by web-based spreadsheet tools, and local authorities should both register with the Helpdesks (Para 1.14) and check the supporting websites (Box 1.1) regularly to ensure that up-to-date material is being used.

Role and structure of this guidance

1.03 This document is designed to guide local authorities through the Review and Assessment process. It sets out the general approach to be used, together with detailed technical guidance.

1.04 The structure of this document follows a logical sequence through the Review and Assessment process, from Progress Reports to Updating and Screening Assessments, and then, if required, from Detailed Assessments to Further Assessments. It draws together previous guidance that has been issued both formally and informally, and new chapters on the preparation of Progress Reports and Further Assessments are now included.

1.05 In preparing this document, consideration has also been given to the lessons learned during the previous rounds of Review and Assessment, and in particular to the recommendations of the Evaluation Report that was commissioned in 2007 by the UK Government and the Devolved Administrations. This report is available from the Review and Assessment Helpdesk website (see Box 1.1).

1.06 The most significant changes affect the way in which Progress Reports and Updating and Screening Assessments should be carried out. It is intended that both reports should be submitted via a web-based system, predominantly based on a series of checklists and proformas. A further major change is that the approach to Updating and Screening Assessments has been revised so that the assessment is carried out on a source-by-source basis, rather than by considering each pollutant in turn.

[1] There are separate Policy Guidance documents for England, Wales, Scotland and Northern Ireland

Statutory background

1.07 This guidance is issued by the Department for Environment, Food and Rural Affairs (Defra), the Scottish Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland. It replaces the guidance previously issued as LAQM.TG(03). Under sections 84 and 88 of the Environment Act 1995 ("the Act"), and articles 13 and 16 of the Environment (Northern Ireland) Order 2002 ("the Order"), local authorities are required to take account of this guidance when carrying out any of their duties under or by virtue of Part IV of the Act, or Part III of the Order.

1.08 The Greater London Authority Act 1999 provides for the Mayor of London to publish an Air Quality Strategy for the capital. The Mayor's Air Quality Strategy was published in September 2002 and sets out the steps the Mayor will take towards meeting the national air quality objectives in London. It also contains further advice to London Boroughs in respect of LAQM.

1.09 The Mayor's Air Quality Strategy does not replace local authority duties under LAQM. However, London local authorities have to take account of it when carrying out their LAQM duties. London local authorities must consult with the Mayor as well as the Secretary of State with regard to their Review and Assessments of air quality, and on their Air Quality Management Area (AQMA) designations and Action Plans. The Mayor of London must take account of this guidance in exercising any powers of direction under section 85(2) to (4) of the Environment Act 1995.

The role of Review and Assessment

1.10 The Air Quality Strategy[2] establishes the framework for air quality improvements. Measures agreed at the national and international level are the foundations on which the strategy is based. It is recognised, however, that despite these measures, areas of poor air quality will remain, and that these will best be dealt with using local measures implemented through the LAQM regime. The role of the local authority review and assessment process is to identify all those areas where the air quality objectives are being or are likely to be exceeded. Experience has shown that such areas may range from single residential properties to whole town centres.

1.11 The air quality objectives applicable to LAQM are set out separately in Air Quality Regulations for England, Scotland, Wales and Northern Ireland[3] ("the Regulations").

[2] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007. Cm 7169 and NIA 61/06-07.

[3] **England:** The Air Quality (England) Regulations 2000 (SI 928), The Air Quality (England) (Amendment) Regulations 2002 (SI 3043),
Scotland: The Air Quality (Scotland) Regulations 2000 (Scottish SI 2000 No 97), The Air Quality (Scotland) (Amendment) Regulations 2002 (Scottish SI 2002 No 297),
Wales: Air Quality (Wales) Regulations 2000, No 1940 (Wales 138), Air Quality (Amendment) (Wales) Regulations 2002, No 3182 (Wales 298),
Northern Ireland: Air Quality Regulations (Northern Ireland) 2003, Statutory Rules of Northern Ireland 2003, no. 342.

Table 1.1: Objectives included in the Air Quality Regulations for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 μg/m^3	running annual mean	31.12.2003
Authorities in England and Wales only	5.00 μg/m^3	annual mean	31.12.2010
Authorities in Scotland and Northern Ireland only	3.25 μg/m^3	running annual mean	31.12.2010
1,3 Butadiene	2.25 μg/m^3	running annual mean	31.12.2003
Carbon monoxide Authorities in England, Wales and Northern Ireland only[a]	10.0 μg/m^3	maximum daily running 8-hour mean	31.12.2003
Authorities in Scotland only	10.0 μg/m^3	running 8 –hour mean	31.12.2003
Lead	0.5 μg/m^3 0.25 μg/m^3	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 μg/m^3 not to be exceeded more than 18 times a year 40 μg/m^3	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[a] All authorities	50 μg/m^3 not to be exceeded more than 35 times a year 40 μg/m^3	24 hour mean annual mean	31.12.2004 31.12.2004
Authorities in Scotland only[b]	50 μg/m^3 not to be exceeded more than 7 times a year 18 μg/m^3	24 hour mean annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 μg/m^3 not to be exceeded more than 24 times a year 125 μg/m^3 not to be exceeded more than 3 times a year 266 μg/m^3 not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

[a] Measured using the European gravimetric transfer sampler or equivalent.
[b] These 2010 air quality objectives for PM_{10} apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

1.12 In addition to the objectives set out in the Regulations, the EU has set limit values in respect of nitrogen dioxide (NO_2), to be achieved by 1 January 2010[4]. Local authorities currently have no statutory obligation to assess air quality against this limit value, but in some cases they may find it helpful to do so, in order to assist with longer-term planning and the assessment of development proposals in their local areas. Therefore, this document provides informal guidance on how to assess against the time-frame of the limit value in 2010.

[4] There are, in addition, separate limit values for carbon monoxide, sulphur dioxide, lead and PM_{10}, to be achieved by 2005, and benzene by 2010.

1.13 The UK Government and the Devolved Administrations have set new national air quality objectives for particulate matter smaller than 2.5 μm diameter ($PM_{2.5}$) which are set out in Table 1.2. These objectives have not been incorporated into LAQM Regulations, and authorities have no statutory obligation to review and assess air quality against them. However, it is recognised that many authorities are currently undertaking monitoring for $PM_{2.5}$, so this document provides some informal guidance on how to approach this monitoring.

Table 1.2: Proposed new $PM_{2.5}$ objectives (not included in Regulations)

Region	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
UK (except Scotland)[a]	25 μg/m^3	annual mean	2020
Scotland[a]	12 μg/m^3	annual mean	2020
UK urban areas	Target of 15% reduction in concentrations at urban background locations	3-year mean	Between 2010 and 2020

[a] The concentration cap is to be seen in conjunction with the 15% exposure reduction target.

1.14 The methodologies described within this guidance are based upon the most up-to-date understanding of pollutant concentrations and sources, and of methods to predict future levels. They draw, as appropriate, on experience from the previous rounds of Review and Assessment. The UK Government and the Devolved Administrations are continuing to sponsor research into all of these areas, and it is therefore inevitable that some of the assessment methodologies may need to be revised at some stage in the future. Supplementary or revised technical guidance will be issued periodically in light of any new information. New information is also made available, as it arises, through the Frequently Asked Questions sections of the websites operated by the Helpdesks (Box 1.1). Local authorities should register for updates at the Helpdesk websites, which will ensure that they are automatically notified of new guidance as soon as it is issued. Local authorities need only register at one of the Helpdesks; the registration will be automatically recorded by the others.

1.15 Local authorities can register by visiting one of the Helpdesks, or by emailing the Review and Assessment Helpdesk (aqm-review@uwe.ac.uk) or the Local Authority Air Quality Support Helpdesk (lasupport@aeat.co.uk) directly.

The phased approach to Review and Assessment

1.16 This guidance document maintains the phased approach to review and assessment established in previous technical guidance. The intention is that local authorities should only undertake a level of assessment that is commensurate with the risk of an air quality objective being exceeded. Not every authority will, therefore, need to proceed beyond the first step in future rounds of Review and Assessment. A description of the phased approach is set out in Box 1.2.

Box 1.1: Helpdesks for Local Authorities		
Helpdesk	**Operated by**	**Contact Details**
Review & Assessment	Air Quality Consultants Ltd and University of West of England, Bristol	0117 328 3668 aqm-review@uwe.ac.uk www.uwe.ac.uk/aqm/review
Local Authority Air Quality Support (monitoring, modelling and emissions inventories)	AEA, Air Quality Consultants Ltd and Bureau Veritas	0870 190 6050 lasupport@aeat.co.uk www.laqmsupport.org.uk
Action Plan	AEA	0870 190 6050 lasupport@aeat.co.uk www.laqmsupport.org.uk

Box 1.2: The Phased Approach to Review and Assessment		
Level of Assessment	**Objective**	**Approach**
Updating and Screening Assessment	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.

Updating and Screening Assessments

1.17 The first step of the Review and Assessment process is an Updating and Screening Assessment, which is to be undertaken by all authorities. This is based on a checklist to identify those matters that have changed since the previous round was completed, and which may now require further assessment. This updating and screening assessment should cover: new monitoring data; new objectives; new sources or significant changes to existing sources, either locally or in neighbouring authorities; and other local changes that might affect air quality. If there is a risk that these changes may be significant, then a simple screening assessment should be carried out. Nomograms and similar tools are provided to help with this screening assessment.

1.18 Guidance on the preparation of Updating and Screening Assessment Reports is set out in Chapter 5.

Detailed Assessments

1.19 Where the Updating and Screening Assessment has identified a risk that an air quality objective will be exceeded at a location with relevant public exposure, the authority will be required to undertake a Detailed Assessment following the guidance set out in this document. The aim of this Detailed Assessment should be to identify with reasonable certainty whether or not a likely exceedence will occur.

The assumptions within the Detailed Assessment will need to be considered in depth, and the data that are collected or used, should be quality-assured to a high standard. This is to ensure that authorities are confident in the decisions they reach. Where a likely exceedence is identified, then the assessment should be sufficiently detailed to determine both its magnitude and geographical extent. Local authorities should not declare an AQMA unless a Detailed Assessment has been completed.

1.20 Guidance on the preparation of Detailed Assessment reports is set out in Chapter 6.

Progress Reports

1.21 Progress Reports are intended to maintain continuity in the LAQM process, and fill in the gaps between the three-yearly cycle of Review and Assessment. Progress Reports are required in all years when the authority is not completing an Updating and Screening Assessment.

1.22 Guidance on the preparation of Progress Reports is set out in Chapter 4.

Further Assessments

1.23 Once a new AQMA has been declared, Section 84(1) of the Act, and Article 13 of the Order, require that local authorities complete a Further Assessment within 12 months of designating the AQMA. This also applies when an AQMA is amended, although in many cases it will be sufficient to inform Defra and the Devolved Administrations that the previous Further Assessment covers the assessment for the amended AQMA.

1.24 The Further Assessment is intended to supplement the information provided in the Detailed Assessment. It should aim to confirm the exceedence of the objectives; define what improvement in air quality, and corresponding reduction in emissions is required to attain the objectives; and provide information on source contributions. The latter will provide useful information for the development of the Air Quality Action Plan, and assist in the targeting of appropriate measures. The level of detail required in the Further Assessment is, to some extent, dependant on what information the authority has also accrued and reported in other Review and Assessment reports.

1.25 Guidance of the preparation of Further Assessments is set out in Chapter 7.

Timetable

1.26 Box 1.3 sets out the timetable for Review and Assessment reports up to and including 2017. The next Updating and Screening Assessments are to be completed by all local authorities by the end of April 2009. If these identify the need for a Detailed Assessment, then this should be completed within 12 months of the date they are initiated. All authorities should complete a Progress Report by the end of April 2010, **regardless of whether they are undertaking a Detailed Assessment or not.**

Box 1.3: Timescales for Review and Assessment			
Year	**Updating and Screening Assessment**	**Progress Report**	**Detailed Assessment**
Round 4 – Completion Dates			
2009	30 April 2009	–	Whenever necessary[a]
2010	–	30 April 2010	Whenever necessary
2011	–	30 April 2011	Whenever necessary
Round 5 – Completion Dates			
2012	30 April 2012	–	Whenever necessary
2013	–	30 April 2013	Whenever necessary
2014	–	30 April 2014	Whenever necessary
Round 6 – Completion Dates			
2015	30 April 2015	–	Whenever necessary
2016	–	30 April 2016	Whenever necessary
2017	–	30 April 2017	Whenever necessary

[a] Detailed Assessments are due within 12 months of the date they are initiated, which can be at any time.

1.27 Authorities are reminded that if they identify a risk of an objective being exceeded at any point in time, then they should proceed without delay to a Detailed Assessment.

1.28 Further Assessment reports are required within 12 months of the AQMA order coming into operation.

Public exposure

1.29 The Regulations make clear that likely exceedences of the objectives should be assessed in relation to *"the quality of the air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present"*. It is particularly important that Review and Assessments focus on those locations where members of the public are likely to be **regularly present and are likely to be exposed for a period of time appropriate to the averaging period of the objective.** Authorities should not consider exceedences of the objectives at any location **where relevant public exposure would not be realistic[5].**

1.30 It should be noted that the health studies which provide the basis for the air quality standards are based on data for individuals within a population, and therefore the exposure should relate to that of an individual.

[5] It is reasonable to consider land designated for some form of public use, including residential development, but not currently in such use, as being a location with relevant exposure.

1.31 Several factors have been taken into account when developing the guidance on locations considered relevant:

- The Regulations refer to locations where members of the public are regularly present. This does not imply that it should be the same persons regularly present at that location. This is important for an understanding of relevant exposure where a **short-term objective** allows a number of exceedences of the standard. The standard is the basis for a potential risk to health, thus a single exposure of an individual above the standard is to be avoided. The objective allows a number of exceedences of the standard because of considerations of feasibility and practicability. Thus for sulphur dioxide (SO_2), where there is a 15-minute standard, a relevant location would be anywhere where a member of the public might be exposed for a single 15-minute period, as long as members of the public are regularly present at that location. The allowance of up to 35 exceedences before the objective is breached determines the need to control concentrations at that location, not whether that location is relevant in terms of exposure. The 1-hour objective for NO_2 should be treated in a similar way.
- The **long-term objectives** apply where members of the public are likely to be exposed over the averaging period of the objective. As with the discussion of short-term objectives, this does not require the same individual to be present for a full year at a particular location, but the location must be one where people are likely to be regularly present for long periods. For instance, in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day, while for the annual mean objectives this might be where people are exposed for a cumulative period of six months in a year.
- There is a link between pollutant concentrations measured both inside and outside of a building. For this reason it is considered appropriate to measure at the building façade to represent relevant exposure. Thus, for exposure alongside a busy road, it is considered reasonable to select the façade of residential properties closest to the road as a representative location to assess exposure for pollutants with a 24-hour or annual mean objective.

1.32 For the purpose of assisting local authorities, some examples of where the objectives should, and should not apply, are summarised in Box 1.4. However it should be borne in mind that it is not possible to be prescriptive in this matter, and authorities should bear local circumstances in mind when considering the application of the objectives. The examples given in the table are not intended to be a comprehensive list, and it is expected that local judgement will often be required. In the case of doubt, further guidance may be obtained from the Review and Assessment Helpdesk.

On what basis should an Air Quality Management Area be declared? How should uncertainty be taken into account?

1.33 The local authority should aim at the end of the Review and Assessment process to be confident that it has identified all locations and pollutants for which the air quality objective(s) is or will be exceeded in the relevant year of the objective and beyond[6]. This confidence will be determined by uncertainties, both in the monitoring data and in the modeling predictions.

[6] The objectives are to be met in all future years beyond the target dates set out in Regulations.

Box 1.4: Examples of where the air quality objectives should/should not apply		
Averaging Period	**Objectives should apply at:**	**Objectives should generally not apply at:**
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
24-hour mean and 8-hour mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties[7].	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets) Those parts of car parks, bus stations and railway stations etc which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-min mean	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

1.34 Authorities should demonstrate that they are aware of the uncertainties in their monitoring data, and in all of the data inputs used for modelling, and show what steps have been taken to minimise these uncertainties.

1.35 For monitoring data, the level of confidence in the results will be greater if a chemiluminescent analyser is used to measure NO_2 concentrations, as opposed to diffusion tubes. Where diffusion tubes are used, the confidence will be greater where the precision is shown to be "good". In general terms, the uncertainty of a measurement using a chemiluminescent analyser is expected to be of the order of +/- 10%, and for diffusion tubes that have been bias adjusted +/- 20%. The level of confidence in PM_{10} measurement will be greater when a method equivalent to the European reference sampler is used. It is very difficult to quantify the uncertainty associated with a non-equivalent method. Issues related to the important requirements for monitoring data are set out in Chapter 3 of this document, and are explored in greater detail within Annex 1.

[7] Such locations should represent parts of the garden where relevant public exposure is likely, for example where there are seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

1.36 There are many components that contribute to the uncertainty of modelling predictions. Dispersion models often rely on the output of traffic models, which themselves have an inherent uncertainty. There will be additional uncertainties introduced because the model simplifies real-world installation into a series of algorithms. For example, the model generally assumes that the vehicle fleet in the study area conforms to a national or regional composition; that the emissions per vehicle correspond to those factors published by the Department for Transport (DfT); that the meteorological conditions at the study area are the same as those at the location from which they were derived (which may be some distance away); and that the dispersion of pollutants conforms to the algorithms in the model.

1.37 An important stage in the process is verifying the model results against measurements, as this allows the combined uncertainties in the model to be evaluated. The level of confidence in the outcome will be greater if the verification is based on monitoring carried out to the standards of the national network, ie, using chemiluminescent analysers for NO_2 and equivalent methods for PM_{10}, with an appropriate level of quality assurance and quality control (QA/QC). Similarly, the confidence in model results for a section of road will be greater if the traffic data are based on detailed traffic counts, rather than flows derived from a traffic model. Where uncertainties are potentially high and the outcome is marginal, then the authority should look to obtaining more reliable data to improve the confidence in its decision.

1.38 In all cases, the importance of these uncertainties will be more critical where the final outcome of the Review and Assessment, to declare an AQMA or not, is finely balanced, ie, where the concentrations are just above or just below the objective. In such cases, authorities are advised against placing reliance on the results of a single NO_2 diffusion tube location, or those of non-equivalent methods for PM_{10}, as the sole means of deriving their conclusions.

1.39 Whilst authorities are encouraged to be aware of the uncertainties in their Review and Assessments, it is not generally recommended that uncertainty estimates are applied to absolute monitoring or predicted data values as a means of correction, unless there is good reason to do so[8]. Such estimates of uncertainty may however be useful in assisting the authority in its decision as to the geographical extent of the AQMA boundary. Further guidance on this approach is given in the document published by Environmental Protection UK (formerly the National Society for Clean Air and Environmental Protection) "Air Quality Management Areas: Turning Reviews into Action"[9].

On what basis should an Air Quality Management Area be revoked or amended?

1.40 There is the potential that the Review and Assessment process may result in the need for an existing AQMA to be amended or revoked. The process for amending or revoking an AQMA is similar (from the technical point of view) to that for declaring an AQMA in the first instance. The authority will therefore need to be able to demonstrate the same degree of confidence in its decision to revoke or amend an AQMA, as was provided for the original declaration.

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[8] This is different to systematic bias, which should be corrected for.

[9] Available from www.environmental-protection.org.uk

1.41 In the majority of cases, it is envisaged that a Detailed Assessment will be required to support any decision to amend or revoke an AQMA. The Updating and Screening Assessment may be sufficient in circumstances where:

- It can be demonstrated that the source(s) giving rise to the original AQMA declaration have been removed, for example, due to the closure of an industrial installation or road;
- The pollutant emissions assumed for the original AQMA declaration have significantly changed, for example, due to the construction of a bypass around a town centre, or modification to an industrial installation.

1.42 The decision to revoke an AQMA should recognise that pollutant concentrations can vary significantly from one year to the next, due to the influence of meteorological conditions. It is important that authorities should avoid cycling between declaring, revoking and declaring again, due simply to these variations. The authority therefore needs to be reasonably certain that any future exceedences (that might occur in more adverse meteorological conditions) are unlikely. For this reason, it is expected that authorities will need to consider measurements carried out over several years or more, as well as the national trends in emissions, and local factors that may affect the AQMA, including measures introduced as part of the Action Plan, together with information from national monitoring on high and low pollution years.

1.43 The UK Government and the Devolved Administrations expect that all decisions to amend or revoke AQMAs should be subject to full consultation. Further guidance on the recommended approach to consultation is given in the Policy Guidance documents.

Strategies for Review and Assessment

1.44 Authorities are advised to give careful consideration to the monitoring and modelling strategies that they employ, particularly when they undertake work for a Detailed Assessment. Monitoring and modelling can prove to be both resource and cost-intensive activities, and authorities are recommended to make use of the guidance on monitoring, emissions and modelling as set out in Annexes 1 to 3. Authorities should also check the Helpdesk websites (Box 1.1) to ensure that the latest advice and up-to-date tools are being used, and if necessary seek advice from the relevant Helpdesks, in particular to ensure that appropriate monitoring and modelling is carried out. Some general tips for monitoring and modelling strategies are provided in Box 1.5.

Box 1.5: Strategies for Detailed Assessments

Monitoring and modelling can be both time-consuming and expensive. Some tips on Review and Assessment strategies are provided here. More detailed guidance is given in Annexes 1 to 3, and assistance is available from the Helpdesks (Box 1.1).

- When considering site selection, bear in mind the important issue of public exposure, and locate samplers where the measured concentrations will be relevant.
- For urban centres, or in the vicinity of single roads, it would be most appropriate to site monitoring equipment at the building façade of the closest properties to the roads, as this is likely to represent the highest exposure to members of the public (unless there is also relevant exposure to the shorter-term objectives).
- A Detailed Assessment of traffic related sources will almost certainly require a period of monitoring using a continuous analyser (for example, a chemiluminescent analyser for NO_2). However, these data can be usefully supplemented by simpler techniques, such as passive diffusion tubes, in order to define the spatial distribution. In such cases, it is important to establish and then allow for the bias that is often found with diffusion tubes, ideally by co-locating tubes (in triplicate) alongside the inlet to the continuous analyser, or by use of national bias adjustment factors available on the Review and Assessment Helpdesk website (see Box 1.1).
- When assessing industrial or other emissions from point sources, then the focus should be on the short-term concentrations (15-mins or 1-hour). This should guide any monitoring or modelling programme.
- Monitoring is likely to be less useful for assessing emissions from a chimney stack because of the difficulty of ensuring that the worst-case location has been identified (this location is likely to change from one year to another). Such sources are usually best assessed using recognised models that have been well validated.
- Where ambient monitoring is carried out for a point source, then a period of nine to 12 months monitoring is advised. For road traffic sources a period of six to 12 months is advised. Where fewer than nine months of data are available it will be essential to compare the data with those from long-term sites over the same period, so as to provide an estimate of the annual mean. If the monitoring covers fewer than nine months, and the measured concentrations are close to the objective, for example, within ±10%, then it will probably be necessary to monitor for a longer period to ensure adequate confidence in the decision to declare or not declare an AQMA.

What is expected in the Review and Assessment report?

1.45 For the Review and Assessment process, all local authorities should complete Progress Reports and Updating and Screening Assessment reports according to the timetable provided in Table 1.3. Some authorities will also need to produce a Detailed Assessment report, and pending the outcome of this report, a Further Assessment report where a new AQMA has been declared. These reports should describe all the information used to carry out the assessment in sufficient detail to justify the decision(s) to proceed from:

i The Updating and Screening Assessment to a Detailed Assessment;

ii The Detailed Assessment to the decision to declare, amend or revoke an AQMA.

1.46 The Progress Reports and Updating and Screening Assessment reports should be completed using the web-based proformas and checklists provided by the UK Government and the Devolved Administrations. These templates follow the format of the checklists provided in the following sections. Tables and figures will be added to the template as necessary, and an appropriate front cover, before uploading onto the web-based reporting website.

1.47 Authorities may also find it helpful to look at the "useful examples" of reports produced during previous rounds of Review and Assessment. These are also held on the Review and Assessment website (see Box 1.1).

1.48 Given the importance of providing details of all the assumptions that have been made, particularly during a Detailed Assessment, authorities may wish to consider the publication of a summary report for wider distribution, together with a detailed technical report for distribution to a more limited audience.

1.49 When submitting their Review and Assessment reports, it is imperative that local authorities assume "ownership" of the report and any conclusions or recommendations drawn from it. This is particularly the case where the authority has contracted a third party organisation to prepare the report on its behalf. In this case, the authority should provide an accompanying letter, stating that the report is submitted in fulfillment of its responsibilities under the LAQM system, and that it fully endorses the conclusions and recommendations therein.

Other Local Air Quality Management guidance documents

1.50 Authorities are reminded that this Technical Guidance should be read alongside the relevant Policy Guidance documents[10], which set out in detail the LAQM process and the policy background.

1.51 In particular, it should be noted that the Policy Guidance documents for England (LAQM.PG(09)) contain new guidance related to the development of Air Quality Action Plans. Similar guidance has been produced as part of the Scottish Policy Guidance LAQM.PG(S)(09), the Welsh Policy Guidance (LAQM.PG(W)(09)) and will also be present in the Northern Ireland version (LAQM.PGNI(09)).

1.52 This new guidance aims to establish the general economic principles that can be applied to the assessment of local air quality measures and schemes, and provides a means to improve LAQM practice and performance. The guidance is intended to assist local authorities in the development of their Action Plans, but also addresses more general plans and policies for improving air quality.

1.53 The Policy Guidance is accompanied by four Practice Guidance documents. The Practice Guidance on economic principles sets out the economic approaches that can be used for appraising air quality improvements, including:

- Estimating the benefits: this includes guidance on how to estimate the monetary benefits of the proposed measures;
- Estimating the costs: this includes guidance on which cost elements to consider, and how to express these in terms that allow comparison of options;
- Analysis of cost-effectiveness: this provides guidance on how to combine the elements of an Action Plan to achieve a reduction in exceedences of the objectives in the most cost-effective manner; and
- Cost-benefit analysis: this provides guidance on how to assess the wider costs and benefits of proposed measures.

1.54 The Practice Guidance on economic principles is supported by more specific Practice Guidance on three specific measures to improve air quality:

- Incentivising low emission vehicles;
- Designating low emissions zones; and
- Incentivising the retrofitting of existing vehicle fleets.

[10] Separate Policy Guidance documents have been published in England, Wales, Scotland and Northern Ireland.

Sources and health effects of air pollutants

1.55 Box 1.6 provides a summary of the sources and health effects of the regulated pollutants that are the subject of this technical guidance.

Box 1.6: Sources of pollutants and health effects		
Pollutant	**Sources**	**Health Effects**
Nitrogen Dioxide	Nitric oxide (NO) is mainly derived from road transport emissions and other combustion processes such as the electricity supply industry. Nitric oxide is not considered to be harmful to health. However, once released to the atmosphere, NO is usually very rapidly oxidized, mainly by ozone (O_3), to nitrogen dioxide (NO_2), which can be harmful to health. Nitrogen dioxide and NO are both oxides of nitrogen and together are referred to as nitrogen oxides (NO_X).	Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.
Fine Particles (PM_{10}, $PM_{2.5}$ and PM_1)	Fine particles are composed of a wide range of materials arising from a variety of sources including: *combustion sources* (such as road traffic); *secondary particles,* mainly sulphate and nitrate formed by chemical reactions in the atmosphere, and often transported from far across Europe; *coarse particles,* suspended soils and dusts (eg, from the Sahara), sea salt, biological particles and particles from construction work.	Particles are measured in a number of size fractions according to their mean aerodynamic diameter. Most monitoring is currently focused on PM_{10}, but the finer fractions such as $PM_{2.5}$ and PM_1 are becoming of increasing interest in terms of health effects. Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs.
Sulphur Dioxide	Sulphur dioxide (SO_2) is produced when a material, or fuel, containing sulphur is burned. Globally, much of the SO_2 in the atmosphere comes from natural sources, but in the UK the predominant source is power stations burning fossil fuels, principally coal and heavy oils. Widespread domestic use of coal can also lead to high local concentrations of SO_2.	Even moderate concentrations may result in a fall in lung function in asthmatics. Tightness in the chest and coughing occur at high levels, and lung function of asthmatics may be impaired to the extent that medical help is required. Sulphur dioxide pollution is considered more harmful when particulate and other pollution concentrations are high.
Benzene	Benzene is a volatile organic compound (VOC) which is a minor constituent of petrol. The main sources of benzene in the atmosphere in Europe are the distribution and combustion of petrol. Of these, combustion by petrol vehicles is the single biggest source (70% of total).	Possible chronic health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.
1,3-Butadiene	1,3-butadiene, like benzene, is a VOC emitted into the atmosphere principally from fuel combustion of petrol and diesel vehicles. 1,3-butadiene is also an important chemical in certain industrial processes, particularly the manufacture of synthetic rubber.	Possible chronic health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.
Carbon Monoxide	Carbon monoxide (CO) is a colourless, odourless poisonous gas produced by incomplete, or inefficient, combustion of fuel. It is predominantly produced by road transport, in particular petrol-engine vehicles.	This gas prevents the normal transport of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease.
Lead	Since the introduction of unleaded petrol in the UK there has been a significant reduction in urban lead levels. In recent years industry, in particular secondary non-ferrous metal smelters, have become the most significant contributors to emissions of lead. The highest concentrations of lead and heavy metals are now therefore found around these installations in industrial areas.	Even small amounts of lead can be harmful, especially to infants and young children. In addition, lead taken in by the mother can interfere with the health of the unborn child. Exposure has also been linked to impaired mental function, visual-motor performance and neurological damage in children, and memory and attention span.

CHAPTER 2: Tools and supporting information

Introduction

2.01 This chapter brings together a series of tools and other supporting information to help local authorities carry out their Review and Assessments. Where appropriate, the general approach and methodology is described, and the user is then referred to a website where more detailed information and spreadsheet tables or tools can be accessed. This allows information to be updated as and when necessary. Local authorities are encouraged to check that the latest versions of tables and tools are always used; this can be most easily achieved by registering for automatic updates with the Helpdesks (see Para 1.15).

Background pollutant concentrations

2.02 Emissions from local pollutant sources (such as roads, chimney-stacks etc) will be added to local background concentrations. In many situations the background contribution may represent a significant or dominant proportion of the total pollutant concentration, and it is thus important that authorities give careful consideration to background levels and how they are estimated for future years.

2.03 Background concentrations are expected to decline in future years as a result of Government and EU policies and legislation to reduce pollutant emissions[11]. Where appropriate, specific advice on how to treat background concentrations is given in subsequent chapters. In many instances it is recommended that use is made of the national background maps, which are provided for each 1x1 km grid square across the UK. Where appropriate these data can be supplemented by and compared with local measurements of background, although care should be exercised to ensure that the monitoring site is representative of background air quality. If the local background is derived from area-wide (regional) modelling, then the results should be validated against background monitoring sites and/or compared with the national maps.

2.04 For 1,3-butadiene, benzene, carbon monoxide (CO) and sulphur dioxide (SO_2), the background maps derived from a 2001 base year remain unchanged. These maps and a future year calculator may be accessed from the Internet[12].

2.05 For Nitrogen oxides (NO_X), nitrogen dioxide (NO_2) and particulate matter below 10 µm diameter (PM_{10}), new background maps have been prepared for this Guidance, derived from a 2006 base year, and are provided for all years up to 2020. An important change to the way in which these new background maps are provided means that it is now much simpler to avoid the problem of "double-counting", for example, where a very busy road passes through a grid square in a rural or suburban area. The various source contributions to the estimated background concentration in each 1x1 km grid square are now provided, such that it is possible to remove those sources that are explicitly modelled. The contributions from emissions inventory sources are provided separately for the sources within the 1 km x 1 km grid square and sources outside the 1 km x 1 km grid square.

[11] Background concentrations of nitrogen dioxide are expected to decline, in the future, despite the recent increasing proportion of primary nitrogen dioxide in nitrogen oxides emissions. This increase in primary nitrogen dioxide has had a greater impact at roadside locations, but even here concentrations of nitrogen dioxide are expected to resume a downward trend.

[12] The maps can be accessed at www.airquality.co.uk/archive/laqm/tools.php

This is to enable individual sectors to be subtracted from the total if a more detailed local assessment is to be carried out for that sector. Sector maps are not available for NO_2 (as it would not be feasible to produce them) but the projections of future year NO_2 do take account of the expected changes in the proportion of primary NO_2 emissions ("f-NO_2").

2.06 The sector contributions for NO_X in the background maps include:

- Motorways;
- A-roads (trunk and primary separately);
- Minor roads;
- Industry (point sources, combustion, energy production, fossil fuel extraction and waste);
- Domestic, institutional and commercial space heating;
- Aircraft;
- Rail;
- Other (shipping, minor roads and cold starts, off-road, rail and other emissions);
- Regional rural contribution.

2.07 The sector contributions for PM_{10} in the background maps include:

- Motorways;
- A-roads (trunk and primary separately);
- Minor roads;
- Brake and tyre wear emissions from road traffic;
- Industry (point sources, agriculture, combustion, construction, energy production, fossil fuel extraction, industrial installations, quarries, solvents and waste);
- Domestic, institutional and commercial space heating;
- Rail;
- Secondary PM (organic and inorganic);
- Sea salt, regional primary PM and residual non-characterised sources;
- Other (aircraft, shipping, minor roads and cold starts, off-road, rail and other emissions).

2.08 The majority of these contributions are split into sources within the 1 km x 1 km grid square, designated "in" in the spreadsheets, and sources outside the 1 km x 1 km grid square, designated "out" in the spreadsheets. This makes it easier to avoid double counting of sources being explicitly modelled within the grid square, while retaining those source outside the grid square that are not being explicitly modelled.

2.09 The background maps can be accessed from the internet[13].

Future year projections

2.10 In many cases, local authorities will need to consider background concentrations in different years, or project forwards data collected from monitoring campaigns. A number of different approaches are now used.

[13] The maps can be accessed at www.airquality.co.uk/archive/laqm/tools.php

2.11 The approach for 1,3-butadiene, benzene, CO, lead and SO_2 remains unchanged, and authorities are advised to use the Year Adjustment Calculator spreadsheet available from the internet[14].

2.12 For background NO_X, NO_2 and PM_{10}, there is no need to apply adjustment factors to the mapped data as was the case previously, as a separate map is now provided for each year. To adjust monitoring data from background locations, the year adjustment factors appropriate to any 1x1 km grid square can be simply calculated by comparing the maps for the two years in question. For example, if an authority wishes to project forwards a background measured concentration of NO_2 in 2008 to 2010, the appropriate factor would be the ratio between the 2010 and 2008 mapped concentrations for the appropriate grid square.

2.13 This approach cannot be used to adjust measured roadside NO_2 concentrations, due to the differing proportions of primary NO_2 emissions assumed in each year. Year adjustment factors for roadside NO_2 concentrations have been calculated, with different factors for London (Central, Inner and Outer) and the rest of the UK. The factors have been calculated as the average of modelled concentrations across approximately 1900 road links in London, and 7000 links elsewhere, taking into account the changes in traffic activity, and emission factors for NO_X and primary NO_2 (f-NO_2). The appropriate factors and an example of the approach are set out in Box 2.1.

2.14 Future year adjustment factors for measured roadside PM_{10} also need a different approach, as set out in Box 2.2.

Exceedences and percentiles

2.15 The short-term objectives are framed in terms of the number of occasions in a calendar year on which the objective concentration should not be exceeded. Wherever possible, authorities are encouraged to express the results of their monitoring and modelling in terms of the number of hours, days, etc., above the objective level. This is the clearest basis for strict comparison with the objectives set out in the 2000 and 2002 Regulations. However, for a strict comparison on this basis, there must be a minimum of 90% data capture throughout a calendar year[15]. In certain circumstances, where the measured data capture is less than 90%, it may be appropriate to express short-term concentrations as percentile values that approximate the permitted number of exceedences. Where modelling predictions are carried out, the specific model used may not permit the number of exceedences to be calculated, or the meteorological dataset may contain less than 90% of valid observations in the year. Once again, it may be more appropriate to express the results as a percentile. Further guidance is provided in Annexes 1 and 3. Relationships between the permitted numbers of exceedences of short-period concentrations and the equivalent percentiles are provided in Table 2.1 below to help express results in relevant terms.

[14] The year adjustment calculator can be accessed at www.airquality.co.uk/archive/laqm/tools.php

[15] An exceedence of short-term objectives may of course be demonstrated with a much lower data capture rate.

Box 2.1: Projecting measured annual mean roadside nitrogen dioxide concentrations to future years					
Year	**Adjustment factor to be applied**				**Example**
	Central London	**Inner London**	**Outer London**	**Rest of UK**	The measured NO_2 concentration at a roadside site in Outer London in 2008 is 45.2 µg/m^3. The projected concentration for 2010 would be 45.2 x (0.902/0.951) = 42.9 µg/m^3 Roadside locations are typically within 1 to 5 metres of the kerbside, but may extend up to 15 metres depending upon the road configuration and traffic flow.
2006	1.000	1.000	1.000	1.000	
2007	0.960	0.964	0.969	0.967	
2008	0.920	0.928	0.937	0.935	
2009	0.881	0.892	0.906	0.902	
2010	0.820	0.827	0.854	0.861	
2011	0.780	0.791	0.823	0.828	
2012	0.740	0.756	0.791	0.795	
2013	0.700	0.720	0.760	0.763	
2014	0.661	0.684	0.728	0.730	
2015	0.621	0.648	0.697	0.697	
2016	0.602	0.628	0.674	0.669	
2017	0.584	0.608	0.652	0.640	
2018	0.565	0.588	0.629	0.611	
2019	0.547	0.568	0.606	0.583	
2020	0.529	0.548	0.584	0.544	

This Table may be updated from time to time – check with Review and Assessment Helpdesk (Box 1.1)

Box 2.2: Projecting measured annual mean roadside PM_{10} concentrations to future years

Annual mean PM_{10} concentrations at roadside locations in future years can be estimated from measured values using the following method. This method is only appropriate for roadside locations and cannot be used at locations where there is a strong influence from fugitive or industrial sources.

Step 1: Identify the total background concentration for the relevant grid square in µg/m^3, for the measurement year from the national maps published at www.airquality.co.uk. (If the background concentration is more than that measured then project forward using the approach in paragraphs 2.02 to 2.08).

Step 2: Subtract the background concentration (Total_PM_{10}) for the appropriate year from the measured concentration to determine the local PM_{10} road concentration in that year.

measured – background = local road concentration

Step 3: For the relevant grid square for the year of monitoring add together concentrations from the following road sources:

Motorway_in and Motorway_out
Trunk_A_Rd_in and Trunk_A_Rd_out
Primary_A_Rd_in and Primary_A_Rd_out
Minor_Rd_in and Minor_Rd_out
Brake_Tyre_in and Brake_Tyre_out

motorways + trunk A roads + primary A Roads + minor roads + brake & tyre = background road contribution

Step 4: Repeat step 3 for the future year.

Step 5: Divide the background road contribution in the future year by the background road contribution in the measurement year. The result is the "year adjustment factor".

background road contribution in future year ÷ background road contribution
in measurement year = year adjustment factor

Step 6: Multiply the local road concentration (from Step 2) by the adjustment factor (from Step 5) to determine the concentration from local road sources in the future year.

local road measured x adjustment factor = local road concentration in future year

Step 7: Identify the local background concentration in the future year from the national maps published at www.airquality.co.uk.

Step 8: Add the local road concentration in the future year to the background concentration in that year to determine the total roadside concentration in the future year.

local road concentration + background = Total PM_{10} concentration

Further assistance with this procedure and interpretation of the results can be obtained from the Review and Assessment Helpdesk (see Box 1.1).

Table 2.1: Approximate equivalent percentiles to the air quality objectives

Pollutant	Time Period	Permitted Exceedences	Equivalent Percentile
Nitrogen dioxide	1-hour	18 per year	99.8th percentile
PM_{10}	24-hour	35 per year	90th percentile
	24-hour	7 per year	98th percentile
Sulphur dioxide	15-minute	35 per year	99.9th percentile
	1-hour	24 per year	99.7th percentile
	24-hour	3 per year	99th percentile

Fall-off in nitrogen dioxide concentrations with distance from the road

2.16 Concentrations of NO_2 close to roads are expected to form the focus of attention for many local authorities. However, it is often not possible to measure concentrations at the desired location for a range of practical reasons, for example, continuous monitoring stations require space, security and power, and diffusion tubes must be attached to suitable surfaces.

2.17 Wherever possible, authorities are strongly encouraged to ensure that monitoring locations are representative of exposure (as set out in Box 1.4), and further guidance is provided in Chapter 3 and Annex 1 of this document. Where measurements made at one location alongside a road are used to estimate concentrations at a different distance from the same road, a new approach for adjustment is provided, as set out in Box 2.3. Due to the greater uncertainty of the results derived by this approach, it is unlikely to be suitable for use in Detailed Assessments.

Box 2.3: Predicting nitrogen dioxide concentrations at different distances from roads

A method has been developed to allow NO_2 measurements made at one distance from a road to be used to predict concentrations at a different distance from the same road. It is appropriate for distances between 0.1 m and 140 m of the kerb.

Step 1: Identify the local background concentration in µg/m^3, either from local monitoring or from the national maps published at www.airquality.co.uk. (Note that the background concentration must be less than the measured concentration).

Step 2: apply the following calculation

$$C_Z = ((C_y - C_b) / (-0.5476 \times Ln(D_y) + 2.7171)) \times (-0.5476 * Ln(D_z) + 2.7171) + C_b$$

Where:

C_z is the total predicted concentration (µg/m^3) at distance D_z;
C_y is the total measured concentration (µg/m^3) at distance D_y;
C_b is the background concentration (µg/m^3);
D_y is the distance from the kerb at which concentrations were measured; and
D_z is the distance from the kerb (m) at which concentrations are to be predicted.
Ln(D) is the natural log of the number D.

Results derived in this way will have a greater uncertainty than the measured data. Further assistance with this procedure and interpretation of the results can be obtained from the Review and Assessment helpdesk (www.uwe.ac.uk/aqm/review).

Calculator

The equation above is available as a simple calculator[16]. This is set up to work from 0.1 to 50 m from the kerb, as this is the range that is likely to be relevant for Local Air Quality Management (LAQM) work. Kerbside sites should be treated as being at 0.1 m from the kerb. The calculator works for receptors either closer to or further from the kerb than the monitor. The greater the distance between the receptor and monitor, the greater the uncertainty in the derived receptor concentration. It is therefore recommended that if the receptor is further from the kerb than the monitor it should be no more than 20 m away. If the receptor is closer to the kerb, then it should be no more than 10 m from the monitor.

Use of the Design Manual for Roads and Bridges Model

2.18 The Design Manual for Roads and Bridges (DMRB) Screening Model is provided by the Highways Agency. The latest version to use and procedures for its use are described on the Local Authority Air Quality Support Helpdesk website[17].

2.19 The DMRB model is used to predict the annual mean concentrations of NO_2 and PM_{10}. The empirical relationships described in a subsequent section of this chapter are then applied for assessment of the short-term objectives.

[16] The calculator can be accessed at www.airquality.co.uk/archive/laqm/tools.php

[17] www.airquality.co.uk/archive/laqm/tools.php

2.20 Where the DMRB assessment indicates that exceedences of the objectives are likely, a more detailed study may then be required. This may include the use of more complex dispersion models, and/or the use of local monitoring. However, where a good agreement between the DMRB model results and monitoring (at relevant locations) is demonstrated, then the results of the DMRB model should, in many instances, be sufficient to determine the area of exceedence of the objective. In circumstances where complex road layouts, such as large junctions or complex street canyons are being assessed, then more detailed modelling is recommended.

2.21 Further guidance on modelling for Detailed Assessments is provided in Chapter 6.

Relationships between nitrogen oxides and nitrogen dioxide

2.22 Nitrogen oxides, NO_X ($NO+NO_2$) are predominantly emitted into the atmosphere in the form of nitric oxide (NO) which is then converted to nitrogen dioxide (NO_2) through chemical processes in the atmosphere. Under most atmospheric conditions, the dominant pathway for NO_2 formation is via the reaction of NO with ozone (O_3).

2.23 Recent trends in concentrations of NO_X have shown a general downward trend across urban areas, in line with the reductions in emissions from road traffic. However, measured NO_2 concentrations have not declined as expected, particularly at roadside sites, and at some locations have actually increased in recent years.

2.24 The recent AQEQ report[18] investigated these unexpected findings, and concluded that the most plausible explanation was an increased proportion of direct (or primary) NO_2 emission from road traffic, often referred to as "f-NO_2"[19]. Increased primary NO_2 emissions are associated with the greater penetration of diesel cars into the vehicle fleet, and the use of catalytically regenerative particle traps on some heavy duty vehicles. The proportion of primary NO_2 emissions has been steadily increasing over recent years, and looks set to increase up to 2015, albeit at a slower rate.

2.25 An approach to calculating NO_2 from NO_X concentrations at roadside sites was developed for the previous version of this Technical Guidance (LAQM.TG(03)). The approach was updated in 2007 to take account of the historic change in the proportion of primary NO_2 emissions, but it was always recognised that such an empirically-derived method was not suited to the prediction of NO_2 concentrations in future years.

2.26 A new approach has been developed to allow the calculation of NO_2 from NO_X concentrations, taking account of the difference between fresh emissions of NO_X and background NO_X, the concentration of O_3, and the different proportions of primary NO_2 emission, in different years.

2.27 The new approach has been developed as a simple spreadsheet calculator which can be downloaded from the internet[20]. This calculator allows the calculation of NO_2 from NO_X and vice versa. It differs from previous versions in that it allows for varying proportions of primary NO_2. It also allows more than one calculation to be performed at once.

[18] AQEG (2007) Trends in primary nitrogen dioxide in the UK. www.defra.gov.uk/environment/airquality/publications/primaryno2-trends/index.htm

[19] This is the fraction of NO_X that is emitted as nitrogen dioxide.

[20] The calculator is available at www.airquality.co.uk/archive/laqm/tools.php

Other approaches

2.28 Other approaches for NO_X to NO_2 conversion may be used, and may be preferred by the authority depending on the type of dispersion model that is employed. For example, the Generic Reaction Series, or other chemical reaction schemes may be used. In this case, appropriate parameters to describe f-NO_2 and future year O_3 concentrations should be carefully considered and described. The "Derwent-Middleton" equation is no longer a suitable approach. Where a conversion method is incorporated within a dispersion model, care should be taken to follow the advice given in Box 6.2, which explains that the model should be verified using NO_X and not NO_2.

2.29 Methods for the conversion of NO_X to NO_2 for stack emissions are described in Chapter 6 of this guidance, and these should be used for specific studies investigating stack impacts alone, which are likely to be more related to short-term impacts. These methods are consistent with those used by the Environment Agency and other regulators. However, where stacks are included within models representing wider urban areas with a large number of emissions sources, and where annual mean concentrations are the main focus, the method described in Paragraph 2.27 above may be used for the conversion of total annual mean NO_X to annual average NO_2 concentrations.

Relationship between the annual mean and 1-hour mean nitrogen dioxide objective

2.30 It is not straightforward to either measure or predict exceedences of the 1-hour objective for NO_2. By its nature, exceedences of the 1-hour objective will be highly variable from year to year, and from site to site. If monitoring is to be relied upon, then this must be carried out for an extended period, and often a full calendar year, to ensure that the occurrence of occasional peaks is adequately captured. Dispersion models are inevitably poorer at predicting short-term peaks than they are at predicting annual mean concentrations, and the process of model verification is extremely challenging.

2.31 Previous research carried out on behalf of Defra and the Devolved Administrations[21] identified a relationship between the annual mean and the 1-hour mean objective, such that exceedences of the latter were considered unlikely where the annual mean was below 60 $\mu g/m^3$. The report identified the need to re-evaluate the monitoring data from time to time in order to confirm that this relationship remained appropriate.

2.32 An updated analysis[22] has been carried out, taking into account new monitoring data collected over the period 2003-2007. This new analysis has identified a number of exceedences of the 1-hour mean objective where annual mean concentrations were below 60 $\mu g/m^3$. The majority of these occurrences were recorded at kerbside and roadside sites, and were at sites within south-east England (and in particular within Greater London), but not exclusively so. A large number of these exceedences were associated with a regional pollution event that occurred over several days in December 2007.

2.33 Such regional pollution events are extremely difficult to predict, and are beyond the remit of LAQM which is necessarily focused on local hot-spots. If exceedences associated with the December 2007 regional event are excluded from the analysis, the number of exceedences of the 1-hour mean where annual mean concentrations are below 60 $\mu g/m^3$, is extremely limited.

[21] Laxen D and Marner B (2003). Analysis of the relationship between 1-hour and annual mean nitrogen dioxide at UK roadside and kerbside monitoring sites. Available at www.airquality.co.uk/archive/reports/list.php

[22] Cook A (2008) Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective Available at www.airquality.co.uk/archive/laqm/tools.php

2.34 On the basis of this new evidence, the guidance remains unchanged and authorities may assume that exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60 µg/m^3 or above. Defra and the Devolved Administrations will keep the situation under close review, and will issue revised guidance in the future should this prove necessary.

2.35 Guidance on how authorities should proceed when annual mean concentrations of NO_2 are measured or predicted to be 60 µg/m^3 and above, is provided in subsequent chapters.

Relationship between the annual mean and 24-hour mean PM_{10} concentrations

2.36 Dispersion models are inherently less accurate at predicting the number of exceedences of the 24-hour mean PM_{10} objective than for the annual mean objective. There are also occasions where current year monitoring data need to be adjusted forwards to a year in the future, taking into account the likely number of 24-hour exceedences of 50 µg/m^3. A relationship between the annual mean and the number of 24-hour mean exceedences of has been devised. It is unchanged at the time of writing from that used in the previous guidance and takes the form:

$$\text{No. 24-hour mean exceedences} = -18.5 + 0.00145 \times \text{annual mean}^3 + (206/\text{annual mean})$$

2.37 Important issues regarding the monitoring of PM_{10} concentrations are set out in Chapter 3. The equation above has been derived by applying the default 1.3 correction factor to the Tapered Element Oscillating Microbalance (TEOM) analyser data. As stated in Chapter 3, the UK automatic monitoring networks are currently being restructured to include instruments that are equivalent to the EU reference sampler, and as new data becomes available it is possible that the relationship between the annual mean and the number of 24-hour mean exceedences may change.

2.38 Defra and the Devolved Administrations will keep this under review, and will issue revised guidance to local authorities on the Helpdesk websites (Box 1.1), as and when necessary.

Emissions tools

2.39 A suite of emissions tools to assist local authorities is provided in the form of databases, maps, and spreadsheets, and are available for download from the Internet. These include:

- Emissions Factor Database (EFD) – this database contains the emissions factors used in the UK National Atmospheric Emissions Inventory (NAEI), as well as factors specially designed for local inventories[23];
- Mapped emissions data – estimates of atmospheric emissions on a 1x1 km grid square basis for the UK[23];

[23] Tools available for download at: www.airquality.co.uk/archive/laqm/tools.php

- Emissions Factor Toolkit (EFT) – a spreadsheet tool that allows the calculation of road traffic exhaust emissions for different vehicle categories and splits, at various speeds, and on different road types. The emissions factors included in the EFT are consistent with the EFD (see above) but the spreadsheet tool allows local authorities to carry out these calculations more easily. (Note: the road transport emissions factors contained in the EFD and EFT are expected to be updated in 2009, following a review undertaken by Department for Transport (DfT). At such a time, the EFD and EFT will be updated. Further details on the new emissions factors are provided in Annex 2)[23].
- London Atmospheric Emission Inventory (LAEI) – a detailed emission inventory for the Greater London area, including road traffic flows, and disaggregated emissions by 1x1 km grid square[24].

[24] Available at: www.london.gov.uk/mayor/environment/air_quality/research

CHAPTER 3: Monitoring

Introduction

3.01 Monitoring data form the backbone of the Review and Assessment process. They provide:

- a measure of actual concentrations and exceedences of objectives;
- information on trends in air quality; and
- a basis for verifying the results of air quality dispersion models.

However, the collection of monitoring data is not without its challenges. This chapter sets out the approaches required to obtain valid and meaningful data.

3.02 Monitoring data are likely to be available from a variety of sources, including: national networks; regional networks; local data collected by the authority; and local data collected by other bodies or organisations. For the purpose of Review and Assessment, authorities will need to have confidence in the quality of the monitoring data they are using. This chapter sets out the important requirements for monitoring and how the data should be used in the Review and Assessment process. More detailed guidance is provided in Annex 1.

3.03 This chapter focuses on monitoring of nitrogen dioxide (NO_2) and particulate matter (PM) as these two pollutants are likely to dominate local authority requirements; however many of the principles set out are equally applicable to other pollutants. If authorities need to undertake monitoring for other pollutants, they are advised to refer to Annex 1 of this document (which also covers NO_2 and PM), and/or contact the Local Authority Air Quality Support Helpdesk (see Box 1.1) if necessary.

3.04 As the "to be achieved by" dates for the objectives (in particular 2004[25] for PM_{10}, and 2005 for NO_2) have now largely passed, there is inevitably an increasing reliance on monitoring data, as opposed to modelling predictions, to determine actual exceedences. Provided that the data are "fit for purpose", then precedence should always be given to measured concentrations over those that have been predicted using a model. In this context, "fit for purpose" means that:

- a suitable monitoring method has been used;
- the data have been subject to suitable quality assurance/quality control checks;
- the monitoring has been carried out over a sufficient period of time; and
- the monitoring sites represent likely worst-case exposure to members of the public, at relevant locations (see Chapter 1), bearing in mind the averaging periods of the objectives.

3.05 Detailed guidance on these issues is provided in Annex 1. Particular matters to take account of when preparing and assessing monitoring results are set out in Box 3.1.

[25] Scotland has additional PM_{10} objectives, which will apply from 2010.

Box 3.1: Matters to take into account when reporting monitoring data	
1	When presenting automatic monitoring data, it should be made clear whether or not the results have been ratified. It may be necessary to have a combination of ratified and unratified data. The fully ratified data can then be updated in subsequent reports. Information on data capture should also be provided.
2	Where results are presented for new monitoring sites, then a description of the sites should be provided. This should include the reason they were set up, for example, to represent worst-case relevant exposure alongside a particular road.
3	Where data are available for a period of less than 9 months, then they should be adjusted to provide an estimate of the annual mean using the procedure set out in Box 3.2.
4	To help understand the results, the type of monitoring site should be specified (see Annex 1 for definitions). For roadside sites the distance from the kerb should be provided. For industrial sites the distance to the source(s) should be specified.
5	Where NO_2 diffusion tube data are provided, then it should be made clear whether the results have been adjusted for "bias". Where they have been adjusted, brief details should be provided of the adjustment carried out and the source of the bias adjustment factor. Details should also be provided of the laboratory being used, the tube preparation method and the exposure period.
6	Summary information should be provided on Quality Assurance and Quality Control (QA/QC). This can be by way of a reference to a previously published document, so long as the document is still readily available, eg, a report published on the web.
7	When describing sites, it should be made clear whether they represent relevant exposure. For instance, if the site is kerbside, it would be appropriate to say that *"the nearest relevant exposure is residential properties set back 5 m from the kerb."*
8	For short-term objectives, eg, 1-hour for NO_2, the results should be presented as number of hours (or 15-mins for sulphur dioxide (SO_2), or days for PM_{10}) above the objective value. This should only be done where data capture is more than 90% of a full year. If data capture is less than 90% or monitoring is for less than a full year, then it is only appropriate to present the results as percentiles. The following percentiles roughly equate to the objectives: 99.8th percentile for 1-hour NO_2; 99.9th percentile for 15-min SO_2; 99.7th percentile for 1-hour SO_2; 99.2nd percentile for 24-hour SO_2; 90th percentile for 24-hour PM_{10}, for 2004 objective; and 98.08th percentile for 2010 objective in Scotland. Guidance on calculating percentiles is available in Annex 1.
9	When reporting results a note should be made of any local circumstances that may have affected the results, eg, construction activities close to a PM_{10} monitor, or changes in traffic flows due to road works, new bus lanes etc.

Quality assurance and quality control

3.06 A detailed description of quality assurance and quality control (QA/QC) programmes is provided in Annex 1. In general terms the QA/QC programme should be designed to ensure that:

- Data are representative of the ambient conditions in the local area, and are not unduly affected by very localised artifacts; and
- Measurements are sufficiently accurate and precise to meet the requirements of the study.

3.07 There are a number of different terminologies in use. The process of data validation generally involves a first level screening of the data (by manual and/or automatic methods), to remove obvious erroneous values. These data will have been suitably calibrated against reference standards where appropriate. Within the national monitoring networks, these validated data are labelled "provisional". The subsequent process of data ratification involves a more thorough checking of the data, for example, data rescaling to allow for drift in the calibration standards, or data adjustments following site audits, which have identified problems that could not have been identified remotely (eg, internal sampling leaks).

3.08 Authorities must always use validated data, and are advised to use ratified data wherever possible. If provisional data must be used, it should be noted that the process of ratification will be unlikely to significantly affect the measured annual mean, but may change the number of shorter-term (eg, hourly or 15-minute) means exceeding the relevant objective value.

Locations of monitoring sites

3.09 It is important that authorities have due regard to the objectives of any local monitoring campaigns at the outset, in order to ensure that the data are fit for purpose. Monitoring data may be used to provide direct information as to whether the air quality objectives are being exceeded. They are also frequently used to help demonstrate the performance of dispersion models via the process of model verification.

3.10 It is not always straightforward to find ideal monitoring locations, and there are many considerations to be borne in mind. Automatic sites require power and suitable space. Passive samplers, for example, diffusion tubes, require a suitable object or surface to which they may be attached. For all types of monitoring, security is also an issue.

3.11 Despite these constraints, there is little purpose in commissioning a large network of diffusion tube samplers at kerbside sites, if the outcome of the Review and Assessment process is to then conclude that these locations do not represent relevant exposure. Similarly, if the conclusions of the Review and Assessment are to be based solely on the use of monitoring data, then it will be critical to ensure that these sampling locations take into account those places where concentrations are expected to be the highest, and where the public may be exposed over the relevant averaging period of the objectives. The monitoring programme should also be designed to assist the authority in defining the geographical extent of any exceedences. The type of monitoring site, eg, roadside, background etc, should always be specified (see Annex 1 for site classifications).

3.12 Where the data are specifically required to assist in the verification of a dispersion model, care should be taken to ensure that the monitoring site is sufficiently close to the dominant pollution source. For example, there is little point in commissioning a site at a background location if the intent is to use these data to verify a road traffic model.

3.13 Further guidance on the location of monitoring sites, and specific case-study examples, is provided in Annex 1.

Duration of monitoring

3.14 The air quality objectives are all based upon concentrations measured over a calendar year, and ideally, periods of monitoring data should be consistent with this. Inevitably however, it is often necessary to use monitoring data collected over shorter periods of time.

3.15 For assessment against the annual mean objective for NO_2, it may in many circumstances prove possible to use data from a shorter period of monitoring, for example, six months consecutive sampling (including three months winter and three months summer), preferably with monitoring commencing in January or July. A minimum period of three months should always be used. For PM_{10}, where the focus is on the 24-hour mean objective (except in Scotland where the annual mean in 2010 is the focus), similar guidance applies, but in some circumstances an exceedence of the objective may be demonstrated within a shorter time-frame, eg, if more than 35 days above 50 $\mu g/m^3$ (or seven days in Scotland, during or after 2010) are recorded over the period January to May, then the objective for that year has already been breached. In other cases, it may be necessary to monitor for a full year, as episodes (exceedence days) will occur sporadically throughout the year. Data capture rates of 90% or more over the year should be achievable[26], while data capture rates of 75% or less should be treated with extreme caution, as episodes may be missed. Further guidance on the applicability of short-term monitoring studies, and the issue of seasonality, is provided in Annex 1.

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[26] Data capture refers to the period of sampling, ie, there can be a 90% data capture over a three month period of monitoring. The 10% data loss will be due to problems with the analyser etc. When monitoring is over a three month period then this should not be described as a 25% data capture for the year.

3.16 Where only short-term periods of monitoring data are available, the results may be adjusted to estimate an annual mean concentration using the approach set out in Box 3.2. In the case of 24-hour PM_{10} data it will be more appropriate to present the 90th percentile (and in Scotland the 98th percentile), where data for a full year are not available.

Box 3.2: Estimation of annual mean concentrations from short-term monitoring data

Example

It has only been possible to carry out a monitoring survey (automatic or diffusion tube) at site **S** for six months between July and December 2008. The measured mean concentration **M** for this period is 30.2 µg/m^3. How can this be used to estimate the annual mean for this location?

Adjustment to estimate annual mean

The adjustment is based on the fact that patterns in pollutant concentrations usually affect a wide region. Thus if a six month period is above average at one place it will almost certainly be above average at other locations in the region. The adjustment procedure is as follows:

1. Identify two to four nearby, long-term, continuous monitoring sites, ideally those forming part of the national network. These should be background sites to avoid any very local effects that may occur at roadside sites, and should, wherever possible lie within a radius of about 50 miles.
2. Obtain the annual means, **Am,** for the calendar year for these sites, 2008 in this example.
3. Work out the period means, **Pm,** for the period of interest, in this case July to December 2008. [It may be necessary to use unratified automatic data.]
4. Calculate the ratio, **R,** of the annual mean to the period mean (**Am**/**Pm**) for each of the sites.
5. Calculate the average of these ratios, $\mathbf{R_a}$**.** This is then the adjustment factor.
6. Multiply the measured period mean concentration **M** by this adjustment factor $\mathbf{R_a}$ to give the estimate of the annual mean for 2008.

Long term site	Annual mean 2008 (Am)	Period Mean 2008 (Pm)	Ratio (Am/Pm)
A	28.6	29.7	0.963
B	22.0	22.8	0.965
C	26.9	28.9	0.931
D	23.7	25.9	0.915
		Average (R_a)	**0.944**

For this example the best estimate of the annual mean for site **S** in 2008 will be **M** x $\mathbf{R_a}$ = 30.2 x 0.944 = 28.5 µg/m^3.

Notes

- Monitoring data for the long-term sites must have adequate data capture rates: above 90% is preferable; sites with data capture below 75% should not be used.
- It may be appropriate to use diffusion tube results from a long-term survey to adjust short-term diffusion tube results. To allow for the greater uncertainty of diffusion tubes results from four or more sites should be used. Ensure that the tubes are from the same supplier using the same method of preparation.
- If the short-term period covers, for instance, February to June 2009, and the work is being carried out in August 2009, then an annual mean for 2009 will not be available. The calculation can then be carried out using the ratio to the 2008 annual mean, but the result is then an estimate of the 2008 annual mean at the short-term site.

Nitrogen dioxide

3.17 Monitoring for NO_2 is usually carried out using a continuous analyser (such as a chemiluminescence analyser, open path DOAS analyser or other MCERTS approved instrument), passive diffusion tubes, or a combination of the two. The type of monitoring that is carried out will inevitably vary depending upon local circumstances, and the part of the Review and Assessment process being undertaken. The various merits of different monitoring approaches are set out below. Local authorities are reminded that passive diffusion tubes have a greater uncertainty than automatic analysers, and the results are thus less reliable. However, this can be partially compensated for by the fact that a number of tubes can be placed in the area of interest, giving good spatial coverage, and because they can be placed more easily at the building façade than is the case for an automatic monitor. Ideally authorities should not rely upon diffusion tube data alone as the basis of any decision to declare an Air Quality Management Area (AQMA). However, where tubes do have to be relied upon, the results should cover a full year, they should have a good precision and be appropriately bias adjusted.

3.18 Wherever possible, authorities are encouraged to use continuous monitoring data, either from national networks sites, or from local monitoring campaigns. The overall uncertainty of measurements from a continuous analyser is expected to be about +/-10%, provided that appropriate QA/QC methods are applied. In addition, continuous analysers also provide useful information on hourly mean concentrations, and on concentrations of nitrogen oxides (NO_X). The latter greatly assists with model verification, as it allows a direct comparison between the measured and modelled source contributions.

Diffusion tubes

3.19 Monitoring of NO_2 concentrations using passive diffusion tubes is widely used throughout the UK. Provided that care is taken with the storage, handling and analysis of the tubes, and an appropriate "bias-adjustment" factor is applied, the overall uncertainty of the annual mean is expected to be about +/-20%. The key issues to be considered are the performance of the laboratory, the precision of the diffusion tubes, and the application of a suitable bias adjustment factor. These issues are considered in turn below.

3.20 Additional information and support can be obtained from the Local Authority Air Quality Support Helpdesk (see Box 1.1), which provides a set of centralised QA/QC services to assist local authorities in their use of diffusion tubes. Amongst other services, the site offers access to a web-based data entry system, which allows authorities to securely store and share their data with others.

Laboratory performance

3.21 There is considerable difference in the performance of tubes prepared by different laboratories, such that they may systematically under or over-read NO_2 concentrations when compared with the reference chemiluminescence analyser. This is partly due to factors affecting diffusion tubes during exposure, but in large part is considered to be related to the different ways in which individual laboratories prepare and analyse the tubes. In order to improve the consistency between different laboratories, Defra and the Devolved Administrations commissioned the Local Authority Air Quality Support Helpdesk to coordinate a Working Group to harmonise the methodology that is used in the preparation and analysis of the tubes. The Working Group comprised a wide number of relevant stakeholders, including laboratories and local authorities.

3.22 The Working Group report was published in February 2008[27], and sets out a series of recommendations for laboratories in the preparation and analysis of diffusion tubes, and for tube users in the handling and deployment of diffusion tubes. Defra and the Devolved Administrations **expect local authorities to select laboratories that operate in accordance with this guidance,** for the purpose of Review and Assessment. Where an authority chooses a laboratory that employs methods which do not conform to this guidance, the authority will be expected to provide justification for this selection, and a detailed assessment of the laboratory performance.

3.23 Laboratories participate in two centralised QA/QC schemes; the WASP scheme that is managed by the Health & Safety Laboratory, and a monthly field intercomparison exercise that is managed by AEA. The outcomes of these QA/QC schemes are evaluated on a regular basis against a set of pre-defined performance criteria. In order to get the best value, authorities should ensure that their diffusion tubes are supplied by a laboratory that has demonstrated satisfactory performance with regard to these criteria over the past year. A regularly updated list of laboratory performance can be downloaded from the Local Authority Air Quality Support Helpdesk website (see Box 1.1).

Precision and bias

3.24 Two terms, "precision" and "bias", are frequently used to describe the performance of diffusion tubes, and it is important not to confuse them. Diffusion tube *precision* can be described as the ability of a measurement to be consistently reproduced, ie, how similar the results of duplicate or triplicate tubes are to each other. *Bias* represents the overall tendency of the diffusion tubes to depart from the true value, ie, to under or over-read relative to the reference method (the chemiluminesence analyser). It is important to appreciate that whilst it is possible to adjust the results to account for bias, it is not possible to correct for poor precision.

3.25 The precision of diffusion tubes can be calculated from duplicate, or preferably triplicate tube exposures, ideally from a site that is co-located with a chemiluminescence analyser so that a local bias-adjustment factor can be derived (see below). A spreadsheet-based tool has been developed that allows local authorities to easily calculate the precision of their tubes[28]. Tube precision is categorised as "good" or "poor" as follows: "good" precision applies where the coefficient of variation (CV) of triplicate diffusion tubes for eight or more periods during the year is less than 20%, and the average CV of all monitoring periods is less than 10%; "poor" precision applies where the CV of four or more periods is greater than 20% and/or the average CV is greater than 10%. It should be noted that this is merely an arbitrary criterion, based on what a competent laboratory should be able to achieve. Many laboratories routinely achieve a CV of 5% or less.

3.26 The distinction between "good" and "poor" precision is an indicator of the overall performance of the diffusion tubes in a particular co-location study. The precision will reflect both the laboratory's performance in preparing and analysing the tubes, as well as the handling of the tubes in the field. Any laboratory can have a "poor" precision for a particular co-location study due to poor handling of the tubes in the field. The precision results of tubes used in co-location studies are regularly summarised for the different laboratories supplying and analysing the tubes on the Review and Assessment Helpdesk website (see Box 1.1). When assessing the performance of a particular laboratory, account should be taken of the proportion of "poor" precision co-location studies, and particular care should be exercised when interpreting the results for a laboratory with only a few precision results.

[27] Available at: www.airquality.co.uk/archive/reports/cat05/0802141004_NO_2_WG_PracticalGuidance_Issue1a.pdf

[28] The tool is available at www.airquality.co.uk/archive/laqm/tools.php

3.27 Where results show "poor" precision, then they should be treated with caution. This will particularly be the case if reliance is placed on these results to assist with model verification, or where the concentrations are close (for example, within +/- 10%) to the objective.

3.28 As described above, diffusion tubes may systematically under or over-read NO_2 concentrations when compared to the reference chemiluminescence analyser. This is described as "bias", and can be corrected for to improve the accuracy of the diffusion tube results, using a suitable bias-adjustment factor. The bias-adjustment factor may be determined from a local study that has co-located diffusion tubes with a chemiluminescence analyser, or the factor may be derived from the national database of co-location studies. This database is updated on a regular basis and is available from the Review and Assessment Helpdesk website (see Box 1.1). Separate adjustment factors are provided for each calendar year, as laboratory performance may change over time. The factor for the relevant monitoring year should always be used.

3.29 There is no straightforward answer as to whether it is better to use a bias-adjustment factor derived from the national database of co-location studies, or from a single local co-location study. Guidance on the most suitable approach to be taken is provided in Box 3.3. If a local factor is being used then the factor from the national database should also be presented to help place the local factor in context and to indicate the dependence of the results on the choice of the factor.

Box 3.3: Choice of bias adjustment factors: locally-derived or from the national database.

The most important factors to be considered when deciding which bias-adjustment factor to use are:

- Tube exposure time (1 week, 2 weeks, 1 month)
- Length of the monitoring study
- QA/QC of the chemiluminescence analyser
- QA/QC of diffusion tubes
- Siting of the co-location study
- Siting of other tubes in the survey

Local Authorities using diffusion tubes as part of their Review and Assessment are advised to report both the adjustment factor from their local study, and the bias adjustment factor from the national database. However, the decision of which to use will depend upon a number of factors that will need to be considered. Ultimately it will be up to each Local Authority to take account of these factors and set out the reasons for the choice made. Specific factors that should be addressed are:

Cases where the locally obtained bias adjustment factor may be more representative:

- Where the diffusion tube exposure periods are weekly or fortnightly (or anything other than monthly – the national database of co-location results only covers monthly exposure.)
- If the co-location site is unusual in some way: for example, affected by specific large NO_X sources other than road traffic, such as local industrial installations. (This is a strong indication in favour of using a locally-derived factor).
- For tubes exposed in a similar setting to the co-location site (open/shelter, height etc.)
- Where the duration of the whole diffusion tube study is less than one year, especially if it is less than nine months (when adjustment is best made for a matched time period, rather than using an annual factor).
- Where the Review and Assessment Helpdesk spreadsheet contains data from fewer than five other studies using the same laboratory and preparation.
- Where the co-location study is spread across more than one calendar year, eg, October 2003 to September 2004 – especially where there is evidence of different bias-adjustment factors for different calendar years.
- For co-location sites with "good" precision for the diffusion tubes and with high quality chemiluminescence results, ie, to national AURN standards.

Cases where the combined bias adjustment factor may be more representative:

- Where the survey consists of tubes exposed over a range of settings, which differ from the co-location site, eg, the co-location site is in a very exposed setting and the tubes being assessed are on a building façade in a canyon-like street.
- Where the co-location study is for less than nine months, although the diffusion tube monitoring is for a longer period.
- Where the automatic analyser has been operated using local, rather than national, QA/QC procedures.
- Where data capture from the automatic analyser is less than 90%, or there have been problems with data quality
- For co-location sites with "poor" precision or laboratories with predominately "poor" precision, as set out on the Review & Assessment Helpdesk website (see Box 1.1).

3.30 It should be noted that diffusion tube bias can vary from year to year, (possibly due to changes in laboratory procedures, meteorological conditions at the co-location sites, and other factors). For this reason, bias adjustment factors should be calculated specifically for the calendar year being reviewed.

Particulate matter

3.31 This section discusses the important aspects of monitoring concentrations of PM in ambient air, for the purpose of Review and Assessment. The focus is upon PM_{10} as the objective for this measure of PM is set in Regulations. Objectives for $PM_{2.5}$ (see Table 1.2) have also been introduced by the UK Government and the Devolved Administrations, but these are not included in Regulations and there is no obligation upon local authorities to review and assess against them.

3.32 It is recognised that many authorities are currently undertaking, or are planning to undertake, $PM_{2.5}$ monitoring in order to provide their own information on this measure of PM. These data are used to inform local needs and policies, but are also useful in the development of national plans and strategies. Therefore, this section also provides informal advice on $PM_{2.5}$ monitoring.

3.33 Monitoring concentrations of PM, be it PM_{10} or $PM_{2.5}$, in ambient air is not straightforward. This is due to the complex nature and composition of PM. Amongst many other issues, it is not possible to calibrate the analysers in the traditional sense (eg, the use of a standard gas for NO_X analysers), and there are potentially significant problems with the loss of semi-volatile components when using samplers heated to drive off excess moisture, and the absorption and retention of water vapour. The method selected for the collection and determination of the particle mass thus has an influence upon the mass concentration that is subsequently reported.

3.34 The UK objectives (and the EU limit values) are based upon measurements carried out using the European reference sampler; this is a gravimetric device, where the particle mass is collected onto a filter and subsequently weighed. This type of sampler has significant disadvantages, in that only 24-hour mean concentrations are recorded, the data cannot be disseminated to the public in real-time, and the operation is labour-intensive. Historically, the national networks, and many local authority PM_{10} monitoring sites have used continuous analysers, predominantly the Tapered Element Oscillating Microbalance (TEOM) analyser. The TEOM was known, however, to under-read with respect to the gravimetric method, and, until recently, a default correction of 1.3 has been applied to TEOM data in order to generate a nominal "gravimetric-equivalent result".

3.35 In 2006, the UK Government and the Devolved Administrations published a report on the outcome of detailed equivalence tests for various PM_{10} samplers, when compared with the European reference sampler. The tests carried out were based on the Guidance for the Demonstration of Equivalence of Ambient Air Monitoring Methods issued by an EC Working Group. In simple terms, the Guidance sets out an approach whereby it is possible to test whether an instrument is able to comply with the Data Quality Objective for overall uncertainty as defined within the relevant Air Quality Directive – in the case of PM_{10} this is 25%. The tests were conducted at four sites within the UK, over both summer and winter seasons. The full report can be downloaded from the web[29]. A total of six instruments were tested, and the outcome of the study is summarised in Table 3.4.

[29] Harrison D (2006) UK Equivalence Programme for Monitoring of Particulate Matter. Available at: www.airquality.co.uk/archive/reports/list.php

Table 3.4: Summary of UK Equivalence Tests	
Instrument	**Outcome of Test**
TEOM (PM_{10})	Fails the equivalence criteria
FDMS "Model B" (PM_{10})	Meets the equivalence criteria
FDMS "Model B" ($PM_{2.5}$)	Meets the equivalence criteria
Partisol 2025 (PM_{10})	Meets the equivalence criteria
OPSIS SM200 (PM_{10})	Beta – Meets the equivalence criteria Mass – Meets the equivalence criteria with correction for slope and intercept
Met-One BAM (unheated) (PM_{10})	Meets the equivalence criteria with correction for slope
Notes: The "Model B" FDMS is no longer commercially available. Local Authorities are advised to contact the Helpdesks (see Box 1.1) for updates on the latest position regarding the status of FDMS analysers. The Partisol 2025 was operated with Teflon coated glass-fibre filters.	

3.36 As a result of these original equivalence tests, the UK networks are currently being restructured and upgraded to use instruments that are equivalent to the European reference sampler.

3.37 There are, however, several important points to be noted from Table 3.4. Firstly, the outcomes of the equivalence tests are only valid for the operational set-up, the instrument version, and the specific filter type etc, used in the study. Changes to any of these parameters may result in the use of a method that is not equivalent.

3.38 The issue concerning the instrument version is particularly important, as manufacturers continually seek to modify and improve instrument design and operation. To this end, the UK Government and the Devolved Administrations are currently supporting the Environment Agency in a further programme of equivalence testing under the remit of the Agency's MCERTS programme. At the time of writing, initial discussions on the approach to the study have been set out. Initial results from this programme are expected shortly. Pending the outcome of these further tests, local authorities should contact the Local Authority Air Quality Support Helpdesk for advice where changes in existing methodologies and capital expenditure will be incurred.

Correction of Beta Attenuation Monitor PM_{10} data

3.39 Many local authorities use Beta Attenuation Monitors. As noted in Table 3.4, the Met-One BAM (with unheated inlet) meets the equivalence criteria for PM_{10} monitoring, provided the results are corrected for slope (and bearing in mind the caveats set out in Para 3.37). This correction should be carried out as follows: the measured concentrations should be divided by a factor of 1.21[30]. For example, if the reported PM_{10} mass concentration were 20 µg/m^3, the corrected PM_{10} mass would be 20/1.21 = 16.5 µg/m^3.

[30] This applies to Met-One BAMs with the data reported at standard conditions (standard analysers).

The Volatile Correction Model for Tapered Element Oscillating Microbalance analysers

3.40 **Tapered Element Oscillating Microbalance (TEOM)** analysers are widely used by local authorities to support Local Air Quality Management (LAQM) work. However, the outcome of the equivalence study means that TEOM analysers cannot strictly be used to measure PM_{10} concentrations for comparison with the air quality objectives.

3.41 Wherever practicable, local authorities are encouraged to use instruments that conform to the equivalence criteria[31]. This should be an important consideration when purchasing new instruments, or replacing existing equipment. Authorities are also encouraged to have particular regard to those locations where concentrations are expected to be close to the objectives. It is not possible to precisely define what "close to the objectives" means, but as an approximate guide it is likely to be in the range 30 to 40 days exceedence (as measured by the TEOM multiplied by 1.3), or in the case of the 2010 annual mean objective for Scotland 16 to 20 µg/m^3. In such cases it may be possible to restructure local networks, for example by re-locating existing instruments.

3.42 The UK government and the Devolved Administrations recognise that many local authorities have invested considerable resources in TEOM analysers, and it may not be practicable to replace these instruments in the short term. It is therefore considered appropriate that TEOM analysers should remain suitable for use for the purpose of LAQM, but wherever possible the data collected should be adjusted using the Volatile Correction Model (VCM) (as described below) rather than the use of a simple 1.3 multiplication factor.

3.43 A study commissioned by Defra and the Devolved Administrations has identified a model that can be used to correct measurements of PM_{10} made by the TEOM, referred to as $TEOM_{VCM}$, such that the resulting concentrations may be considered as equivalent to the objectives.

3.44 The VCM is based on an assumption that the volatile component of PM_{10}, lost during the heated sampling of PM with a standard TEOM, is consistent across a defined geographical area, such that measurements of this component at one location may be used to correct measurements at another.

3.45 The model uses the Filter Dynamics Measurement System (FDMS) "purge measurement"[32] as an indicator of the volatile component of PM_{10}. Thus the mean PM_{10} concentration measured by a TEOM (µg/m^3, TEOM) may be corrected to a concentration that is equivalent to the European reference method (µg/m^3, gravimetric) using the following equation:

$TEOM_{VCM}\ PM_{10} = TEOM\ PM_{10} + (1.87 \times \text{Regional FDMS } PM_{10} \text{ purge})$

3.46 The approach to using the VCM is described in Box 3.4.

[31] This equipment will be noted by the suppliers as shown to meet equivalence criteria set out in the report on "UK equivalence programme for monitoring of particulate matter".

[32] The FDMS purge measurement as recorded by the instrument is a negative concentration. The UK Air Quality Archive (see Box 2.2) reports these data as a "positive volatile PM_{10} concentration". This component needs to be added to the TEOM concentration

Box 3.4: Application of the Volatile Correction Model

A VCM web portal is available through the national air quality archive at www.volatile-correction-model.info/Default.aspx. This allows local authorities to download geographically specific correction factors to apply to the TEOM PM_{10} results.

There are a number of steps that need to be taken to apply the VCM, as the default settings for the TEOMs used in the UK contain a "US EPA correction factor" and are reported at standard temperature and pressure (STP).

Step 1: Remove the default "US EPA correction factor" from the measured TEOM PM_{10} data.

TEOM instruments, as supplied by the manufacturer, include a default US EPA adjustment that is embedded into the software. This adjustment factor is:

Reported TEOM PM_{10} (μg/m^3) = (TEOM PM_{10} at STP (μg/m^3) * 1.03) + 3 μg/m^3

The TEOM PM_{10} concentration at STP, with the US EPA adjustment factor removed, is given by:

$$TEOM_{STP}\,PM_{10} = \frac{TEOM\,PM_{10} - 3}{1.03}$$

Step 2: Correct the measurements to atmospheric temperature and pressure

The TEOM is configured to report measurements at a standard temperature (25°C) and a standard pressure (1 atm). This differs from the European position, which reports at ambient conditions and this difference therefore increases uncertainty in the comparison with the European reference method. By using measurements of ambient temperature and pressure, the temperature and pressure correction can be removed from the TEOM measurements at STP to provide an ambient temperature and pressure TEOM measurement ($TEOM_{ATP}$) using the following equation:

$$TEOM_{ATP}\,PM_{10} = \left[\frac{TEOM\,PM_{10} - 3}{1.03}\right] x\ \frac{1}{P}\ x\ \frac{T + 273}{273}$$

Where P = ambient pressure in atmospheres and T = ambient temperature in °C

Step 3: The Regional Purge Concentration

The regional purge concentration is the mean of up to three of the nearest Automatic Urban and Rural Network (AURN) FDMS instruments within the model domain. Current evidence suggests that the model domain extends to approximately 130 km from the measurement site. This is multiplied by 1.87 to account for the additional loss of volatile material from the TEOM filter, which is maintained at 50°C, compared to the FDMS filter, which is maintained at 30°C. This factor has been derived from TEOM and FDMS co-location studies.

Step 4: The calculating the $TEOM_{VCM}$ concentration

Steps 1 and 3 can be combined into the equation below.

$$TEOM_{VCM}\,PM_{10} = \left\{\left[\frac{TEOM\,PM_{10} - 3}{1.03}\right] x\ \frac{1}{P}\ x\ \frac{T + 273}{273}\right\} - 1.87\ x\ Regional\ Purge\ Concentration$$

These calculations will be undertaken by the VCM web portal to provide a time series of daily or hourly correction factors that can then be applied to TEOM PM_{10} measurements as they are recorded by the instrument.

3.47 There are some areas in Scotland, where the VCM cannot be used as there are no FDMS instruments in the vicinity[33]. Where this is the case, the Scottish Government has issued interim guidance based on local intercomparison tests. For annual mean objectives, it is recommended that local authorities should correct the TEOM-measured concentration using multiplication factors of both 1.3 and 1.14. Both results should be compared with the annual mean objective. If the TEOM value multiplied by 1.3 results in a concentration above the objective, but the TEOM value multiplied by 1.14 factor results in a concentration below the objective, the authority is advised to carry out further monitoring using a method that meets the equivalence criteria.

3.48 There remain some areas elsewhere in the UK, where the VCM cannot be used, for the same reason. In these areas, as an interim measure, it is still acceptable to apply the 1.3 correction factor to annual mean TEOM PM_{10} data, in order to obtain an indicative estimate of gravimetric equivalent concentrations.

3.49 In all cases the local authority should make clear what instrument has been used to make the PM_{10} measurements and what adjustments, if any, have been applied.

Monitoring for $PM_{2.5}$

3.50 The $PM_{2.5}$ fraction of particulate matter differs from PM_{10} only in respect of the size of the particles that are measured. Thus, the fundamental difference between PM_{10} and $PM_{2.5}$ analysers/samplers is, in most cases, related solely to the design of the size-selective inlet. Continuous analysers, such as the TEOM, FDMS and BAM, and gravimetric samplers can all be readily adapted for $PM_{2.5}$ monitoring by simply switching the inlet.

3.51 However, the measurement of $PM_{2.5}$ is inherently more difficult for two reasons:

- there is a much smaller mass of PM to measure;
- the proportion of semi-volatile material is likely to be greater.

3.52 Monitoring of $PM_{2.5}$ concentrations thus requires even more care and attention than does PM_{10}.

3.53 As is the case with PM_{10}, both the objectives and limit values for $PM_{2.5}$ are based on measurements carried out using the EU reference sampler[34]. Monitoring for compliance with the objectives should therefore strictly be carried out using the reference sampler, or an equivalent method. As set out in Para 3.38 above, further equivalence tests, including $PM_{2.5}$ instruments, are underway at the time of writing. Pending the outcome of these further tests, local authorities should contact the Local Authority Air Quality Support Helpdesk for advice particularly where capital expenditure will be incurred.

[33] A map is provided on the VCM website showing where the model applies, at: www.volatile-correction-model.info/Default.aspx

[34] This is a gravimetric sampler as defined in EN14907

CHAPTER 4: Progress Reports

Introduction

4.01 This chapter provides guidance to local authorities in the preparation of air quality Progress Reports. It replaces previous guidance; LAQM.PRG(03) in England, Scotland and Wales, and LAQM.PRGNI(04) in Northern Ireland.

Role of Progress Reports

4.02 Progress Reports were introduced into the Local Air Quality Management (LAQM) system following a detailed evaluation of the Review and Assessment process at the end of the first round. This evaluation identified a need to maintain continuity in the LAQM process, which in turn would make the periodic Review and Assessments easier to carry out.

4.03 The Evaluation Report that was commissioned in 2007 by the UK Government and the Devolved Administrations identified no specific local authority concerns with the preparation of Progress Reports, other than a general requirement to simplify the process. It is thus considered that Progress Reports continue to provide a useful function, as set out in Box 4.1.

4.04 Progress Reports are not intended to represent a further Updating and Screening Assessment, although authorities are reminded that if at any time they identify a risk of an air quality exceedence then they should proceed immediately to a Detailed Assessment and not delay until the next round of Review and Assessment.

When are Progress Reports required?

4.05 Progress Reports are intended to provide continuity in the LAQM process. They fill the gaps between the three-yearly requirement to undertake an Updating and Screening Assessment. The timetable for Progress Reports is illustrated in Chapter 1 (Box 1.3). They are only required in years when the authority is not undertaking an Updating and Screening Assessment.

The format and content of Progress Reports

4.06 The format of Progress Reports remains effectively unchanged from the previous rounds, but completed reports should be filed electronically using the web-based system that has been provided by Defra and the Devolved Administrations. The intent has been to simplify the process for local authorities. The web-based reports are available for download from the Internet[35].

4.07 The web-based system allows authorities to download a proforma Progress Report, which is then completed off-line. The format of this proforma follows the checklist that is provided in Box 4.2. It is possible to paste in any relevant data, maps or graphs, where appropriate. When complete, the report should be submitted electronically.

[35] www.airquality.co.uk/archive/laqm/tools.php

Box 4.1: Advantages of Progress Reports

- Helps retain a profile for LAQM within the authority, including the retention of staff with a knowledge of air quality issues;
- Provides a means of communicating air quality information to Council Members and the public;
- Maximises the usefulness and interpretation of monitoring data collected by the authority;
- Maximises the investment in monitoring equipment and resources;
- Provides up-to-date information in a readily available fashion to assist future rounds of Review and Assessment;
- Provides a mechanism for local authorities to access information to respond to requests regarding air quality;
- Provides information to drive and support air quality measures in other policy areas, such as transport and planning;
- Provides a useful resource to assist with planning applications and associated environmental assessments;
- Demonstrates progress with the implementation of air quality Action Plans and/or air quality strategies;
- Provides an early alert system to identify further measures that may be needed to improve air quality, rather than waiting for the next round of Review and Assessment.

4.08 Once submitted, the authority may, if it chooses, use the completed document for incorporation into its own "local" report, including, for example, a suitable front cover and introductory statement. These reports may then be posted onto the authority's own website, or disseminated in any other suitable fashion.

4.09 This guidance sets out the minimum reporting requirements for Progress Reports that form part of the Review and Assessment process. It also discusses recommended additional elements that can usefully be included in Progress Reports. For those authorities implementing Air Quality Action Plans, there is a separate requirement to prepare annual Action Plan Progress Reports. It is strongly advised that authorities needing to report progress on Action Plans produce a single Progress Report covering both the Review and Assessment and Action Plan reporting requirements.

Box 4.2: Progress Report Checklist

Item	Minimum requirement	Recommended additional elements
New monitoring results	(Paras 4.16 – 4.18) Data for regulated pollutants	(Para 4.28) Data for un-regulated pollutants
	Highlight results for new sites. Present a table describing the site type, distance from kerb (if roadside or kerbside site) and grid reference for each monitoring location. Present a map showing monitoring locations. Present summary tables of concentrations of regulated pollutants in a format to allow comparison with the objectives. Provide plots of summary data to show annual trends. Discuss trends. Take account of number of years of available data.	Report any results for unregulated pollutants, for example, ozone (O_3), polycyclic aromatic hydrocarbons (PAH_S), etc. Report other air quality data, for example, odour complaints, dust deposition results, radiation monitoring, etc.
New local developments	(Paras 4.19 – 4.20) Identify and list new developments that may affect air quality	
Air Quality Action Plans		(Paras 4.24 – 4.25 and Box 4.3) List measures in Air Quality Action Plan and implementation timescales. Provide update on progress implementing measures.

Box 4.2: Progress Report Checklist *(cont'd…)*		
Local Air Quality Strategy		(Paras 4.29 – 4.30) Summarise Strategy or progress on preparing a Strategy or reviews of the Strategy Describe consultation/publicity for Strategy Report on progress on implementing measures within strategy.
Planning and Policies		(Paras 4.31 – 4.33) Log planning applications for new developments for which air quality assessment is being provided. (Para 4.34 – 4.35) List local policies that relate to air quality and any changes that may have been introduced.
Local Transport Plans and Strategies		(Paras 4.36 – 4.38) Summarise measures in the Local Transport Plan (LTP) (Local Transport Strategies (LTS) in Scotland and Local Implementation Plans (LIP) in London) that have a direct bearing on air quality. Report on progress with implementing these measures.

4.10 When preparing their reports, authorities should bear in mind that the overall aim should be to report progress on implementing LAQM, and progress in achieving, or in many cases maintaining, concentrations below the air quality objectives. Examples of Progress Reports are available on the Review and Assessment helpdesk website, and will continue to be updated as they become available. These can be viewed at www.uwe.ac.uk/aqm/review/examples/index.html.

4.11 Defra, the Mayor of London and the Devolved Administrations will appraise the reports to confirm that they follow the minimum requirements set out in this Guidance and that progress is being made with working towards meeting the air quality objectives or maintaining concentrations below the objectives.

Minimum requirements for Progress Reports

4.12 The overall aims of the Progress Report should be to:

- report progress on implementing LAQM;
- report progress in achieving, or in many cases maintaining, concentrations below the air quality objectives.

4.13 It is considered these aims can best be achieved by addressing two matters:

- new monitoring results;
- new local developments that might affect local air quality.

4.14 This section provides guidance on the minimum requirements for what is expected under each of these headings.

New monitoring results

4.15 Most local authorities are carrying out some form of air quality monitoring in their area. Some have been doing so for many years. In certain cases this supplements data available from national network sites. **The Progress Report should provide a summary of all available monitoring data in a format suitable for comparison with the relevant air quality objectives.** For example, data should be reported as annual mean concentrations, and, where relevant, as the number of exceedences of the 1-hour objective value of 200 $\mu g/m^3$ for nitrogen dioxide (NO_2), and the number of exceedences of the 24-hour objective value of 50 $\mu g/m^3$ for particulate matter (PM_{10}).

4.16 To maximise the value of air quality monitoring, careful attention should be paid to the type of equipment used and the locations where the monitors are placed, as well as the quality assurance and quality control (QA/QC) and data verification procedures. Guidance on these issues is provided in Chapter 3 and Annex 1 of this document.

4.17 When reporting the monitoring data the following should be included where possible:

- a table describing the site type, distance from the kerb (if roadside or kerbside sites), the grid reference of each monitoring location, whether it is in an Air Quality Management Area (AQMA), and whether it is representative of relevant exposure;
- a map showing the monitoring locations. It may be possible to refer to a map in a previously published document, as long as it is readily available, for example, published on the web;
- summary tables of concentrations that allow ready comparison with the objectives, for example, annual mean values for NO_2 for the measurement year;
- plots showing trends in concentrations, for example, plots of annual mean NO_2 concentrations for the last ten years.

4.18 The Progress Report should draw attention to:

- results for new monitoring sites and whether they reveal any new information about air quality, specifically with regard to any exceedences of the objectives;
- evidence of any trends over recent years. Care should be exercised in discussing trends, as changes in concentrations occur from year to year due to weather conditions. It is normal practice to only consider a trend as being significant when five years worth of data are available, although a longer timescale may be appropriate for some pollutants, for example, PM_{10}. When reporting PM_{10} trends care will be needed to ensure only data derived from the same method are used. Thus if Volatile Correction Model (VCM) corrections are being applied to recent Tapered Element Oscillating Microbalance (TEOM) data (see Box 3.4), then the results cannot be mixed with those presented for the site as TEOM x 1.3 for earlier years.

New local developments

4.19 This section should deal with changes that have taken place that may affect air quality. The items to include are:

- new industrial installations with the potential to impact upon local air quality;
- new biomass boilers that have been granted planning permission;
- new developments with an impact on air quality, especially those that will significantly change traffic flows. This need only include developments that have been granted planning permission;
- new landfill sites, quarries etc, that have been granted planning permission, and which have nearby relevant exposure.

4.20 The local authority is advised to make clear in its report that it has considered all these categories of potential developments.

4.21 Where applications for new developments have been accompanied by air quality assessments within Environmental Statements, it is useful if the outcome of these assessments is summarised and referenced.

4.22 The Progress Report should log these changes so that they can be considered more thoroughly during the next full round of Review and Assessment.

Recommended additional elements

4.23 The guidance on the contents of a Progress Report set out above is designed to provide the minimum information to demonstrate to stakeholders the progress that is being made in addressing air quality issues within the local authority area. The Progress Report provides, however, an ideal opportunity to report on other aspects of the authority's work on air quality. Possible elements that could be added to Progress Reports are:

- implementation of Air Quality Action Plans;
- reporting of additional monitoring data;
- progress on local air quality strategies;
- a list of planning applications that have the potential to affect local air quality;
- progress on implementing those elements of the LTP (LTS in Scotland and LIP in London) that might affect air quality; and
- any relevant updates on planning policies that relate specifically to air quality.

4.24 There may be other areas of local interest that the authority also wishes to incorporate into its Progress Report.

Implementation of Action Plans

4.25 Although local authorities can submit separate Progress Reports on Action Plans, they are strongly advised to combine the two reports into one "Air Quality Progress Report". The role of Action Plan Progress Reports is set out in the relevant Policy Guidance documents.

4.26 Defra, the Mayor of London and the Devolved Administrations also require local authorities to include some comments within the Action Plan Progress Report detailing, where possible, the impact the measures have had/are having on local air quality. Local authorities should outline what progress was made during the year, and compare it with the original plan. It is important to set out the original timescales for implementation of the measures, and the dates (to the nearest month) when the measures were actually implemented. It is also important to distinguish progress made during the most recent year, from that made over the lifetime of the action plan so far. Finally, the report should look forward to the next year: the original targets set in the Action Plan should be reviewed (and if necessary revised for the forthcoming year) and an implementation plan for the forthcoming year should be included. An example of a summary of the Action Plan elements that should be covered in the Action Plan Progress Report is provided in the example in Box 4.3. Defra, the Mayor of London and the Devolved Administrations require local authorities to have regard to this when completing their Action Plan Progress Reports and the Action Plan element of the Air Quality Progress Report[36].

[36] Local authorities in England and Wales should note that this layout supersedes that set out in Appendix B of LAQM.PG(03).

Box 4.3: Example of Action Plan Progress Report

Summary from Action Plan								Progress Report 2013			
No	**Measure**	**Focus**	**Lead authority**	**Planning phase**	**Implementation phase**	**Indicator**	**Target annual emission reduction in the AQMA**	**Progress to date**	**Progress in last 12 months**	**Estimated completion date**	**Comments relating to target emission reductions**
1	Implement Air Quality strategy	Improve ability to manage air quality across services and set an air quality target	District Council	2009	2010	Adoption of strategy	N/a	Strategy was adopted in 2011			
2	LTP integration	Analyse, decide on and implement best options to reduce queuing time in AQMA	County Council	2009-11	2011-15	Individual indicators and targets for each specific measure	5%	Analysis completed in 2011	First specific measure was implemented in 2012	2015	Analysis now indicates an overall 10% reduction in emissions may be possible
3	Integration with planning system	Avoid worsening air quality by adopting local planning policies and opening a funding stream	District Council	2009	2010	1) Reduce reliance on cars in new development and set emission criteria 2) Adoption and use of S106 funds in implementing the action plan	1%	No significant progress	The Council has formally decided not to pursue this measure further	Will not be implemented	The plan will not be varied since measure 2 and associated measures may bring about a sufficient emissions saving

Box 4.3: Example of Action Plan Progress Report *(cont'd…)*

Summary from Action Plan								Progress Report 2013			
No	**Measure**	**Focus**	**Lead authority**	**Planning phase**	**Implementation phase**	**Indicator**	**Target annual emission reduction in the AQMA**	**Progress to date**	**Progress in last 12 months**	**Estimated completion date**	**Comments relating to target emission reductions**
4	Travel information campaign	Reduce reliance on car and reduce queuing time in AQMA via proactive provision of information	County Council	2009-10	2011-15	10% reduction in car journeys monitored via survey	2%	Capacity to provide information and travel planning support was put in place in 2011. All schools and local authority offices now have travel plans with targets for reduction in car use	The second annual campaign and targeted travel plans were implemented Surveys suggest that the 10% reduction in car journeys was maintained this year	2015	The 10% reduction in car journeys was estimated to deliver a 2% reduction in emissions in the AQMA
5	Institutional travel planning	Reduce reliance on car and reduce queuing time in AQMA by engaging to implement proactive travel plans	County Council	2009-10	2011-12	See measure 4	See measure 4				
6	Manage bus emissions	Reduce unit emissions in the AQMA using Bus Quality Partnership Agreements (BQPA)	County Council	2009-10	2011-14	Elimination of Euro I and II buses by 2014	2%	The failure to reach a BQPA meant the authority applied for a Traffic Regulation Condition (TRC)	The TRC was adopted with the condition of having no Euro I and Euro II buses passing through the AQMA from 2014 onwards	2014	Elimination of remaining few Euro II buses still estimated to deliver a 2% reduction in annual emissions

Box 4.3: Example of Action Plan Progress Report *(cont'd…)*

Summary from Action Plan								Progress Report 2013			
No	**Measure**	**Focus**	**Lead authority**	**Planning phase**	**Implementation phase**	**Indicator**	**Target annual emission reduction in the AQMA**	**Progress to date**	**Progress in last 12 months**	**Estimated completion date**	**Comments relating to target emission reductions**
7	Vehicle idling measure	Sign junction and hold occasional events to promote message to reduce queuing emissions in the AQMA	County Council	2009	2010	Reduced queuing/idling time in AQMA (via engine switch-off) monitored via survey	1%	Signs have been installed and an annual campaign to raise awareness at the junction has been instituted	This year's survey indicates that approximately 5% of drivers regularly pay attention to the sign	The authority has decided to continue with the annual survey	The measure is estimated to be achieving the annual emission reduction of 1% below the baseline
At a later date	Specific LTP measures will be defined by completing measure 2	Implementing the measures to reduce queuing at the AQMA	County Council/Highways Agency	2009-11	2011-15		See measure 2	A new right filter lane has been introduced following the analysis that this would markedly reduce congestion	Traffic and congestion levels indicators were surveyed	Complete	Filter lane was estimated to deliver a 5% reduction in emissions and other measures identified may deliver additional 5%

Summary

Although some measures have not delivered their anticipated activity and emission reductions others have been found to deliver more than their original assessment suggested. We therefore still anticipate that the action plan will deliver at least a 10% reduction in road transport emissions in the AQMA by 2015.

In conjunction with this year's monitoring data we are therefore still predicting that the local action plan alone will be sufficient to achieve the air quality standard in 2015.

Additional monitoring data

4.27 The minimum requirement is to report monitoring data and trends for the regulated pollutants over recent years.

4.28 Authorities may also find it helpful to report on their monitoring for pollutants not covered by the regulations, for example, O_3, PAH etc, as well as other air quality data, for example, odour complaints, dust deposition, radiation monitoring etc. Authorities will already be reporting such data to Members and the public, and it should be straightforward to include the information in a single report.

Local air quality strategy

4.29 The relevant Policy Guidance documents recommend that all authorities, particularly those that have not had to designate AQMAs or do not expect to designate an AQMA in future, but who have areas close to the exceedence levels, should consider drawing up a local air quality strategy.

4.30 Progress Reports provide the opportunity for the authority to report on the development of its strategy, or where a strategy is in place, to report on progress with implementation of any specific measures within the strategy. The following questions could usefully be addressed:

- To what extent has the authority developed an air quality strategy?
- If this has been completed, how far has it been implemented?
- How accessible is the strategy (for example, deposited in local libraries and/or published on the internet)?
- When will the strategy next be reviewed?

Planning applications

4.31 The land-use planning system is recognised to play an integral part in improving air quality. This requires close co-operation between planners and environmental health officers. Some local authorities have developed procedures to help ensure that planning applications that might have impacts on air quality are forwarded to the environmental health department for comment. This is considered to be an important first step and authorities are encouraged to ensure that suitable procedures are in place.

4.32 Updating and Screening Assessments and Detailed Assessments should take account of planning applications that have been approved, but not those in the pipe-line. Progress Reports, on the other hand, provide the opportunity to log planning applications for new developments to give a picture of areas where changes may take place and where combined impacts from several developments may become important.

4.33 The information provided in a planning section of the Progress Report could therefore include a list of the major developments under consideration that might affect air quality. Such a list could be based on those applications for which an air quality assessment was being provided or for which an air quality assessment had been requested.

Air quality planning policies

4.34 The policies set out in local authority planning documents determine the authority's approach to the relationship between planning and air quality. They are important as new developments are judged against these policies. The Progress Report provides an ideal place to list these policies and to record changes that are introduced from time to time. This should extend to providing a reference to any supplementary planning guidance that is occasionally developed to address air quality matters.

4.35 It should be noted that in England, the planning system is currently undergoing a change from Development Plans, Structure Plans and Local Plans to effectively a folder of documents called the Local Development Framework (LDF). The "folder" will eventually contain a Local Development Scheme setting out the content, structure and timescale of the LDF, the Core Strategy (identifying where significant growth or change is proposed) and Supplementary Planning Documents. The timescale of this conversion varies between local authorities dependent on the original timescale of Development Plans and Local Plans. In Scotland, the related documents are called Structure Plans, Local Plans and Supplementary Guidance; in Wales, Local Development Plans; and in Northern Ireland, Development Plans.

4.36 At present, Northern Ireland development plans are prepared by the Planning Service, an Agency within the Department of the Environment, rather than by Local Authorities. The context for these plans is found in the Department's Planning Policy Statements and the Regional Development Strategy for Northern Ireland 2025 (RDS) published by the Department for Regional Development in September 2001. While currently there is no regional planning policy dealing with the control of air pollution the RDS contains a number of Strategic Planning Guidelines in relation to the improvement of air quality. Advice on the role of land use planning on air quality will also contained in the updated LAQM Policy Guidance, due to be issued by the Department of the Environment early in 2009. It should be noted that the planning system in Northern Ireland is currently undergoing change as part of ongoing Planning Reform announced by the Minister. In addition responsibility for preparation of development plans and the determination of planning decisions in Northern Ireland is due to transfer to new Local Authorities in 2011 as part of the Review of Public Administration.

Implementation of local transport plans and strategies

4.37 The majority of air quality issues in the UK relate to emissions from the road transport sector. Measures to improve air quality on a local scale are thus closely related to the LTP, LPS or LIP. Local authorities could choose to make a reference within the Progress Report to those measures within the LTP/LPS/LIP that specifically relate to bringing about air quality improvements. It may be appropriate to use the same text in both reports. Repetition should not be an issue as the reports address different audiences.

4.38 Authorities in England and Wales could also report on any other measures aimed at addressing transport-related air quality issues that have not been (or will not be) reported in the LTP/LIP Progress Report.

4.39 After 2008, an annual report will not be required by the Department for Transport on progress with LTPs. However, English local authorities that have integrated transport related Air Quality Action Plans with LTPs (or LIPs) should continue, with mandatory consultation and reporting to Defra (and the Greater London Authority) on Action Plans and Action Plan Progress Reports. The integration of Action Plans with LTPs or LIPs will continue to provide a systematic way to join up air quality management and transport planning. Guidance on Local Transport Planning is available on the Department for Transport website at www.dft.gov.uk/spgr/regional/. Information on the Transport Innovation Fund and other useful information is also available from this site.

CHAPTER 5: Updating and Screening Assessments

Introduction

The Updating and Screening Assessment process

5.01 The Updating and Screening Assessment is intended to identify any significant changes that may have occurred since the previous rounds of Review and Assessment were completed. This will include new monitoring data, new or changed emissions sources (either locally or in neighbouring authorities), or any other local changes that might affect air quality.

5.02 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and draw upon the work completed during earlier rounds of Review and Assessment.

5.03 It is recognised that many local authorities, through their previous Review and Assessment work, may have established detailed emissions inventories and applied various dispersion models. The following sections of this chapter set out the screening approach to use to complete the Updating and Screening Assessment.

Changes to the Updating and Screening Assessment checklists and reporting formats

5.04 To date, over 200 Air Quality Management Areas (AQMA) have been declared. Of these, the vast majority are related to road traffic emissions, where attainment of the annual mean objective for nitrogen dioxide (NO_2) is considered unlikely, sometimes in association with exceedences of the 24-hour mean particulate matter (PM_{10}) objective, or in Scotland the annual mean PM_{10} objective.

5.05 By comparison, there are very few AQMAs associated with domestic, industrial or other transport-related emissions.

5.06 A specific recommendation from the 2007 Evaluation Report[37] that was commissioned by Defra and the Devolved Administrations, was to consider restructuring the format of the Updating and Screening Assessment to help simplify the process. Previously, the approach was to consider each pollutant in turn, and as a result it was often necessary to assess the same emission source several times. As the majority of problems are related to road traffic, this is no longer considered to be the most efficient approach for many local authorities.

5.07 While the Updating and Screening Assessment checklists are broadly the same, they have been completely re-ordered, so that they follow a source-by-source approach. In circumstances where a local authority only has potentially significant road traffic sources, the assessment is done once for both NO_2 and PM_{10}. Where other potentially significant sources are identified, again the assessment need only be completed once.

[37] Report available from www.defra.gov.uk/environment/airquality/local/eval/ss-review.htm

5.08 A further change to the Updating and Screening Assessment is that the completed reports should be filed electronically using the web-based system that has been provided by Defra and the Devolved Administrations. The web-based system involves local authorities downloading a proforma Updating and Screening Assessment report from the Internet[38], which is then completed off-line. The format of these proforma follows the checklist items that are provided in the following sections. It is possible to paste in any relevant data, maps or graphs. When complete, the report should be submitted electronically.

5.09 A summary of the emission source categories for the Updating and Screening checklists is provided in Box 5.1, with guidance on the use of monitoring data provided in Box 5.2.

5.10 Detailed checklists for each source type are then set out in the following sections of this Chapter, and in Boxes 5.3 to 5.8 and 5.10.

[38] www.airquality.co.uk/archive/laqm/tools

Box 5.1: Summary of emission sources and relevant pollutants to be considered as part of the Updating and Screening Assessment

Overview

In each case, these sources need only be considered if they are new, if they have not previously been considered, or if there have been significant changes since the last round of Review and Assessment.

Reference No.	Emission sources to be assessed	Relevant Pollutants
A: Road transport sources		
A.1	Narrow congested streets with residential properties close to the kerb	NO_2
A.2	Busy streets where people may spend 1-hour or more close to traffic	NO_2
A.3	Roads with a high flow of buses and/or Heavy Goods Vehicles (HGVs)	NO_2, PM_{10}
A.4	Junctions (including busy roads and junctions in Scotland)	NO_2, PM_{10}
A.5	New roads constructed since the last round of Review and Assessment	NO_2, PM_{10}
A.6	Roads with significantly changed traffic flows	NO_2, PM_{10}
A.7	Bus and coach stations	NO_2
B: Other transport sources		
B.1	Airports	NO_2
B.2	Railway (diesel and steam trains)	Sulphur dioxide (SO_2), NO_2
B.3	Ports (shipping)[1]	SO_2
C: Industrial sources		
C.1	Industrial installations (new installations and those with significantly increased emissions)	Benzene, 1,3-butadiene, lead, NO_2, SO_2, PM_{10}
C.2	Major petrol storage depots	Benzene
C.3	Petrol Stations	Benzene
C.4	Poultry farms	PM_{10}
D: Commercial and domestic sources[2]		
D.1	Biomass combustion (including domestic solid-fuel burning for PM_{10})	NO_2, PM_{10}
D.2	Domestic solid-fuel burning	SO_2
E: Fugitive or uncontrolled sources		
E.1	Quarries, landfill sites, opencast coal mining, waste transfer sites, materials handling (ie, ports, major construction sites)	PM_{10}

[1] Fugitive emissions from materials handling at docks and ports etc dealt with in E.1

Box 5.2: Updating and Screening Assessment checklist – monitoring data		
Relevant Pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Overview This section sets out the relevant steps that should be taken to review and assess any new monitoring data in order to determine whether the air quality objectives are exceeded. The focus is upon new monitoring data, but it is also useful to show longer-term trends wherever possible.		
Box 5.2 (1): Collate and ratify monitoring data		
	Approach	
All pollutants	1. Collate all monitoring data	Include local authority monitoring data, as well as data from national networks and other organisations, including data from neighbouring authorities if relevant. Include all relevant information on site types, monitoring methods, quality assurance and quality control etc.
	2. Ratify the monitoring data if not already carried out.	Ideally, all monitoring data should be ratified before use. The key steps are to ensure that continuous monitoring data have been screened and scaled – see Annex 1 for details of how to do this. Where data are provisional, they should be clearly indicated as such. NO_2 diffusion tube data must be "bias-corrected", and the approach taken to do this clearly set out. Details regarding the laboratory performance and precision of the tubes should be provided wherever possible. A detailed consideration of the issues regarding diffusion tubes is provided in Chapter 3 and Annex 1.
	3. Calculate annual mean concentrations for the data. Where appropriate also calculate the relevant shorter-term statistics for comparison with the objectives, for example, the number of days >50 $\mu g/m^3$ PM_{10}	The annual mean concentrations should represent a calendar year if possible. Where fewer than nine months of data are available for a calendar year, adjust the result to estimate the annual mean using the procedure set out in Box 3.2. Short-term statistics (such as the number of 8-hour and 1-hour means above a threshold) can only be calculated from continuous monitoring data. Where data capture is less than 90%, it is more appropriate to calculate the equivalent percentiles, for example, the 90th percentile of daily mean PM_{10} concentrations
PM_{10}	4. Confirm that PM_{10} data have been measured by a method that is equivalent to the reference method.	The reference method is a gravimetric method. Certain methods have been shown to be equivalent to the reference method, some after adjustment (see Paras 3.31 – 3.49). Check with the Local Authority Air Quality Support Helpdesk (see Box 1.1) as to which methods are acceptable. The Tapered Element Oscillating Microbalance instrument has been widely used. A method to estimate gravimetric-equivalent concentrations is described in Paras 3.40-3.49. This replaces the use of the default 1.3 factor.
PM_{10}	5. Estimate the annual mean PM_{10} concentration in 2010 (Scotland only)	Box 2.2 describes the approach for this. Both existing and future estimated concentrations should be summarised.

<table>
<tr><th colspan="3">Box 5.2 (2): Collate and ratify monitoring data</th></tr>
<tr><td rowspan="8">Nitrogen dioxide</td><td colspan="2">Question – Outside of an AQMA</td></tr>
<tr><td>• Are any of the measured annual mean concentrations outside of an AQMA greater than 40 µg/m^3?
• Are there more than 18 1-hour exceedences of 200 µg/m^3, or does the 99.8th percentile of 1-hour concentrations exceed 200 µg/m^3 outside of an AQMA?
• Are any of the annual mean concentrations, measured using diffusion tubes, greater than 60 µg/m^3?</td><td>Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13). If they are not, and the site is roadside, calculate the concentration at the nearest relevant exposure using the tool described in Box 2.3 and use this value to compare against the objective. Exceedences of the 1-hour objective may occur at roadside sites if the annual mean is above about 60 µg/m^3.</td></tr>
<tr><td colspan="2">Action</td></tr>
<tr><td>If the answer is YES to any of the questions, then the authority should proceed to a Detailed Assessment.</td><td>The Detailed Assessment will be with a view to determining whether or not to declare an AQMA.</td></tr>
<tr><td colspan="2">Question – Within an AQMA for nitrogen dioxide</td></tr>
<tr><td>• Are all of the measured annual mean concentrations within an AQMA lower than 40 µg/m^3?
• Are there fewer than 18 1-hour exceedences of 200 µg/m^3, or are any 99.8th percentiles of 1-hour concentrations below 200 µg/m^3 within an AQMA?
• Are any of the annual mean concentrations, measured using diffusion tubes, greater than 60 µg/m^3?</td><td>Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13). If they are not, and the site is roadside, calculate the concentration at the nearest relevant exposure using the tool described in Box 2.3 and use this value to compare against the objective. Exceedences of the 1-hour objective may occur at roadside sites if the annual mean is above about 60 µg/m^3.</td></tr>
<tr><td colspan="2">Action</td></tr>
<tr><td>If the answer is YES to either of the first two questions, then the authority should consider proceeding to a Detailed Assessment.
If the answer is YES to the third question the authority may choose to assume there is an exceedence of the 1-hour mean objective in addition to the annual mean objective within the AQMA. There is no requirement to proceed to a Detailed Assessment in this case. The authority should just amend its AQMA order to cover the 1-hour objective and review its Air Quality Action Plan (see Paras 5.17 to 5.18).</td><td>For the first two questions the Detailed Assessment will be with a view to determining whether or not to revoke an AQMA. If the monitoring sites are not at worst-case locations then it may not be appropriate to consider revoking the AQMA. Take into account the results of previous modelling for the AQMA. The decision will also depend on the history of results. Concentrations should normally be below the objective for several years before considering revoking, to avoid cycling between revoking and declaring.</td></tr>
</table>

Box 5.2 (2): Collate and ratify monitoring data *(cont'd…)*		
PM_{10}	**Question – Outside of an AQMA**	
	For 2004 objectives (all local authorities): • Are there **more** than 35 24-hour exceedences of 50 µg/m^3, or does the 90th percentile of 24-hour concentrations exceed 50 µg/m^3? For 2010 objectives (Scotland only): • Are any of the measured annual mean concentrations **greater** than 18 µg/m^3?	Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13). These questions are based on the 24-hour 2004 objective being more stringent than the annual mean objective, while the 2010 annual mean objective in Scotland is more stringent than the 24-hour objective.
	Action	
	If the answer is YES, proceed to a Detailed Assessment for PM_{10} at these locations.	The Detailed Assessment will be with a view to determining whether or not to declare an AQMA.
	Question – Within an AQMA for PM_{10}	
	For 2004 objectives (all local authorities): • Are there **fewer** than 35 24-hour exceedences of 50 µg/m^3, or does the 90th percentile of 24-hour concentrations exceed 50 µg/m^3? For 2010 objectives (Scotland only): • Are any of the measured annual mean concentrations **less** than 18 µg/m^3?	Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13). These questions are based on the 24-hour 2004 objective being more stringent than the annual mean objective, while the 2010 annual mean objective in Scotland is more stringent than the 24-hour objective.
	Action	
	If the answer is YES to either of the first two questions, then the authority should consider proceeding to a Detailed Assessment.	The Detailed Assessment will be with a view to determining whether or not to revoke an AQMA. If the monitoring sites are not at worst case locations then it may not be appropriate to consider revoking the AQMA. Take into account the results of previous modelling for the AQMA. The decision will also depend on the history of results. Concentrations should normally be below the objective for several years before considering revoking, to avoid cycling between revoking and declaring.
Sulphur dioxide	**Question – Outside of an AQMA**	
	• Are there **more** than 35 15-minute exceedences of, or 99.9th percentiles greater than, 266 µg/m^3? • Are there **more** than 24 1-hour exceedences of, or 99.7th percentiles greater than, 350 µg/m^3? • Are there **more** than three 24-hour exceedences of, or 99th percentiles greater than, 125 µg/m^3?	Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13).
	Action	
	If the answer is YES to any of these questions, proceed to a Detailed Assessment for sulphur dioxide at these locations.	The Detailed Assessment will be with a view to determining whether or not to declare an AQMA.

Box 5.2 (2): Collate and ratify monitoring data *(cont'd…)*		
	Question – Within an AQMA for sulphur dioxide	
	• Are there **fewer** than 35 15-minute exceedences of, or 99.9th percentiles greater than, 266 µg/m^3? • Are there **fewer** than 24 1-hour exceedences of, or 99.7th percentiles greater than, 350 µg/m^3? • Are there **fewer** than 3 24-hour exceedences of, or 99th percentiles greater than, 125 µg/m^3?	Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13).
	Action	
	If the answer is YES to all of these questions, then the authority should consider proceeding to a Detailed Assessment.	The Detailed Assessment will be with a view to determining whether or not to revoke an AQMA. If the monitoring sites are not at worst case locations then it may not be appropriate to consider revoking the AQMA. Take into account the results of previous modelling for the AQMA. The decision will also depend on the history of results. Concentrations should normally be below the objective for several years before considering revoking, to avoid cycling between revoking and declaring.
Benzene	**Question – Outside of an AQMA**	
	• Are any running annual mean concentrations **greater** than 16.25 µg/m^3? (for 2003 objective) • Are any annual mean concentrations **greater** than 5 µg/m^3? (for 2010 objective) • Are any running annual mean concentrations **greater** than 3.25 µg/m^3? (Scotland and Northern Ireland only)	Ensure that the monitoring site locations are representative of relevant public exposure (see Paras 3.09 – 3.13).
	Action	
	If the answer is YES to any of these questions, proceed to a Detailed Assessment for benzene at these locations.	The Detailed Assessment will be with a view to determining whether or not to declare an AQMA.
	Question – Within an AQMA for benzene	
	• Are any running annual mean concentrations **less** than 16.25 µg/m^3? (for 2003 objective) • Are any annual mean concentrations **less** than 5 µg/m^3? (for 2010 objective) • Are any running annual mean concentrations **less** than 3.25 µg/m^3? (Scotland and Northern Ireland only)	Ensure that the monitoring site locations are representative of relevant public exposure (see 3.09 – 3.13).
	Action	
	If the answer is YES to any of these questions, then the authority should consider proceeding to a Detailed Assessment.	The Detailed Assessment will be with a view to determining whether or not to revoke an AQMA. If the monitoring sites are not at worst case locations then it may not be appropriate to consider revoking the AQMA. Take into account the results of previous modelling for the AQMA. The decision will also depend on the history of results. Concentrations should normally be below the objective for several years before considering revoking, to avoid cycling between revoking and declaring.

What needs to be considered within the Updating and Screening Assessment?

5.11 The Updating and Screening Assessment is intended to identify changes that have occurred since the previous round of Review and Assessment. The focus is therefore upon new sources (for example, new roads, new industrial installations etc), sources that have changed significantly (for example, changed traffic flows, changed industrial installations, etc), or sources that were not previously considered (for example, where there is new exposure).

5.12 In addition, new source types have been introduced into the guidance, for example, for biomass boilers and poultry farms. All local authorities will need to consider these new source types.

5.13 There is no need to provide information on sources that have not changed and were adequately covered in previous rounds of Review and Assessment.

Monitoring data

5.14 As described previously in Chapter 3, it is expected that monitoring data will play an increasingly important role in the Review and Assessment process as the "to be achieved dates" of the objectives have mostly passed. Monitoring data may be used to identify new locations where there is a risk of exceedence of one or more of the objectives, or to provide evidence that a previously declared AQMA requires reconsideration. In both cases, this would lead to a requirement for a Detailed Assessment.

5.15 The focus should be upon new monitoring data collected since the previous round of Review and Assessment was completed, but wherever possible historical data should also be included, as these provide valuable information on longer-term trends. The steps that should be taken are set out in Box 5.2.

5.16 The relationship between the annual mean and the number of exceedences of the 1-hour mean objective for NO_2 is described in Chapter 2. Where the annual mean concentration measured at roadside locations is equal to or above 60 µg/m^3, there is a risk that the 1-hour mean objective may be exceeded. However, Defra and the Devolved Administrations recognise that Review and Assessment against the 1-hour mean objective for road traffic sources is far from straightforward; monitoring requires the use of a continuous analyser, for a period of up to a full calendar year; and modelling 1-hour concentrations is inherently problematic, being subject to considerable uncertainty, and difficult to verify.

5.17 Where local authorities measure annual mean concentrations of NO_2 at roadside locations that are equal to or above 60 µg/m^3, and an AQMA has already been declared at this location in respect of the annual mean objective, then the authority may choose to assume that the 1-hour mean objective is exceeded, and there is no requirement to proceed to a Detailed Assessment. In this case the authority should amend its AQMA order to reflect an exceedence of the 1-hour mean objective, and should also review its Air Quality Action Plan to ensure that all measures to address exceedences of the 1-hour objective have been appropriately considered.

5.18 Where an AQMA for the annual mean objective has not been previously declared at this location, then the authority should proceed to a Detailed Assessment.

Sources of emissions

A. Road traffic sources

5.19 The focus of attention for road traffic sources should be on relevant locations close to busy roads, especially in congested areas and near to junctions, where emissions will be higher, and in built up areas where the road is canyon like, with the buildings either side of the road restricting dispersion and dilution of the emissions. The Updating and Screening Assessment should consider locations not addressed in previous rounds of Review and Assessment and locations where conditions have changed significantly since being previously assessed.

5.20 Where sufficient monitoring data are not available to assess potential exceedences at all relevant locations, a screening assessment for road traffic sources may be carried out using the Design Manual for Roads and Bridges (DMRB) model. This model is currently being revised and updated by the Highways Agency. Authorities should check with the Local Authority Air Quality Support Helpdesk website (Box 1.1) before carrying out any such modelling to ensure that the latest version is being used.

5.21 In many cases the DMRB model should prove the simplest and most convenient approach for the screening assessment. However, it is recognised that many authorities have set up detailed dispersion models during previous rounds of Review and Assessment, and if preferred, the screening assessment can be carried out using these models, if this proves the most efficient route. It is assumed that these detailed models have been appropriately verified (see Annex 3) and are suitable for identifying "hot spots".

5.22 Assessments of road traffic sources will inevitably require information on traffic flows and speeds. Various approaches to obtaining traffic data are set out in Annexes 2 and 3. Within Greater London, the London Atmospheric Emissions Inventory (LAEI) provides detailed information[39].

5.23 Where predicted concentrations at relevant locations exceed any of the objectives, then local authorities should proceed to a Detailed Assessment.

[39] contact LAEI@london.gov.uk and www.london.gov.uk/mayor/environment/air_quality/research/emissions-inventory.jsp

Box 5.3: Updating and Screening Checklist

(A) Road traffic sources

Relevant pollutants	Steps that must be taken to complete the assessment	Notes relevant to each step
Overview The focus of the assessment should be on locations or sources where experience has shown that there is a risk of the objectives being exceeded, sufficient to require a Detailed Assessment to be carried out. Attention needs to be given to NO_2 in all cases and PM_{10} in some cases. No other pollutants need to be considered. In most cases a basic distinction needs to be made between light duty vehicles (LDVs) and heavy duty vehicles (HDVs), the latter being all vehicles >3.5 tonnes unladen weight. In some cases a distinction between buses and HGV may also be relevant. The assessment does not need to consider locations within existing AQMAs declared for road traffic sources for the specific pollutant under consideration.		
A.1 Narrow congested streets with residential properties close to the kerb.		
Nitrogen dioxide	**Overview** Concentrations are often higher where traffic is slow moving, with stop/start driving, and where buildings on either side reduce dispersion. Screening models have not proved helpful at identifying potential exceedences, which have only been identified by monitoring. The assessment only needs to consider NO_2. **This item has changed since the last round of Review and Assessment and should be considered by all.**	
	Approach	
	1. Use local knowledge to identify narrow congested streets.	Daily traffic flow (AADT) should be around 5,000 veh/day or more. (Accurate flows are not required – as an approximation, a 5-minute count in the middle of the day would total around 35 vehicles or more, as a two-way flow). A congested street will be one with slow moving traffic that is frequently stopping and starting due to pedestrian crossings, parked vehicles etc throughout much of the day (not just during rush hours). The average speed is likely to be less than about 25 kph (15 mph). A narrow street will be one with residential properties within 2 m of the kerb, and buildings on both sides of the road (the buildings on the other side of the road can be further from the road than 2 m).
	Question	
	• Are there any roads meeting these criteria that are outside of traffic related AQMAs and have not previously been assessed?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for NO_2 at these locations.	The Detailed Assessment is likely to start with diffusion tube monitoring at several relevant locations along the congested street for a minimum period of six months.

A.2 Busy streets where people may spend 1-hour or more close to traffic		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide	**Overview** There will be some street locations where individuals may regularly spend 1-hour or more, for example, streets with many shops and streets with outdoor cafes and bars. People occupationally exposed in such locations should not be included, as they are not covered by the regulations. The assessment only needs to consider NO_2.	
	Approach	
	1. Identify all busy streets where individuals may be exposed within 5 m of the kerb for 1-hour or more that are new, or were not previously assessed. This should include streets with new exposure, where exposure was previously not present.	If all such areas were considered during the earlier rounds, then there is no need to proceed further with this part. A busy street can be taken to be one with more than 10,000 vehicles per day.
	2. Obtain detailed information on traffic flows, speeds and proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	3. Use the DMRB screening model (see Paras 2.18 to 2.20) to predict the current annual mean concentration at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.
	Question	
	• Are any of the predicted annual mean concentrations equal to or greater than 60 $\mu g/m^3$?	The DMRB screening model does not calculate 1-hour concentrations. If the annual mean does not exceed 60 $\mu g/m^3$, then there should be fewer than 18 hours above 200 $\mu g/m^3$.
	Action	
	If the answer is YES, **and** there is an existing AQMA in respect of the annual mean objective for NO_2, the local authority may assume there is an exceedence of the 1-hour mean objective in addition to the annual mean objective within the AQMA. There is no requirement to proceed to a Detailed Assessment in this case. The authority should amend its AQMA order and review its Air Quality Action Plan (see Paras 5.17 to 5.18). If there is no existing AQMA, then the authority should proceed to a Detailed Assessment.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

A.3 Roads with a high flow of buses and/or Heavy Goods Vehicles.		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide	**Overview** There will be some street locations where traffic flows are not necessarily high (fewer than 20,000 vehicles per day) but there is an unusually high proportion of buses and/or HGVs. The assessment needs to consider both NO_2 and PM_{10}.	
	Approach	
PM_{10}	1. Identify all roads with an unusually high proportion of HDV that were not previously assessed or are new. This should include roads with new exposure, where exposure was previously not present.	If all such areas were considered during the earlier rounds and/or are within an existing AQMA for NO_2 and PM_{10}, then there is no need to proceed further with this part. An unusually high proportion can be taken to be greater than 20%. If traffic data are not available, use local knowledge. Such roads could include bus only streets or roads leading to an industrial estate.
	2. Determine whether there is relevant exposure within 10 m of these roads (20 m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million. Relevant exposure should be judged against the annual mean and 1-hour criteria in the case of NO_2 and the 24-hour mean and annual mean for PM_{10}.
	3. Determine whether the flow of HDV is greater than 2,500 vehicles per day.	Items 2 and 3 could be carried out in either order. There would be no need to look for relevant exposure if the flow is less than 2,500 vehicles per day.
	4. Use the DMRB screening model (see Paras 2.18 to 2.20) to predict the current annual mean at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.
	Question	
	• Are any of the predicted NO_2 annual mean concentrations greater than 40 µg/m^3 (for the annual mean objective)? • Are there more than 35, 24-hour PM_{10} exceedences of 50 µg/m^3 predicted? • Are any of the predicted annual mean PM_{10} concentrations in 2010 greater than 18 µg/m^3 (Scotland only)?	

A.3 Roads with a high flow of buses and/or Heavy Goods Vehicles. *(cont'd…)*		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
	Action	
	If the answer is YES to any of the above, it will be necessary to proceed to a Detailed Assessment for NO_2 and/or PM_{10} at these locations.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.
	Question	
	• Are any of the predicted NO_2 annual mean concentrations greater than 60 µg/m^3 (for the hourly mean objective)?	Annual mean predictions should also be carried out at locations where only the 1-hour objective would apply, so that an assessment against the 1-hour objective can be made.
	Action	
	If the answer is YES, **and** there is an existing AQMA in respect of the annual mean objective for NO_2, the local authority may assume there is an exceedence of the 1-hour mean objective, and there is no need to proceed to a Detailed Assessment. In this case, the authority should amend its AQMA order and review its Air Quality Action Plan (see Paras 5.17 to 5.18). If there is no existing AQMA, then the authority should proceed to a Detailed Assessment.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

A.4 Junctions (including busy roads and junctions in Scotland)		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide	**Overview** Concentrations are usually higher close to junctions, due to the combined impact of traffic emissions on two roads, and to the higher emissions due to stop start driving. The assessment needs to consider both NO_2 and PM_{10}.	
	Approach	
PM_{10}	1. Identify "busy" junctions that are new, or were not previously assessed. This should include streets with new exposure, where exposure was previously not present.	If all such areas were considered during the earlier rounds and/or are within an existing AQMA for NO_2 and PM_{10}, then there is no need to proceed further with this part. A "busy" junction can be taken to be one with more than 10,000 vehicles per day. For guidance on how to add flows at junctions see Important Notes at the end of this Box.
	2. Determine whether there is relevant exposure within 10 m of the kerb (20 m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then there is no need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and percentage of heavy duty vehicles.	Heavy duty vehicles are all vehicles greater than 3.5 tonnes gross. They include HGVs and buses.
	4. Use the DMRB screening model (see Paras 2.18 to 2.20) to predict the current annual mean NO_2 concentration and the number of 24-hour exceedences of 50 µg/m^3 at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.
	Question	
	• Are any of the predicted annual mean NO_2 concentrations greater than 40 µg/m^3?	
	• Are more than 35, 24-hour PM_{10} concentrations above 50 µg/m^3 predicted?	
	Action	
	If the answer is YES to either of the above, it will be necessary to proceed to a Detailed Assessment for NO_2 and/or PM_{10} at these locations.	If there are monitoring data for these locations, then use these results in preference to the DMRB model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

A.4 Junctions (including busy roads and junctions in Scotland) *(cont'd...)*

Scottish authorities only

This approach is designed to assess busy roads and junctions against the 2010 PM_{10} objectives that apply in Scotland.

1. Identify "busy" roads and junctions. It is only necessary to include busy roads or junctions not considered in previous Review and Assessment reports, and/or where there has been a significant increase (>10% AADT) in traffic flows since the last assessment, and/or where there is new relevant exposure.	Use the following criteria to define "busy": • Roads and/or junctions with more than 5,000 vehicles per day (AADT), where the annual mean background in 2010 is expected to be above 15 µg/m^3. • Roads and/or junctions with more than 10,000 vehicles per day (AADT), where the annual mean background in 2010 is expected to be below 15 µg/m^3. At junctions, flows should be added – see Important Notes at the end of this Box.
2. Determine whether there is relevant exposure within 10 m of the kerb (20 m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million.
3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown, if the data are available.
4. Use the DMRB screening model (see Paras 2.18 to 2.20) to predict the annual mean in 2010 at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.

Questions (Scotland only)

• Are any of the predicted annual mean PM_{10} concentrations in 2010 greater than 18 µg/m^3?	The focus for 2010 in Scotland is upon the annual mean objective, as this is expected to be more stringent than the 24-hour objective.

Action (Scotland only)

If the answer is YES, it will be necessary to proceed to a Detailed Assessment for PM_{10} at these locations.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

Important Notes

Where two or more roads intersect, for example at a junction, the traffic flows from each arm of the junction should be added to give a combined total, which should then be divided by two. For example at a crossroads with two roads intersecting, where arm [A] has an AADT flow of 17,000 vehicles per day, arm [B] 24,000 vehicles per day, arm [C] 14,000 vehicles per day and arm [D] 26,000 vehicles per day, the combined flow would be 81,000/2 = 40,500 vehicles per day. If there are three arms to the junction, then add the flows then add up the flows on each arm and divide by 3/2. For 5 arms divide by 5/2.

A.5 New roads constructed or proposed since the last round of Review and Assessment		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide **PM_{10}**	**Overview** The approach to considering new roads will depend on whether or not an assessment was carried out in advance of building the new road. The assessment needs to consider both NO_2 and PM_{10}.	
	Approach 1 This approach should be followed if an air quality assessment has been undertaken for the new or proposed road in question.	
	1. Obtain details of the air quality assessment that has been carried out for the new road.	It will be important to confirm that the assessment is sufficient for review and assessment purposes, ie, it should meet the requirements set out in this guidance. Only consider proposed roads for which planning approval has been granted. If the assessment did not cover the new 2010 objectives, then local authorities in Scotland will have to use the approach set out in Checklist item A.4 above (junctions and busy roads in Scotland)
	Question	
	• Have any exceedences of the NO_2 or PM_{10} objectives been predicted at relevant locations?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for NO_2 and/or PM_{10} at these locations.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment for the road. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2 This approach should be followed if there has been no previous air quality assessment.	
	1. Establish whether the traffic flow on the new road is greater than 10,000 vehicles per day **or** whether the new road has increased traffic flow on existing roads previously identified as having a) NO_2 annual mean concentrations greater than 36 μg/m^3, or b) more than 30, 24-hour exceedences of the PM_{10} objective of 50 μg/m^3 (or more than six exceedences in 2010 in Scotland).	The aim is to establish whether there is a risk of exceedences alongside the new road, or existing roads with a significant change in flows. Only proceed if there is relevant exposure within 10 m (20 m in major conurbations). A major conurbation may be considered to be a city with a population in excess of 2 million.

A.5 New roads constructed or proposed since the last round of Review and Assessment *(cont'd…)*		
	2. Use the DMRB screening model (Paras 2.18 to 2.20) to predict the current NO_2 annual mean at relevant locations and/or the number of PM_{10} 24-hour exceedences of 50 µg/m^3, (and for Scotland the annual mean for 2010) at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.
	Questions	
	• Do any of the predicted concentrations exceed the air quality objectives?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment at these locations.	

A.6 Roads with significantly changed traffic flows.		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide **PM_{10}**	**Approach** It is only necessary to consider any roads with significantly changed traffic flows that have not already been considered in parts A.2 to A.5 above. The assessment will need to be completed for both NO_2 and PM_{10}.	
	1. Identify any roads with more than 10,000 vehicles per day that have experienced "large" increases in traffic.	A "large" increase can be taken to be more than 25% increase in traffic flow. Also consider roads where such an increase is identified due to improved traffic data.
	2. Determine whether these roads had previously been identified as being at risk of exceeding the objectives.	A road "at risk" of exceeding the objectives can be taken to be one previously identified with an annual mean above 36 μg/m^3 at a relevant location.
	3. Obtain detailed information on traffic flows, speeds and percentage of heavy duty vehicles.	Heavy duty vehicles are all vehicles greater than 3.5 tonnes gross. They include HGVs and buses.
	4. Use the DMRB screening model (see Paras 2.18 to 2.20) to predict the current annual mean NO_2 concentration and the number of 24-hour exceedences of 50 μg/m^3 in the current year at relevant locations. Predict the annual mean PM_{10} concentration in 2010 (Scotland only).	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations.
	Question	
	• Do any of the predicted concentrations exceed the air quality objectives?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment at these locations.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

A.7 Bus and coach stations		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Nitrogen dioxide	**Approach** This approach only applies to bus stations or sections of bus stations that are not enclosed, and where there is relevant exposure, including at nearby residential properties. The assessment will be against both the annual; mean and the 1-hour NO_2 objectives. (The term bus is used to signify both buses and coaches)	
	1. Collect information on the daily movements of buses at the bus station.	If all such sources were considered during previous rounds of Review and Assessment and/or are within an existing AQMA for NO_2 and PM_{10}, then there is no need to proceed further. A bus coming into the bus station then going out again should be treated as two movements.
	2. Determine whether there is relevant exposure within 10 m of any part of the bus station where buses are present (20 m in major conurbations).	Relevant exposure should be judged principally against the 1-hour criteria (see reference to exposure Box 1.4). If there is residential exposure close to the bus station, then the annual mean will also need to be considered.
	3. Determine whether the number of movements of buses is greater than 2,500 per day.	Items 2 and 3 could be carried out in either order. For instance, there is no point looking for relevant exposure if the flow is less than 2,500 buses per day.
	4. Use the DMRB screening model (Paras 2.18 to 2.20) to predict the annual mean in the current year at relevant locations.	Information will be required on traffic flows, speeds, and the proportion of different vehicle types, as well as on local background concentrations. When using the DMRB screening model enter 100% into the "buses and coaches" column.
	Question	
	• Are any of the predicted annual mean concentrations greater than 40 µg/m^3 (for the annual mean objective)?	This only applies to locations where there is relevant exposure in terms of the annual mean objectives (see Box 1.4).
	Action	
	If the answer is YES, then the authority should proceed to a Detailed Assessment.	
	Question	
	• Are any of the predicted NO_2 annual mean concentrations greater than 60 µg/m^3 (for the hourly mean objective)?	The DMRB screening model does not calculate 1-hour concentrations. If the annual mean does not exceed 60 µg/m^3, then there should be fewer than 18 hours above 200 µg/m^3. Annual mean predictions in this case should be carried out at locations where the 1-hour objective would apply.
	Action	
	If the answer is YES, **and** there is an existing AQMA in respect of the annual mean objective for NO_2, the local authority may assume there is an exceedence of the 1-hour mean objective, and there is no need to proceed to a Detailed Assessment. In this case, the authority should amend its AQMA order and review its Air Quality Action Plan (see Paras 5.17 to 5.18). If there is no existing AQMA, then the authority should proceed to a Detailed Assessment.	If there are monitoring data for these locations, then use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by the modelling.

B. Other Transport Sources

5.24 This section considers non-road transport sources that may be significant, including airports, mainly as a result of aircraft emissions; railways, mainly stations and depots, but also alongside some busy lines with a high number of diesel locomotives; and ports, due to shipping emissions. New evidence has come to light that NO_2 concentrations are elevated alongside rail lines with a large number of diesel locomotive movements – the emissions can be equivalent to those from a busy road. There is thus a new requirement that will apply to a number of local authorities to assess railway lines with a high usage of diesel locomotives to establish whether there is relevant exposure nearby. Table 5.1 provides information on which lines should be considered. These lines need only be considered where the background annual mean NO_2 concentration is above 25 μg/m^3. A list of authorities in which these criteria might be met is provided on the Review and Assessment Helpdesk website (see Box 1.1).

5.25 There are also changes to the screening criteria for airports. Measurements have shown that PM_{10} levels are not significantly elevated, and that impacts on NO_2 are lower than previously thought, thus the screening criteria have been relaxed (see report available on the Review and Assessment Helpdesk website – Box 1.1).

Table 5.1: Rail lines with a heavy traffic of diesel passenger trains

Description
Paddington to Swansea
Swindon to Taunton
Bristol Temple Meads to Bristol Parkway
Rugby to Birmingham New Street
Manchester Piccadilly to Wigan
Crewe to Gretna
Manchester to Crewe
Liverpool Lime Street to Allerton (Liverpool Urban area)
Sheffield to Wincobank Jn
Leeds to Bradford only for about 1 mile to west of Leeds station
Glasgow to Edinburgh

Box 5.4: Updating and Screening Checklist		
(B) Other transport sources		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Overview This section is only likely to be relevant to a small number of local authorities. Most of these sources will have been assessed in previous rounds of Review and Assessment. New work will only be required where there have been significant changes, or where there is new relevant exposure, or if there is a busy rail line with a diesel locomotives.		
B.1 Airports		
Nitrogen dioxide	**Overview** Aircraft are potentially significant sources of nitrogen oxides (NO_X) emissions, especially during takeoff. New information since the last round of Review and Assessment has resulted in the criteria to trigger a Detailed Assessment being relaxed, while the requirement to assess PM_{10} has been removed. This section thus only applies to NO_2. The criterion in this section that requires a Detailed Assessment for NO_2 at airports, only applies to aircraft as a source. The airport may give rise to a requirement for a Detailed Assessment on the basis of road traffic. It is important that this is covered separately, using the guidance in section A above, but taking account of the influence of the airport on the background air quality at the road.	
	Approach	
	1. Establish whether there is relevant exposure within 1000 m of the airport boundary.	Concentrations fall-off rapidly on moving away from the source, and are unlikely to make a significant contribution beyond this distance. If there is no relevant exposure, then there is no need to proceed further with this part.
	2. Obtain information on annual throughput of passengers and tonnes of freight in the most recent year possible. Calculate the total equivalent passenger numbers in million passengers per annum (mppa).	Convert the tonnes of freight to an equivalent number of passengers using 100,000 tonnes = 1 mppa. This only applies to freight taken in "freight-only" planes, not that taken in passenger planes (ie belly hold freight).
	Question	
	Is the total equivalent passenger throughput more than 10 mppa? Is the existing background NO_X concentration above 25 μg/m^3?	
	Action	
	If the answer is YES to either question, it will be necessary to proceed to a Detailed Assessment for NO_2.	If there are monitoring data for worst-case relevant exposure locations near the airport boundary, then use these results in preference to the passenger throughput criteria to reach a decision. This assumes the data have been suitably quality assured (see Chapter 3 and Annex 2) and relate to worst-case locations, including those identified by any modelling that may have been carried out. The Detailed Assessment may need to be no more than reliance on the findings of any air quality assessments carried out by the airport operators. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.

B.2 Railways (diesel and steam trains)		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Sulphur dioxide	**Overview** Stationary locomotives, both diesel and coal fired, can give rise to high levels of sulphur dioxide (SO_2) close to the point of emission. Recent evidence suggests that moving diesel locomotives, in sufficient numbers, can also give rise to high NO_2 concentrations close to the track. These two potentially significant sources are considered separately below. People occupationally exposed to these sources should not be included, as they are not covered by the regulations. **This item has changed since the last round of Review and Assessment in terms of moving locomotives, as set out in Approach 2 below. Reference should be made to Para 5.24 prior to completing the checklist items.**	
	Approach 1 – stationary locomotives (coal or diesel)	
	1. Identify locations where diesel or steam locomotives are regularly stationary for periods of 15 minutes or more.	This could be signals, goods loops, depots or stations.
	2. Establish whether there is the potential for regular outdoor exposure of individuals within 15 m of the stationary locomotives.	Consider locations outside the station or depot, as well as on the station, as long as there is the potential for exposure of individuals for periods of 15-minutes or more. The exposure needs to be "outdoors" in the general sense of the word. If there is no relevant exposure, then there is no need to proceed further with this part.
	3. Obtain information on the number of trains per day that might affect these locations, and the typical duration that they are stationary with their engines running.	This might require a period of observation.
	Question	
	• Are there three or more occasions a day when there might be a locomotive stationary with its engine running for 15 minutes or more?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for SO_2 at these locations.	Remember to take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 µg/m^3.

B.2 Railways (diesel and steam trains) *(cont'd…)*		
Nitrogen dioxide	**Approach 2 – moving locomotives (diesel)**	
	1. Identify sections of track that may have a large number of movements of diesel locomotives.	A list of lines with a substantial number of diesel passenger trains per day is provided in Table 5.1.
	2. Identify whether the background annual mean NO_2 concentration is above 25 µg/m^3.	Use can be made of the national background maps (see Para 2.02-2.09).
	3. Establish whether there is the potential for long-term exposure within 30 m of the edge of the tracks.	
	Question	
	• Are there any sections of rail line meeting the above criteria?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for NO_2 at these locations.	The Detailed Assessment will need to examine the combined impact of locomotive emissions with those of local road traffic. Modelling will not be straight forward, thus the assessment is likely to focus on monitoring.

<table>
<tr><th colspan="3">B.3 Ports (shipping)</th></tr>
<tr><th>Relevant pollutant</th><th>Steps that must be taken to complete the assessment</th><th>Notes relevant to each step</th></tr>
<tr><td rowspan="9">Sulphur dioxide</td><td colspan="2">Overview
Large ships generally burn oils with a high sulphur content in their main engines (bunker oils). If there are sufficient movements in a port they can give rise to sufficient number of 15-minute periods above 266 μg/m^3 to exceed the 15-minute objective. Auxiliary engines used while berthed (hotelling) usually use a lower sulphur fuel, and are unlikely to be significant. If the shipping is using fuel with a sulphur content of less than 1% then it will not be necessary to take the assessment further.</td></tr>
<tr><td colspan="2">Approach</td></tr>
<tr><td>1. Establish whether there is relevant exposure within
(a) 250 m and
(b) 1 km
of the berths and main areas of manoeuvring.</td><td>Modelling has shown that the greatest risk of exceedence may be downwind of the main alignment of berths.</td></tr>
<tr><td>2. Collect information on the number of ship movements per year.).</td><td>This should be confined to large ships, for example, cross-channel ferries, Ro-Ro, container ships, cruise liners.
Every visit from a ship will generate two movements. If possible use information on the number of movements in the most recent year possible.</td></tr>
<tr><td colspan="2">Questions</td></tr>
<tr><td>• Are there between 5,000 and 15,000 movements per year (and exposure within 250 m)?
• Are there more than 15,000 movements per year (and exposure within 1 km)?</td><td></td></tr>
<tr><td colspan="2">Action</td></tr>
<tr><td>If the answer is YES to either of these questions, it will be necessary to proceed to a Detailed Assessment for SO_2.</td><td>Remember to take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 μg/m^3.</td></tr>
</table>

C. Industrial Sources

5.26 Industrial sources are controlled by the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), the Northern Ireland Environment Agency (NIEA), and by local authorities under the Pollution Prevention and Control regulations. Local authorities also have controls over smaller industrial and commercial sources, largely through the Clean Air Act, with its associated control of the stack heights. As a result of these controls, there are relatively few sources that may be relevant to local authorities under the Local Air Quality Management (LAQM) regime. Many of these sources will have been addressed during previous rounds of Review and Assessment. The focus should thus be on new installations and those with significantly changed emissions.

5.27 While the number of sources that may be significant is limited, there is a wider range of pollutants to be considered.

5.28 The checklist is broken into four sections:

- C1 Industrial installations;
- C2 Major fuel (petrol) storage depots;
- C3 Petrol stations; and
- C4 Poultry farms.

5.29 The latter is a new addition. It has been included as a small number of local authorities have identified potential exceedences of the PM_{10} objectives associated with emissions from poultry farms (defined as chickens (laying hens and broilers), turkeys, ducks and guinea fowl).

5.30 To help identify potentially significant sources that will need to be subjected to a Detailed Assessment, nomograms have been developed for a number of pollutants. These are set out at the end of this Chapter.

Box 5.5: Updating and Screening Checklist

(C) Industrial sources

C.1 Industrial installations

Relevant pollutants	Steps that must be taken to complete the assessment	Notes relevant to each step
All pollutants	**Overview** Industrial sources are unlikely to make a significant local contribution to annual mean concentrations, but could be significant in terms of the short-term objectives. Remember to consider sources in neighbouring authorities. Particular attention should be paid to the combined impact of several sources, including those outside the local authority area. The approach to the assessment will depend on whether an assessment has been carried out as part of the planning or permitting process. The assessment should consider all of the regulated pollutants, although those most at risk of requiring further work are SO_2, NO_2, PM_{10} and benzene.	
	Approach 1 This approach should be followed if an air quality assessment has been undertaken for the new or proposed source in question.	
	1. Obtain details of the air quality assessment that has already been carried out for the new industrial source.	It will be important to confirm that the assessment is sufficient for Review and Assessment purposes, ie, it should meet the requirements set out in this guidance. Only consider proposed sources for which planning approval has been granted.
	Question	
	• Have any exceedences of the objectives been predicted at relevant locations?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for the relevant pollutant(s) for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Action 2 This approach should be followed where emissions have increased substantially or new relevant exposure has been introduced.	
	1. Determine whether any of the sources identified during previous rounds of Review and Assessment have: a) experienced substantially increased emissions. b) received new relevant exposure in their vicinity.	A "substantial" increase can be taken to be one greater than 30%.
	2. Obtain information on the total annual emission of the pollutant, and the height of the emission.	See Paras 5.34 to 5.35 onwards, and Annex 2. If it is proving difficult to obtain the information on the emissions contact the Local Authority Air Quality Support Helpdesk (see Box 1.1).
	3. Use the nomograms to determine if the source requires further assessment.	Derive the effective stack height using the procedure described in Box 5.6. The nomograms for the various pollutants are set out in Paras 5.31 onwards

Box 5.5: Updating and Screening Checklist *(cont'd…)*		
	Questions	
	• Do the emissions exceed the threshold in the relevant nomogram?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for the relevant pollutant at these locations.	
	Approach 3 This approach should be followed if there has been no previous air quality assessment.	
	1. Determine whether the installation is likely to give rise to significant pollutant emissions.	Contact the Local Authority Air Quality Support Helpdesk if there is any doubt (see Box 1.1).
	2. Obtain information on the total annual emission of the pollutant, and the height of the emission.	See Paras 5.34 to 5.35 onwards, and Annex 2. If it is proving difficult to obtain the information on the emissions contact the Local Authority Air Quality Support Helpdesk (see Box 1.1).
	3. Use the nomograms to determine if the source requires further assessment.	Derive the effective stack height using the procedure described in Box 5.6. The nomograms for the various pollutants are set out in Paras 5.31 onwards.
	Questions	
	• Does the source exceed the threshold in the relevant nomogram?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for the relevant pollutant at these locations.	

Nomograms for industrial installations

5.31 A series of nomograms have been developed to help identify those pollutants and installations that need to be investigated further as part of a Detailed Assessment[40]. They deal either with stack emissions, or low-level, fugitive emissions. In the case of stack emissions, it is necessary in some situations to use of the "effective" stack height rather than the physical stack height. This is discussed in Box 5.6.

[40] Abbott J (2002) Review of pollutant specific guidance for industrial and domestic emissions. AEAT.

Box 5.6: Calculation of effective stack height

The stack height should be assumed to be equal to the actual (physical) stack height **unless:**

- The height of release is greater than 3 m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $$U_{eff} = 1.66(U_{act} - H)$$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height

  If the stack height is less than the surrounding buildings (ie, U_{eff} is negative) then treat the source as a ground level source.

5.32 The nomograms are provided at the end of this Chapter and the procedures for their use are described below. Authorities may also download various LAQM Tools from the Internet (www.airquality.co.uk/archive/laqm/tools.php). These contain the calculations in the form of an Excel spreadsheet, and requires the user to enter simple details on the emission rate, release conditions (stack height and diameter) and background pollutant concentrations where necessary.

5.33 Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the nomograms described below are unlikely to be applicable, and authorities are advised to proceed to a Detailed Assessment.

Emissions data

5.34 Emission rates for Part A1 (and Part B in Northern Ireland) installations can be obtained from the regulatory agencies (see Para 5.26) or the operator directly. Emissions for installations in England and Wales are also posted on the Internet at the following address: (www.environment-agency.gov.uk). Emission rates for Part A2 and Part B (Part C in Northern Ireland) installations may be obtainable from the local authority's authorisation documents in England and Wales, from SEPA in Scotland and NIEA in Northern Ireland. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk/data_warehouse.php). Details of stack heights, diameters and stack exit temperatures, as well as building heights, can often be obtained from the regulator, the operator or the authorisation documents, or, if necessary, dimensions may be estimated from a visual inspection. Further advice can be obtained from the Local Authority Air Quality Helpdesk (see Box 1.1).

5.35 To assist local authorities in the compilation of data related to Part A (and Part B and C in Northern Ireland) installations, the EA, SEPA[41], and NIEA have committed to provide information on any changes that may affect emissions from existing installations, and any new installations that have been, or will be, authorised. The information will be provided from the local office on request.

[41] SEPA have regulatory responsibility for Part A and Part B installations in Scotland.

Use of Nomograms for stacks

5.36 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

Use of Nomograms for low-level/fugitive sources

5.37 To use the nomogram, identify the line which corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

(a) Nitrogen dioxide

5.38 Nomograms for NO_X emissions have been prepared. These estimate the emission rate (in tonnes per annum) that would produce a) a 99.8th percentile ground-level NO_2 concentration of 40 µg/m^3, equivalent to 20% of the short-term (hourly) air quality objective (Figure 5.1), and b) an annual mean ground-level concentration of 1 µg/m^3, equivalent to 2.5% of the annual mean objective (Figure 5.2). If the actual emission rate from the installation exceeds either of these thresholds, then it will be necessary to proceed to a Detailed Assessment.

Stack emissions

5.39 To use the short-term (1-hour) nomogram (Figure 5.1), the following procedure should be used:

- Derive the total oxidant concentration ((NO_2+O_3), as NO_2) at the nearest national network monitoring station. Table 5.2 describes the 99.8th percentile values of (NO_2+O_3, as NO_2) for all sites in 2004-2006;
- Calculate the locally available "headroom" as the objective value (200 µg/m^3) minus the 99.8th percentile of (NO_2+O_3, as NO_2);
- Divide the headroom by 0.05. This procedure assumes that 5% of the NO_X emission is released as NO_2, and that the remaining NO_X released is converted to NO_2 up to the limit of the available O_3;
- Divide the result by four (as a safety margin) to allow for the uncertainty in this screening nomogram. The result is the target concentration for screening. Divide the NO_X emission from the stack (in tonnes/annum) by the target concentration and multiply by 40 to scale the emission to the nomogram;

5.40 To use the annual mean nomogram (Figure 5.2), the following procedure should be used:

- Identify any sensitive receptors within ten stack heights;
- Derive the background NO_2 concentration at the receptor locations. Include any contribution from local roads if this is likely to be significant;
- Calculate the locally available "headroom" as the objective value (40 μg/m^3) minus the maximum background concentration;
- Divide the headroom by four (as a safety margin) to allow for the uncertainty in this screening nomogram. The result is the target concentration for screening. If the calculated target concentration is less than 0.25 μg/m^3, set the target concentration to 0.25 μg/m^3. Divide the annual emission (in tonnes) by this target concentration, to scale the emission to the nomogram;
- Identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the scaled emission rate for the installation. If the scaled emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

Short stack or fugitive emissions

5.41 To use the nomogram for short stack or fugitive emissions (Figure 5.3) it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.42 To use the nomogram, the following procedure should be used:

- Identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the emissions are non-continuous (ie, a batch process); the point of discharge is less than 10 m above the ground or building on which it sits; or the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 1 tonne per annum.

Table 5.2 Summary of 99.8th percentile of total oxidant concentrations (ozone + nitrogen dioxide) at national network monitoring sites, 2004-2006 (µg/m³)

Site Classification	Site	99.8th percentile total oxidant concentration (µg/m³ as nitrogen dioxide)		
		2004	2005	2006
London Harlington	Airport	164	170	220
London Marylebone Road	Kerbside	291	323	304
Bury Roadside	Roadside	178	167	234
Exeter Roadside	Roadside	149	172	207
Swansea Roadside	Roadside	–	–	130
Aston Hill	Rural	138	135	203
Bush Estate	Rural	120	104	134
Eskdalemuir	Rural	71	105	159
Harwell	Rural	163	137	170
High Muffles	Rural	159	131	160
Ladybower	Rural	147	121	131
Lullington Heath	Rural	160	173	209
Market Harborough	Rural	154	135	176
Narberth	Rural	–	110	164
Rochester	Rural	166	152	169
Somerton	Rural	137	139	162
St Osyth	Rural	153	173	188
Wicken Fen	Rural	171	159	217
Yarner Wood	Rural	142	142	158
Fort William	Suburban	–	–	147
Glazebury	Suburban	134	137	178
Leominster	Suburban	–	141	171
London Bexley	Suburban	167	169	189
London Eltham	Suburban	157	170	207
London Hillingdon	Suburban	165	156	198
London Sutton	Suburban	–	–	–
Manchester South	Suburban	102	66	143
Redcar	Suburban	159	111	150
Aberdeen	Urban background	144	121	153

Table 5.2 Summary of 99.8th percentile of total oxidant concentrations (ozone + nitrogen dioxide) at national network monitoring sites, 2004-2006 (µg/m³) *(cont'd…)*

Site Classification	Site	99.8th percentile total oxidant concentration (µg/m³ as nitrogen dioxide)		
		2004	2005	2006
Barnsley Gawber	Urban background	138	136	168
Birmingham East	Urban background	138	–	–
Birmingham Tyburn	Urban background	139	153	179
Blackpool	Urban background	130	–	–
Blackpool Marton	Urban background	–	121	191
Bolton	Urban background	139	130	181
Bournemouth	Urban background	152	163	201
Brighton Preston Park	Urban background	86	173	193
Bristol St Paul's	Urban background	–	–	211
Coventry Memorial Park	Urban background	164	150	180
Cwmbran	Urban background	137	138	172
Derry	Urban background	124	119	151
Edinburgh St Leonards	Urban background	147	133	155
Leamington Spa	Urban background	151	141	192
Liverpool Speke	Urban background	138	136	155
London Brent	Urban background	149	172	205
London Bridge Place	Urban background	–	–	–
London N. Kensington	Urban background	169	195	213
London Teddington	Urban background	157	162	201
London Westminster	Urban background	159	157	227
Northampton	Urban background	170	146	190
Port Talbot	Urban background	142	141	163
Portsmouth	Urban background	156	165	206
Preston	Urban background	138	133	158
Reading	Urban background	–	–	–
Reading New Town	Urban background	163	159	175
Sandwell West Bromwich	Urban background	151	140	183
Southend-on-Sea	Urban background	172	167	202
Sunderland Silksworth	Urban background	82	119	177

Table 5.2 Summary of 99.8th percentile of total oxidant concentrations (ozone + nitrogen dioxide) at national network monitoring sites, 2004-2006 (µg/m³) *(cont'd...)*

Site Classification	Site	99.8th percentile total oxidant concentration (µg/m³ as nitrogen dioxide)		
		2004	2005	2006
Thurrock	Urban background	168	160	191
Wigan Centre	Urban background	94	137	189
Wigan Leigh	Urban background	113	–	–
Wirral Tranmere	Urban background	117	115	179
Belfast Centre	Urban centre	129	172	170
Birmingham Centre	Urban centre	158	150	185
Bradford Centre	Urban centre	136	128	157
Bristol Centre	Urban centre	150	161	–
Cardiff Centre	Urban centre	153	125	183
Coventry Centre	Urban centre	–	–	–
Edinburgh Centre	Urban centre	–	–	–
Glasgow Centre	Urban centre	168	153	142
Hull Centre	Urban centre	–	–	–
Hull Freetown	Urban centre	159	147	149
Leeds Centre	Urban centre	142	134	165
Leicester Centre	Urban centre	148	159	182
Liverpool Centre	Urban centre	–	–	–
London Bloomsbury	Urban centre	162	153	212
London Hackney	Urban centre	201	222	208
London Lewisham	Urban centre	159	206	202
London Southwark	Urban centre	162	166	145
London Wandsworth	Urban centre	164	173	208
Manchester Piccadilly	Urban centre	151	195	173
Newcastle Centre	Urban centre	134	125	160
Norwich Centre	Urban centre	147	159	168
Nottingham Centre	Urban centre	145	139	179
Plymouth Centre	Urban centre	154	132	84
Rotherham Centre	Urban centre	147	132	174
Sheffield Centre	Urban centre	143	131	129

Table 5.2 Summary of 99.8th percentile of total oxidant concentrations (ozone + nitrogen dioxide) at national network monitoring sites, 2004-2006 (µg/m^3) *(cont'd...)*				
Site Classification	**Site**	**99.8th percentile total oxidant concentration (µg/m^3 as nitrogen dioxide)**		
		2004	**2005**	**2006**
Southampton Centre	Urban centre	145	131	175
Stoke-on-Trent Centre	Urban centre	147	138	229
Swansea	Urban centre	143	144	177
Wolverhampton Centre	Urban centre	149	133	163
Middlesbrough	Urban industrial	131	157	170
Salford Eccles	Urban industrial	161	162	187

(b) PM_{10}

5.43 Nomograms for PM_{10} emissions have been prepared. These estimate the emission rate (in tonnes per annum) that would produce a 1 µg/m^3 contribution to the 90th percentile of 24-hour mean concentrations (for assessment against the 2004 objective) and an annual mean ground-level contribution of 1 µg/m^3 (for assessment against the 2010 objective in Scotland). If the actual emission rate from the installation exceeds these thresholds, then it will be necessary to proceed to a Detailed Assessment.

2004 Objectives – Stack emissions

5.44 Emissions from combustion sources will need to be treated separately from low temperature (<100°C) and high temperature (>100°C) sources, due to different buoyancy effects. To use the nomograms (Figures 5.4 and 5.5) it is necessary to estimate/derive details of the emission source(s) as detailed in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6.

5.45 For sources with stack exit temperatures greater than 100°C use Figure 5.4 or Figure 5.5 for sources with stack exit temperatures less than 100°C. To use the selected nomogram, identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the permitted emission rate, the authority will need to proceed to a Detailed Assessment.

5.46 For PM_{10}, the impact of an industrial source will be largely dependent upon the background concentration. A simplified (and precautionary) means of taking this into account is as follows. Determine the permitted emission rate for the installation as described above, and then multiply by (32 minus the background). For example, if the permitted emission rate were 4 tonnes per annum, and the background were 24 µg/m^3, the "background-adjusted" permitted emission would be (32 - 24 = 8) x 4 tonnes per annum = 32 tonnes per annum.

2004 Objectives – Short stack or fugitive emissions

5.47 To use the nomogram for short stack or fugitive emissions (Figure 5.6) it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.48 To use the nomogram, the following procedure should be used:

- Identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment. NOTE: The permitted emission may be adjusted to take account of the background PM_{10} concentration – see Para 5.46.

2010 Objectives – Stack emissions (Scotland only)

5.49 To use the nomograms for PM_{10} emissions in Scotland (Figures 5.7 and 5.8), against the 2010 objectives, it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35 using the effective stack height as described in Box 5.6.

5.50 For sources with stack exit temperatures greater than 100°C use Figure 5.7 or Figure 5.8 for sources with stack exit temperatures less than 100°C. To use the selected nomogram:

- Identify sensitive receptors within ten stack heights;
- Estimate the 2010 background concentration at these receptor locations. If the receptor is close to a road (within 10 metres) then the road traffic contribution should be included in this estimate;
- Calculate the available "headroom" as the objective minus the maximum background concentration at the sensitive receptors, for example, if the maximum estimated background at a site in Scotland were 14 μg/m^3, where the 2010 objective is 18 μg/m^3, the calculated headroom would be (18-14) ie 4 μg/m^3;
- Divide the calculated headroom by a factor of four to take account of the uncertainty in this screening method. From the above example this would be 1 μg/m^3 and would be the target value for the stack contribution to ground-level concentrations. In circumstances where the target value is less than 0.25 μg/m^3, the target value should be set at 0.25 μg/m^3;
- Divide the annual emission rate (in tonnes per annum) by the target value, which will give the scaled emission rate. Identify the line which corresponds to the diameter of the stack under consideration, and locate the point whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the scaled emission rate calculated above. If the scaled emission rate is equal to or greater than the permitted emission rate, then the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority will only need to proceed to a Detailed Assessment if the emission is greater than 0.01 tonnes per annum.

2010 Objectives (Scotland only) – Short stack or fugitive emissions

5.51 To use the nomogram for short stack or fugitive emissions (Figure 5.9) it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.52 To use the nomogram, the following procedure should be used:

- Identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment. NOTE: The actual emission rate should be scaled to take into account the available headroom using the procedure described in Para 5.50 above.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 0.01 tonnes per annum.

(c) Lead

5.53 Nomograms for lead emissions have been prepared (Figures 5.10.and 5.11). These estimate the emission rate (in tonnes per annum) that would produce a maximum annual mean ground-level concentrations of 0.025 $\mu g/m^3$, equivalent to 10% of the 2008 air quality objective. If the actual emission rate from the installation exceeds this threshold, then it will be necessary to proceed to a Detailed Assessment.

5.54 To use the nomograms it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.55 To use the nomogram in Figure 5.10 identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the permitted emission rate, the authority will need to proceed to a Detailed Assessment.

5.56 To use the nomogram in Figure 5.11 identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 0.005 tonnes per annum.

d) Sulphur dioxide

5.57 A nomogram for SO_2 emissions has been prepared (Figure 5.12). This estimates the emission rate (in tonnes per annum) that would produce a 99.9th percentile ground-level concentration of 53.2 μg/m^3, equivalent to 20% of the short-term (15-minute) air quality objective. If the actual emission rate from the installation exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

5.58 To use the nomograms it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6.

5.59 To use the nomogram in Figure 5.12 identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the permitted emission rate, the authority will need to proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 1 tonne per annum.

(e) Benzene

5.60 Nomograms for benzene have been prepared (Figures 5.13 to 5.16). These estimate the emission rate (in tonnes per annum) that would produce a maximum running annual mean ground-level concentration of 1.625 μg/m^3 (for assessment against the 2003 objective) and a maximum annual mean concentration of 0.22 μg/m^3 (for assessment against the 2010 objective). If the actual emission rate from the installation exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

5.61 To use the nomograms it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.62 To use the nomogram in Figures 5.13 and 5.14 identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the permitted emission rate, the authority will need to proceed to a Detailed Assessment.

5.63 To use the nomogram in Figures 5.15 and 5.16 identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 0.25 tonnes per annum.

(f) 1,3-butadiene

5.64 Nomograms for 1,3-butadiene have been prepared. These estimate the estimate the emission rate (in tonnes per annum) that would produce maximum running annual mean ground-level concentrations of 0.225 µg/m^3, equivalent to 10% of the 2003 air quality objective. If the actual emission rate from the installation exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

5.65 To use the nomograms it is necessary to estimate/derive details of the emission source(s) as described in Paras 5.34 and 5.35, using the effective stack height as described in Box 5.6. For fugitive sources, the stack height is assumed to be zero.

5.66 To use the nomogram in Figure 5.17 identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (permitted) emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the permitted emission rate, the authority will need to proceed to a Detailed Assessment.

5.67 To use the nomogram in Figure 5.18 identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the installation. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source. If this assessment indicates a problem, it will only be necessary to proceed to a Detailed Assessment if the emission is greater than 0.05 tonnes per annum.

C.2 Major fuel (petrol) storage depots		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Benzene	**Overview** There is some evidence that major petrol fuel depots could emit sufficient benzene to put the 2010 objective at risk of being exceeded, especially if combined with higher levels from nearby busy roads.	
	Approach	
	1. Identify any major fuel storage depots handling petrol that have not been covered by previous Review and Assessment reports. Include nearby sources in neighbouring authorities.	The Local Authority Air Quality Support Helpdesk is able to provide a list of major fuel storage depots and their locations.
	2. Determine the distance of the nearest relevant exposure.	Guidance on locations that are relevant in terms of the annual mean objective is provided in Box 1.4.
	3. Establish the annual emissions from the storage depot.	Advice on annual emissions from major storage depots may be obtained from the Local Authority Air Quality Support Helpdesk.
	4. Use the nomograms in Figure 5.16 (2010 objective) to determine if the source requires further assessment.	
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for benzene for this source.	If there are monitoring data for this location, then use these results in preference to the nomogram. This assumes the data have been quality assured (see Chapter 3 and Annex 1) and relate to worst-case locations, including those identified by any modelling that may have been carried out.

C.3 Petrol stations		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Benzene	**Overview**	
	There is some evidence that petrol stations could emit sufficient benzene to put the 2010 objective at risk of being exceeded, especially if combined with higher levels from nearby busy roads.	
	Approach	
	1. Identify all petrol stations with an annual throughput of more than 2000 m^3 of petrol (2 million litres per annum), and with a busy road nearby, that have not been covered by previous Review and Assessment reports.	A busy road can be taken to be one with more than 30,000 vehicles per day. Petrol stations fitted with Stage 2 recovery systems can be ignored. Note: Stage 2 recovery systems MUST be fitted to all existing petrol stations with a petrol throughput of > 3,500 m^3/yr, and to all new petrol stations with a petrol throughput of >500 m^3/yr by 1 January 2010. Information on throughput should be available from the authorisations. Only count petrol, not diesel.
	2. Determine whether there is relevant exposure within 10 m of the pumps.	Guidance on locations that are relevant in terms an annual mean objective is provided in Box 1.4. Remember to include residential accommodation located above the garage, ie, a petrol station at the base of a block of flats. Use distance from the pumps, not from the boundary of the site.
	Question	
	• Does the petrol station meet the above criteria?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for benzene at these locations.	

<table>
<tr><th colspan="3">C.4 Poultry farms</th></tr>
<tr><th>Relevant pollutant</th><th>Steps that must be taken to complete the assessment</th><th>Notes relevant to each step</th></tr>
<tr><td rowspan="11">PM_{10}</td><td colspan="2">Overview
A small number of local authorities have identified potential exceedences of the PM_{10} objectives associated with emissions from poultry farms (defined as chickens (laying hens and broilers), turkeys, ducks and guinea fowl).
The advice below is based on experience from studies carried out by the EA, Department for Environment Northern Ireland, and a local authority.
This item has changed since the last round of Review and Assessment and should be considered by all authorities.</td></tr>
<tr><td colspan="2">Approach</td></tr>
<tr><td>1. Identify any farms housing in excess of
400,000 birds if mechanically ventilated.
200,000 birds if naturally ventilated.
100,000 birds for any turkey unit.</td><td>The Integrated Pollution and Prevention (IPPC) public register contains details of these premises.</td></tr>
<tr><td>2. Establish whether there is relevant exposure within 100 m of the poultry units.</td><td>Relevant exposure will include residential properties that form part of the farm itself.</td></tr>
<tr><td colspan="2">Question</td></tr>
<tr><td>• Does the poultry unit meet these criteria?</td><td></td></tr>
<tr><td colspan="2">Action</td></tr>
<tr><td>If the answer is YES, it will be necessary to proceed to a Detailed Assessment for PM_{10} at these locations.</td><td>Assistance may be obtained from the Review and Assessment Helpdesk (see Box 1.1) if required. Further guidance will be provided as and when new information becomes available.</td></tr>
<tr><td colspan="2">Important Notes</td></tr>
<tr><td colspan="2">The "Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs" (BREF(07.03) adopted July 2003 (available at eippcb.jrc.es/pages/FActivities.htm) recognises that dust emissions arise from poultry units and notes that emissions of dust from deep litter systems are much greater than those from cage systems. The presence of dust is an indication of the presence of PM_{10}.</td></tr>
</table>

D. Commercial and domestic sources

5.68 This section covers emissions from the commercial and domestic sector, including the service sector (for example, commercial offices, education, government, health, hotel and catering, retail, sport and leisure, warehousing etc).

5.69 Consideration is given to the use of biomass combustion in the commercial and domestic sectors, and to other solid-fuel combustion in domestic use. The checklists are set out in Box 5.8. The D1a checklist deals with biomass combustion from individual (larger) installations. The D1b checklist deals with the combined PM_{10} impacts of smaller biomass installations (both commercial and domestic). The impact of SO_2 emissions from domestic solid-fuel combustion is dealt with in D2.

5.70 The significance of domestic biomass combustion is currently thought to be relatively small. However, it may become more significant in the future[42,43]. There are concerns, particularly in London and urban areas in Scotland, that a significant increase in biomass combustion generally, and in particular the use of wood fuel, could detrimentally affect local air quality.

5.71 Local authorities will be able to identify any biomass combustion plant in their area that are covered by the Clean Air Act. Further information can then be obtained from the operator. There may be cases where the Clean Air Act has not been rigidly enforced in the recent past. Authorities will need to enforce the Clean Air Act if the air quality impact of biomass combustion is to be effectively managed.

5.72 It should be noted that "domestic furnaces" are not covered by the Clean Air Act. "Domestic furnaces" are defined in Section 64(1) of the Act as any furnace which is:

(a) designed solely or mainly for domestic purposes; and

(b) used for heating a boiler with a maximum heating capacity of less than 16.12 kilowatts.

5.73 A small domestic wood burning stove is not a boiler and so would not require notification under the Act. In the case of domestic wood-burning stoves, it will therefore be necessary for local authorities to use their judgment, and information on housing density, to decide whether domestic biomass combustion will require assessment. Guidance, and a worked example, is provided in "Technical Guidance: Screening assessment for biomass boilers[44]".

[42] Abbott J, Stewart R, Fleming S, Stevenson K, Green J and Coleman P "Measurement and modelling of fine particulate emissions (PM_{10} & $PM_{2.5}$) from wood-burning biomass boilers" Report prepared by AEA for the Scottish Government, ref. CR/2007/38, ISBN 978-0-7559-7296-8, Sep 2008. Available at: www.scotland.gov.uk/Resource/Doc/243574/0067768.pdf

[43] Abbott J, Barker N, Coleman P, Howes P, Stewart R, Leonard A and Collings A "Review of the potential impact on air quality from increased biomass use in London" Report prepared by AEA for the London Councils, ref. AEA/ENV/R/2495/Issue 2, Dec 2007. Available at www.londoncouncils.gov.uk/transport/briefings/ReviewofthePotentialImpactonAirQualityfromIncreasedWoodFuelledBiomassUseinLondon.htm?showpage=2

[44] Abbott, J "Technical Guidance: screening assessment for biomass boilers". AEA Report reference AEA/ED48673005/R2655- Issue 1, prepared for Defra and the Devolved Administrations, July 2008. Available from www.airquality.co.uk/archive/reports/list.php

Box 5.8: Updating and Screening Checklist (D) Commercial and domestic sources D.1a Biomass combustion – Individual installations		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
NO_2 and PM_{10}	**Overview** Biomass burning can lead to an increase in PM_{10} emissions, due to the process of combustion – aerosol formation from volatile materials distilled from the wood is also an issue. Compared to conventional gas-burning, biomass burning can also result in an increase in the overall NO_X emissions due to the fuel-derived portion that is not present in gas combustion. **This item is new since the last round of Review and Assessment and should be considered by all authorities.**	
	Approach	
	1. Identify plant burning biomass in 50kW to 20MW units.	Under the Clean Air Act local authorities should have this information. Start with larger units. Previous Review and Assessment work on boilers >5MW for SO_2 objective should help. Also look at recent planning permissions that have included biomass boilers.
	2. Obtain information on: • Height of the stack • Diameter of stack • Dimensions of buildings within 5 times the stack height (above the ground) • Description of the combustion appliance, and • Maximum emission rates (g/sec) of NO_X and PM_{10}	If the maximum emission rates are not known, the authority can use the maximum thermal capacity (eg, kW th or MW th) of the appliance and then estimate emission rates from the EMEP/CORINAIR Guidebook (see Important Notes below). NB: the emission factors are given in g/GJ. As an example, if the PM_{10} emission factor was 76 g/GJ for a 500 kW th appliance, then the emission rate would be $76 \times 500 \times 10^{-6} = 0.038$ g/s.
	3. Calculate the "background-adjusted" emission rates using the procedures set out in Para 5.78 (PM_{10}) and 5.81 and 5.84 (NO_2).	Background concentrations can be derived from the national 1x1 km maps, as described in Chapter 2.
	4. If necessary, calculate the "effective stack height".	Use the procedure described in Box 5.6.
	5. Use the nomograms in Figure 5.19 (PM_{10}) and Figure 5.20 (NO_2) to determine whether the source requires further assessment.	
	Question	
	Does the source exceed the threshold in the relevant nomogram?	
	Action	
	If the answer is YES to the above, it will be necessary to proceed to a Detailed Assessment for the relevant objective at these locations.	
	Important Notes	
	Limited information is available on the impact of biomass on local air quality. The AEA report "Technical Guidance: screening assessment for biomass boilers" contains a more detailed description of the above approach[44]. There is also guidance for authorities in Scotland in the report "Measurement and modelling of fine particulate emissions (PM_{10} & $PM_{2.5}$) from wood-burning biomass boilers"[42].	

D.1b Biomass combustion – Combined impacts (PM_{10} emissions)		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
PM_{10}	**Overview** There is the potential that many small biomass combustion installations (including domestic solid-fuel burning), whilst individually acceptable, could in combination lead to unacceptably high PM_{10} concentrations, particularly in areas where PM_{10} concentrations are close to or above the objectives. The impact of domestic biomass combustion in most areas is thought to be small at the time of writing, but could become more important in future. The approach set out in this checklist should be used for assessing PM_{10} emissions from domestic solid-fuel burning. **This item is new since the last round of Review and Assessment and should be considered by all authorities.**	
	Approach	
	1. Identify the areas in 500x500 m squares with the highest densities of houses and service sector biomass combustion appliances.	Such plant may be located in the commercial and domestic sectors, including service sector heating (for example, commercial offices, education, government, health, hotel and catering, retail, sport and leisure, warehousing etc) and individual residential homes.
	2. Identify the types of appliance used in each 500x500 m area.	A description of appliance types is provided in Table 5.3.
	3. Count the numbers of each appliance type in each 500x500 m square. Multiply the number of houses for each appliance type by the annual household emission shown in Table 5.3. Sum the emissions from each of the domestic appliance types to give the total annual domestic emission from the 500 m x 500 m square.	
	4. Estimate the floorspace occupied in the service sector in each of the identified 500 m x 500 m squares for each of the identified types of solid-fuel burning plant. Multiply the service sector floorspace (in hectares) for each appliance type by the annual service sector emission per hectare. Sum the emissions from each of the service sector appliance types to give the total annual service sector emission from the 500 m x 500m square.	
	5. Add the service sector emissions to the domestic emissions to give the total emissions from the 500x500 m square.	
	6. Estimate the fraction of space in the 500 x 500 m square occupied by solid-fuel burning premises or domestic properties. Divide the annual emission by the fraction occupied by solid-fuel burning to give the emissions density for the square (kg emissions per 500x500 m area).	

D.1b Biomass combustion – Combined impacts (PM_{10} emissions) *(cont'd…)*		
Relevant pollutant	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
	Question	
	Does the source exceed the threshold in the relevant nomogram?	Use nomogram in Figure 5.22 outside Scotland and Figure 5.23 in Scotland.
	Action	
	If the answer is YES to the above, it will be necessary to proceed to a Detailed Assessment for the relevant objective at these locations.	
	Important Notes	
	Limited information is available on the impact of biomass on local air quality. The AEA report "Technical Guidance: screening assessment for biomass boilers" contains a more detailed description of the above approach[44]. There is also guidance for authorities in Scotland in the report "Measurement and modelling of fine particulate emissions (PM_{10} & $PM_{2.5}$) from wood-burning biomass boilers"[42].	

Biomass combustion

5.74 The use of biomass to generate energy has potentially significant benefits for the reduction of greenhouse gas emissions. The UK Energy White Paper, and the UK Biomass Strategy, both recognise the potential role of biomass combustion in meeting the UK's renewable energy targets. However, there are concerns, particularly in major metropolitan areas, that a large increase in biomass combustion could have a detrimental effect of pollutant concentrations, in particular PM and NO_2. Where the air quality objectives for these pollutants are already high, this can be a particularly sensitive issue.

5.75 The Review and Assessment needs to consider both individual installations and the combined impact of many small biomass installations.

Individual installations

5.76 Consideration needs to be given to biomass combustion installations in the range 50 kW to 20 MW thermal, to see if there is potential for the air quality objectives to be exceeded. Both PM_{10} and NO_2 should be considered. The procedure is set out in Box 5.8 D1a, and is described in more detail in the following section. Some examples of the calculations are provided in Annex 2.

(a) PM_{10}

5.77 A nomogram (Figure 5.19) has been prepared to assess the likelihood of the biomass combustion appliance leading to an exceedence of the 24-hour mean objective for PM_{10}.

5.78 The first step is to calculate the "background-adjusted" emission rate: using:

$$E_A = \frac{E}{(32 - G)}$$

where: E is the emission rate in g/s for the plant operating at capacity; and G is the annual average background concentration in µg/m^3. The 32 µg/m^3 represents the annual average concentration at which, given a typical distribution of concentrations, the 90th percentile of 24-hour means will exceed the objective.

5.79 The nomogram requires the use of the effective stack height, which is defined in Box 5.6. It cannot be used if the building height, H, is greater than the actual stack height U_{act}.

5.80 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration and locate the point on this line whose ordinate corresponds to the effective stack height. Read off the corresponding threshold emission rate on the horizontal axis and compare this with the "background-adjusted" emission rate. If the "background-adjusted" emission rate is greater than or equal to the threshold emission rate, the authority will need to proceed to a Detailed Assessment.

(b) Nitrogen dioxide, annual mean

5.81 A similar procedure applies for the annual mean NO_2, using the nomogram in Figure 5.20. First determine the maximum emission rate. Then calculate the background adjusted emission rate using:

$$E_A = \frac{E}{(40 - G)}$$

where: E is the emission rate in g/s for the plant operating at capacity; and G is the annual average background concentration in μg/m³. The 40 μg/m³ represents the annual average object.

5.82 The nomogram requires the use of the effective stack height, which is defined in Box 5.6. It cannot be used if the building height, H, is greater than the actual stack height U_{act}.

5.83 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration and locate the point on this line whose ordinate corresponds to the effective stack height. Read off the corresponding threshold emission rate on the horizontal axis and compare this with the "background-adjusted" emission rate. If the "background-adjusted" emission rate is greater than or equal to the threshold emission rate, the authority will need to proceed to a Detailed Assessment.

(c) Nitrogen dioxide, 1-hour mean

5.84 A similar procedure applies for the 1-hour objective for NO_2, using the 99.8th percentile hourly nomogram in Figure 5.21. Firstly, determine the maximum emission rate. Then calculate the background adjusted emission rate using:

$$E_A = \frac{40E}{(200 - 2G)}$$

where: E is the emission rate in g/s for the plant operating at capacity; and G is the annual mean background concentration in μg/m³. The 200 μg/m³ represents the annual mean concentration at which, given a typical distribution of concentrations, the 90th percentile of 24 hour means will exceed the objective.

5.85 The nomogram requires the use of the effective stack height, which is defined in Box 5.6. It cannot be used if the building height, H, is greater than the actual stack height U_{act}.

5.86 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration and locate the point on this line whose ordinate corresponds to the effective stack height. Read off the corresponding threshold emission rate on the horizontal axis and compare this with the "background-adjusted" emission rate. If the "background-adjusted" emission rate is greater than or equal to the threshold emission rate, the authority will need to proceed to a Detailed Assessment.

Combined impacts

5.87 There is concern that the effects of many small biomass combustion installations, whilst individually acceptable, could combine and lead to unacceptably high PM_{10} concentrations. The procedure is set out in Box 5.8, D1b, and is described in more detail in the following section. An example is set out in Box 5.9, together with further information in Annex 2.

5.88 Nomograms have been prepared to assist local authorities assess the implications of this, taking into account the improved emissions performance of modern solid-fuel appliances, Figures 5.22 and 5.23. The nomograms are designed to be applied to emissions from the domestic and commercial sectors combined.

5.89 Solid-fuel burning tends to be concentrated into small areas or estates, which generally cover less than 1 km^2. The procedure previously adopted in LAQM.TG(03) required authorities to identify the area with the highest density of solid-fuel burning houses and then to estimate the number of houses burning coal, smokeless fuel or wood within a 500 m x 500 m grid square. The proportion of space in the 500 m x 500m square not occupied by solid-fuel burning houses was also required, together with the annual mean background concentration. A similar procedure is used to assess high densities of biomass combustion installations:

Box 5.9: Example of assessment

Consider a 500 m x 500 m square containing a new 6 hectare development of 400 houses on the outskirts of a large town. The houses are fitted with advanced automatic wood pellet boilers. The new development adjoins an 8 hectare older estate. The older estate has largely converted to gas heating but there remain 50 houses that use conventional boilers burning coal. The 500 m x 500 m square also contains a school with floor area of 0.2 hectares in a plot of 1 hectare: the school is heated by means of a wood-burning advanced automatic boiler. There is also a public house with floor area of 0.1 hectare in a plot of 0.5 hectare; the public house is heated by open wood fires. The remaining part of the 500 m x 500 m square does not contain premises burning solid fuels.

The total emissions of PM_{10} from the residential area is (400 x 3.54) + (50 x 23.03) = 1416 + 1152 = 2568 kg. The total emissions of PM_{10} from the school and the public house are (0.2 x 295) + (0.1 x 2,291) = 59 + 229 = 288 kg. The total emissions from all solid fuel sources are then 2,568 + 288 = 2,856 kg.

The area of the 500 x 500 m square occupied by solid fuel heated premises is 6+8+1+0.5 = 15.5 hectares. Thus the fraction occupied is 9.5/25 = 0.62. The emissions density is then 2,856/0.62 = 4,606 kg /year.

The background PM_{10} in the area is estimated from the national maps to be 21 μg/m^3. From Figure 5.22, the threshold emission density is 5,013 kg/year. In this case, the calculated emissions for the 500 m x 500 m square are less than the threshold and there is no requirement to carry out a Detailed Assessment.

The procedure is as follows:

- Identify the areas with the highest densities of houses and service sector appliances burning solid fuels.
- Identify the types of solid-fuel appliance used in each area from the list in Table 5.3. Annex 2 of this document provides further descriptions of the appliance types.
- Count the numbers of each domestic heating appliance type in the identified 500x500 m squares. Estimate the floorspace occupied in the service sector in each of the identified 500 m x 500 m squares for each of the identified types of solid-fuel burning plant.
- Multiply the number of houses for each appliance type by the annual household emission shown in Table 5.3. Sum the emissions from each of the domestic appliance types to give the total annual domestic emission from the 500 m x 500 m square.
- Multiply the service sector floorspace (in hectares) for each appliance type by the annual service sector emission per hectare. Sum the emissions from each of the service sector appliance types to give the total annual service sector emission from the 500 m x 500m square. Add the service sector emissions to the domestic emissions to give the total emissions from the square[45].
- Estimate the fraction of space in the 500 m x 500 m square occupied by solid-fuel burning premises or domestic properties. Divide the annual emission by the fraction occupied by solid-fuel burning to give the emissions density for the square (kg emissions per 500 m x 500 m area).

5.90 Figure 5.22 describes the annual emissions from a 500 m x 500m square (the threshold emissions density) that may give rise to an exceedence of the 24 hour mean objective for PM_{10} for a particular estimated background PM_{10} concentration. If the emissions density from the square exceeds the threshold emissions density shown in Figure 5.22, then the authority will need to proceed to a Detailed Assessment.

5.91 Figure 5.23 describes the annual emissions from a 500 m x 500m square (the threshold emissions density) that may give rise to an exceedence of the annual mean objective for PM_{10} for Scotland of 18 μg/m^3 for a particular estimated background PM_{10} concentration. If the emissions density from the square exceeds the threshold emissions density shown in Figure 5.23, then the authority will need to proceed to a Detailed Assessment.

[45] Emissions from residential or mixed-use residential “energy centres” can also be accounted for, provided the entire heating demand of the facility is taken into account.

Table 5.3: Estimated annual emissions per household or hectare of service sector floorspace					
Appliance type	**Fuel**	**Emissions per household, kg/year**		**Emissions per hectare of service sector floorspace, kg/year**	
		PM_{10}	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**
Fireplace	Coal	20.00	20.00	1670	1670
	Wood	27.43	27.12	2291	2264
Stove	Coal	27.27	27.27	2277	2277
	Solid smokeless fuel	6.06	6.06	506	506
	Wood	25.84	25.84	2157	2157
Advanced stove	Coal	14.55	13.33	1215	1113
	Wood	7.66	7.66	639	639
Pellet stove	Wood	4.07	4.07	340	340
Boiler < 50 kW th	Coal	23.03	21.82	1923	1822
	Solid smokeless fuels	6.06	6.06	506	506
	Wood	15.15	15.15	1265	1265
Boiler > 50 kW th and < 1 MW th	Coal			962	860
	Solid smokeless fuels			405	405
	Wood			1074	1074
Boiler > 1 MW th	Coal			385	364
	Wood			300	291
Advanced manual boiler	Coal	8.49	7.88	708	658
	Wood	2.42	2.42	202	202
Advanced automatic boiler	Coal	4.61	4.36	385	364
	Wood	3.54	3.54	295	295
Boiler, with fabric filter <20 mg/Nm^3 TSP	Coal			30	25
	Wood			31	27
Older boiler with fabric filter or electrostatic precipitator <100 mg/Nm^3 TSP	Coal			127	61
	Wood			112	54
Boiler with uncontrolled multicyclone	Coal			304	177
	Wood			313	246
Best available domestic	Wood	1.07	1.07		

D.2 Domestic solid-fuel burning (Sulphur dioxide emissions)		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Overview The previous rounds of Review and Assessment have identified areas where domestic solid fuel burning gives rise to exceedences of the objective for SO_2. PM_{10} from domestic solid fuel burning is covered under D.1b Biomass combustion – combined impacts.		
Sulphur dioxide	**Approach**	
	Identify areas where significant coal burning takes place. Smokeless fuel has a similar sulphur content to coal and so should be treated in the same way.	"Significant" is defined as any area of about 500x500 m with more than 50 houses burning coal/smokeless fuel as their primary source of heating. If necessary use professional judgment to identify such areas, including experience of smoke hanging over the area on a winter's evening. Further guidance is provided in Annex 2.
	Collect information on the actual use of coal/smokeless fuel in these areas.	Do not count houses with occasional use of solid fuels.
	Question	
	Does the density of coal burning premises exceed 100 per 500x500 m area?	
	Action	
	If the answer is YES, it will be necessary to proceed to a Detailed Assessment for SO_2 at these locations.	

E. Fugitive or uncontrolled sources

5.92 Dust emissions from a number of uncontrolled and fugitive sources can give rise to elevated PM_{10} concentrations. These sources include, but are not limited to:

- Quarrying and mineral extraction sites;
- Landfill sites;
- Coal and material stockyards, or materials handling;
- Major construction works;
- Waste management sites.

For example, recent studies have identified substantial increases in annual mean PM_{10} concentrations, up to 30 µg/m^3, alongside public roads up to 50 m from the entrances to waste management sites and construction sites[46].

5.93 Emissions from these sources are not well quantified, and it is therefore difficult to predict PM_{10} concentrations with any accuracy. The screening assessment is therefore largely based upon practical experience gained from studies in the vicinity of these sources, and the results of previous rounds of Review and Assessment. Short-lived construction sites will not normally need to be considered for the purpose of Review and Assessment.

5.94 The first step in the assessment is to determine whether there have been any assessments carried out by others for the source in question, and if so whether the assessment is of sufficient quality for the purposes of Review and Assessment. If there is no existing assessment, then it should be established whether there is relevant public exposure near the sources of dust emission. It is important that distances to the actual sources of emission are considered and not the distances to the site boundary. On-site sources can be haul roads, crushers, stockpiles etc. Off-site sources can also be important, in particular the roads used by vehicles accessing the site. Dust and dirt can be tracked out by vehicles leaving the site, deposited on the public highway, and then raised by passing vehicles. Concentrations fall-off rapidly on moving away from the source.

5.95 It must be emphasised that the criteria in this Checklist are subject to greater uncertainty than those prepared for other source types. In the case of doubt, authorities are advised to use local and professional judgment. For example, it is worth considering whether dust nuisance complaints have been received from residential properties in the locality, or whether there is evidence from site inspections of dust emissions or dust deposits, including on off-site access routes, potentially for several hundred metres from the site entrance. In the event of any doubt, the authority should proceed to a Detailed Assessment. The basis for any decision should be clearly documented in the Review and Assessment report.

46 AQEG (2005) Particulate Matter in the United Kingdom, and Fuller G (2008) PM_{10} Source Apportionment at Bexley4, Manor Road, Erith, Kings College, London.

Box 5.10: Updating and Screening Checklist		
(E) Fugitive or uncontrolled Sources		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Overview Dust emissions from a range of fugitive and uncontrolled sources can give rise to elevated PM_{10} concentrations. Particular attention will need to be paid to fugitive sources in Scotland, against the 2010 objectives. Dust arises from the passage of vehicles over unpaved ground and from the passage of vehicles along public roads that have been affected by dust and dirt tracked out from dusty sites. It also arises from the handling of dusty materials, the cutting of concrete etc. There is also wind-blown dust from stockpiles and dusty surfaces. Only locations not covered by previous rounds of Review and Assessment, or where there is new relevant exposure, should be covered in this section.		
E.1 Fugitive and uncontrolled sources		
PM_{10}	**Approach**	
	1. Obtain details of any air quality assessment already carried out for the relevant source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case, confirm that the assessment is sufficient for Review and Assessment purposes. Only consider sources for which planning approval has been granted.
	2. Establish whether there is relevant exposure "near" to the source(s) of dust emissions.	Relevant exposure is defined in Box 1.4. If the relevant exposure is away from off-site roads used as access routes to the site then "near" is defined in relation to the local background PM_{10} concentrations, taken from the national maps (Chapter 2) as follows: For **2004 objectives,** near is within: 1000 m for a background >28 µg/m^3; 400 m for a background >26 µg/m^3; and 200 m for any background. For **2010 objectives (Scotland only),** near is within: 1000 m for a background >17 µg/m^3; 400 m for a background >16 µg/m^3; and 200 m for any background. These distances are from the source, which may not always coincide with the boundary of the site. If there is no relevant exposure near to the source then there is no need to proceed further. If the relevant exposure is within 50 m of an off-site road used to access the site and there are visible deposits on the road, then these sections of road, which may extend up to 1000 m from the site entrance, are considered to be "near", as long as the background is above 25 µg/m^3 for the 2004 objectives and above 11 µg/m^3 for the 2010 objective in Scotland.
	3. Determine whether there are dust concerns associated with the facility.	Base this assessment on dust complaints and/or experience gained from site visits.

Box 5.10: Updating and Screening Checklist *(cont'd...)*		
Relevant pollutants	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
	Question	
	• Is there relevant exposure "near" to a source of dust emissions?	
	• Are there recent complaints about dust?	
	• Does visual inspection indicate significant dust emissions or dust tracked out of the site onto public roads?	
	Action	
	If the answer is YES to the first question and to either the second or third questions, it will be necessary to proceed to a Detailed Assessment for PM_{10} at these locations.	

Figure 5.1: Emissions of nitrogen oxides (tonnes/annum) which will give rise to a 99.8th percentile hourly mean nitrogen dioxide concentration of 40 µg/m³

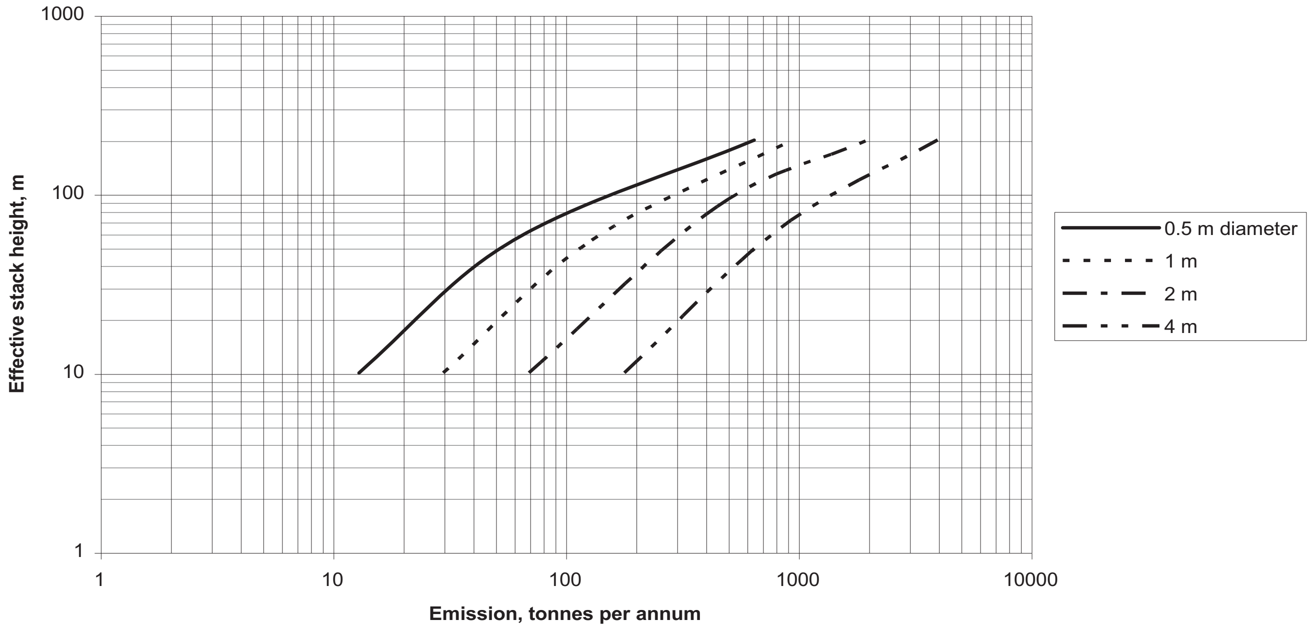


Figure 5.2: Emissions of nitrogen oxides (tonnes per annum) which will give rise to an annual mean ground-level nitrogen dioxide concentration of 1 µg/m³ (stack > 10 metres).

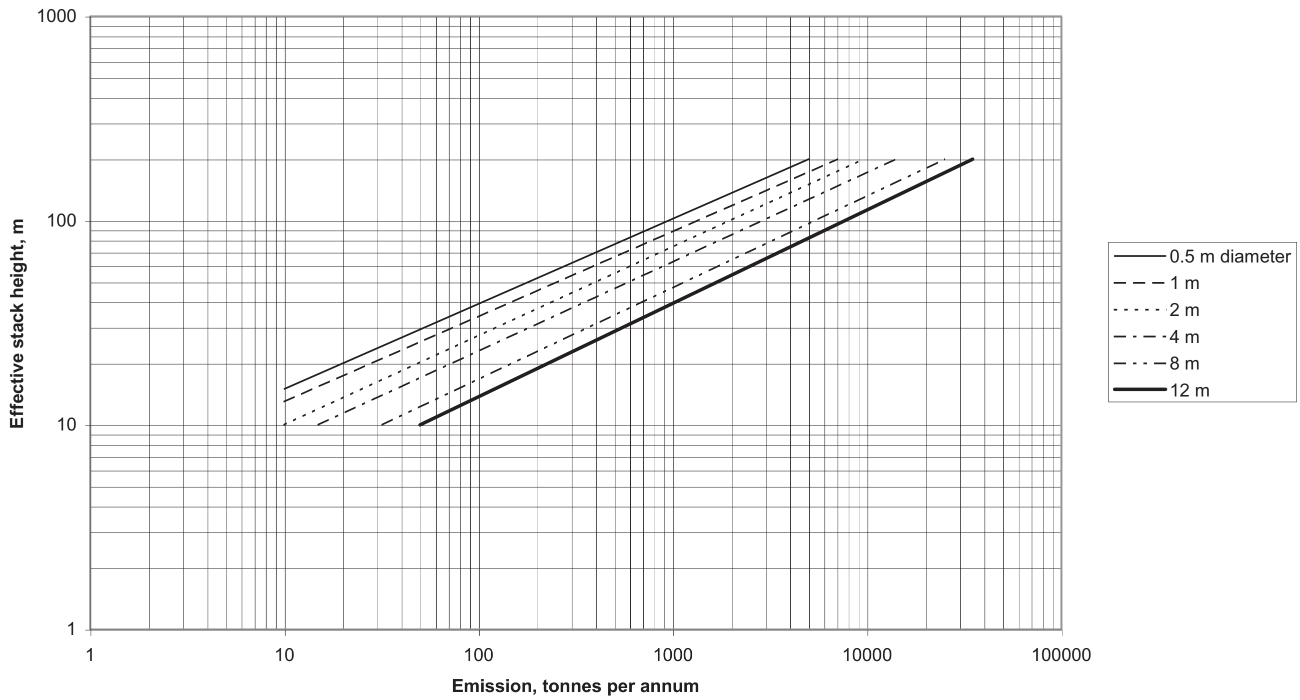


Figure 5.3: Emissions of nitrogen oxides (tonnes per annum) which will give rise to an annual mean ground-level nitrogen dioxide concentration of 1 µg/m³ at receptor locations up to 2 km from fugitive and low-level sources (stack <10 metres).

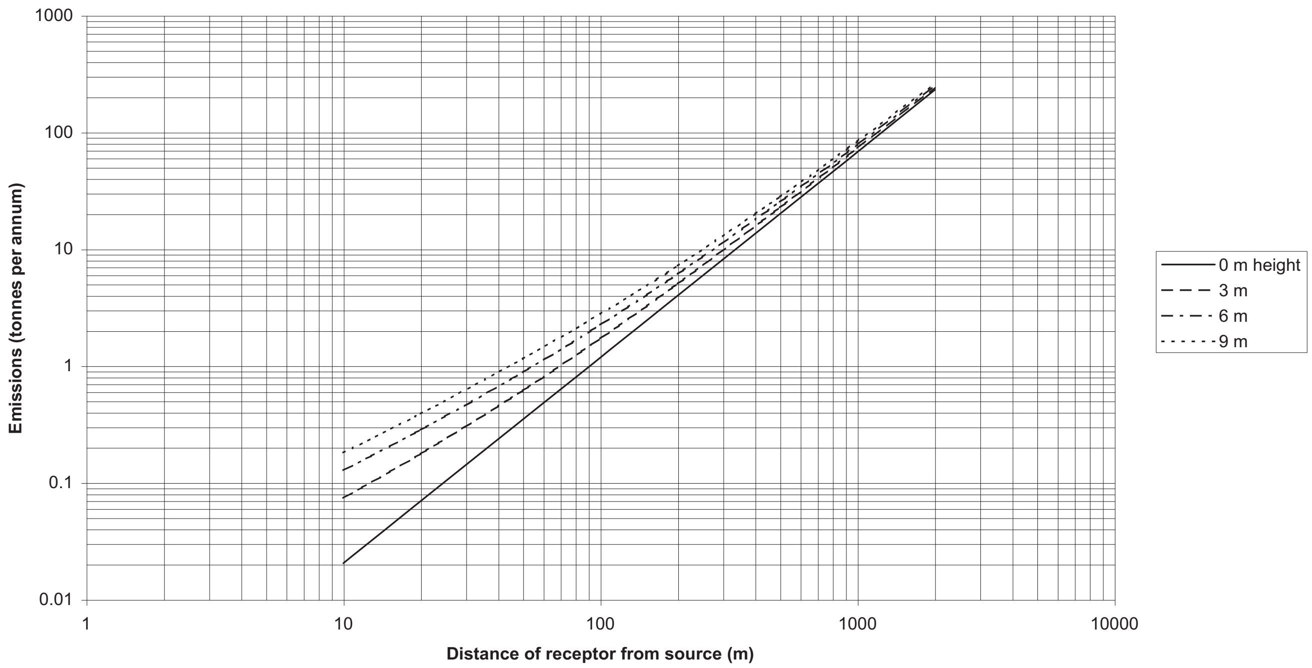


Figure 5.4: PM_{10} emissions (tonnes per annum) from combustion source emissions (>100°C) to give a 90th percentile 24 hour mean concentration of 1 µg/m³ (stack >10 metres).

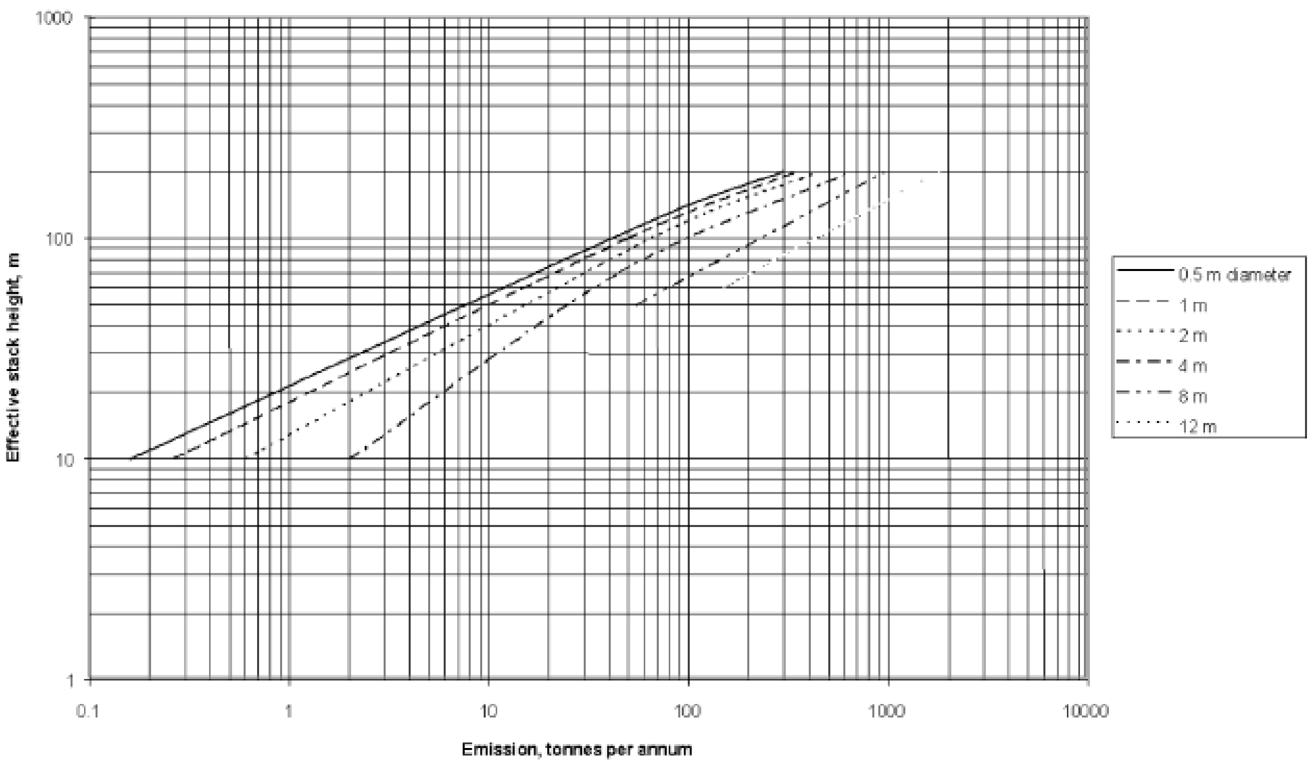


Figure 5.5: PM$_{10}$ emissions (tonnes per annum) from low temperature sources (<100°C) which will give a 90th percentile of daily 24 hour mean ground-level concentration of 1 µg/m^3 (stack >10 metres).

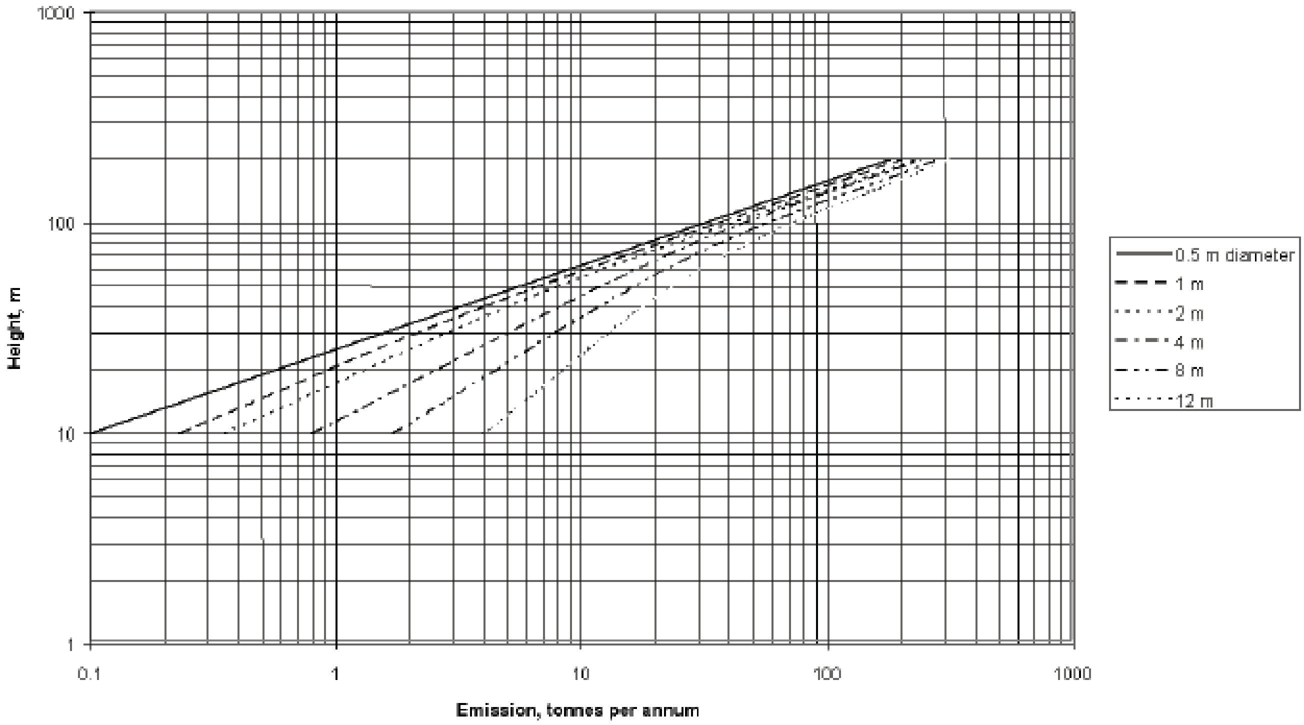


Figure 5.6: PM$_{10}$ emissions (tonnes per annum) which will give a 90th percentile of daily 24 hour mean ground-level concentration of 1 g/m^3 at receptor locations up to 2 km from fugitive and low-level sources (stack <10 metres).

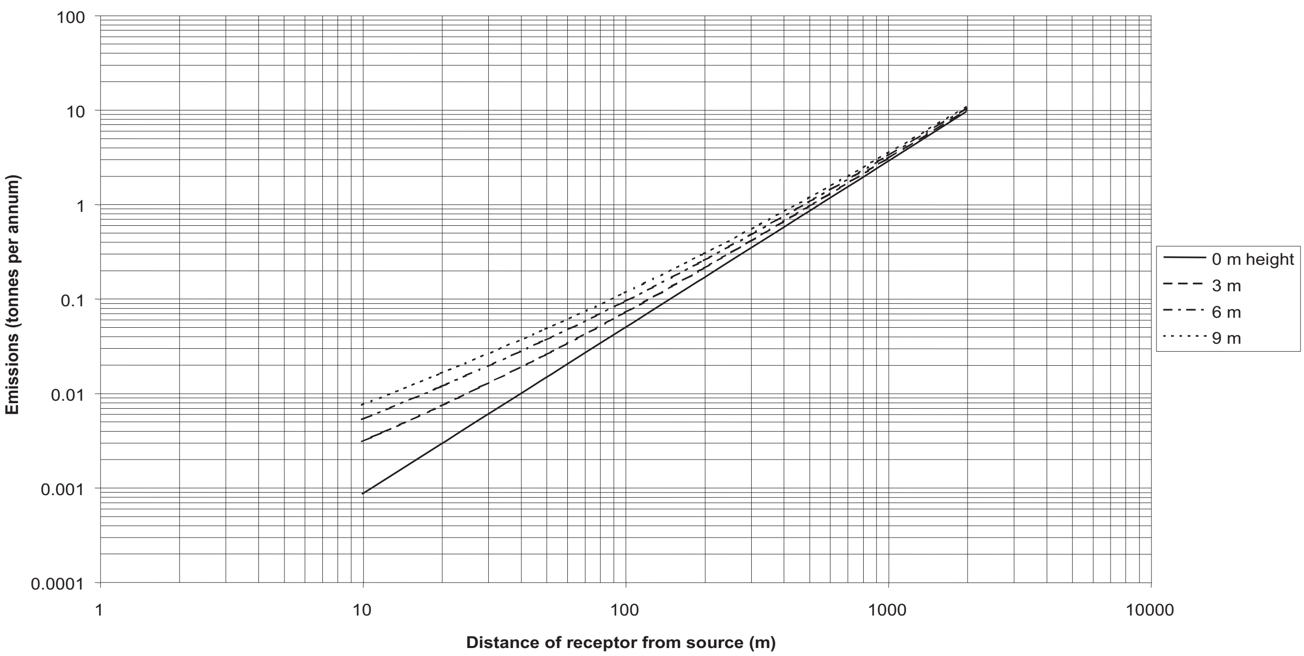


Figure 5.7: PM$_{10}$ emissions (tonnes per annum) from combustion source emissions (>100°C) to give an annual mean ground-level concentration of 1 µg/m³ (stack >10 metres).

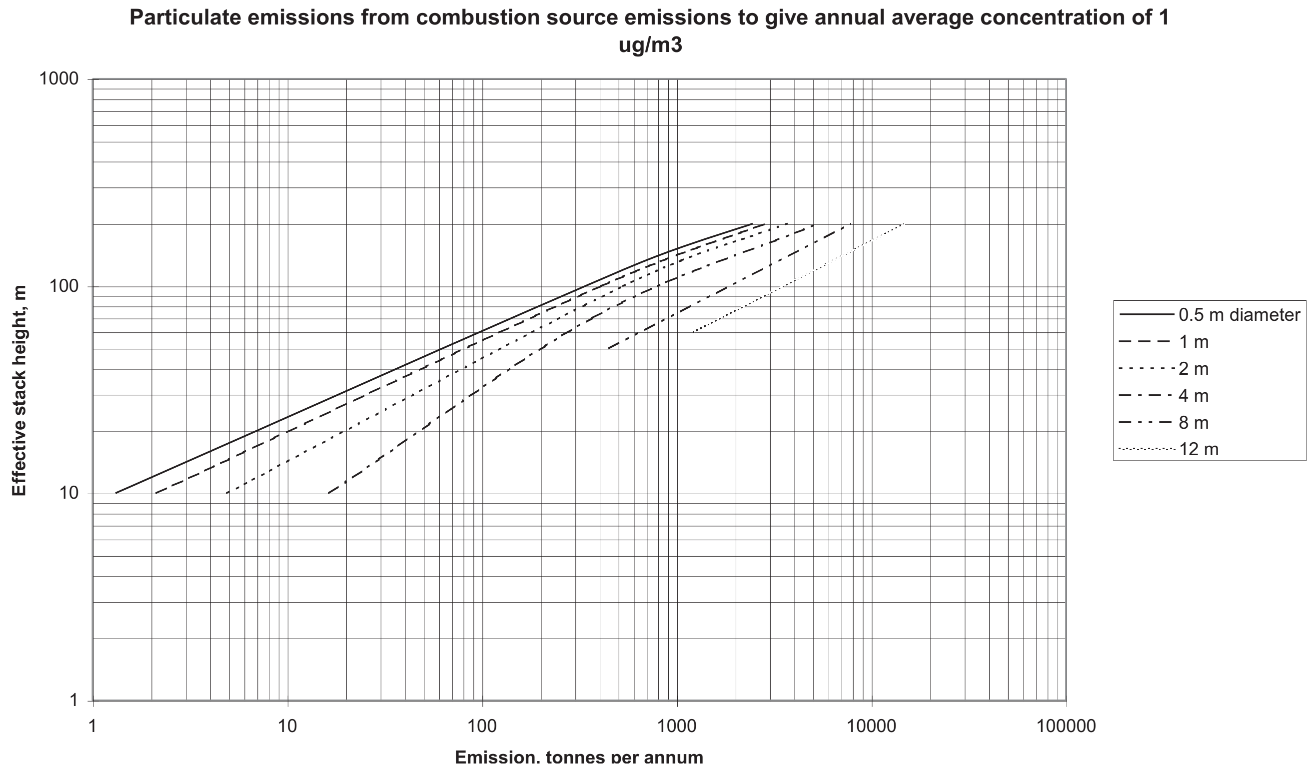


Figure 5.8: PM$_{10}$ emissions (tonnes per annum) from low temperature sources (<100°C) which will give an annual mean ground-level concentration of 1 µg/m³ (stack >10 metres).

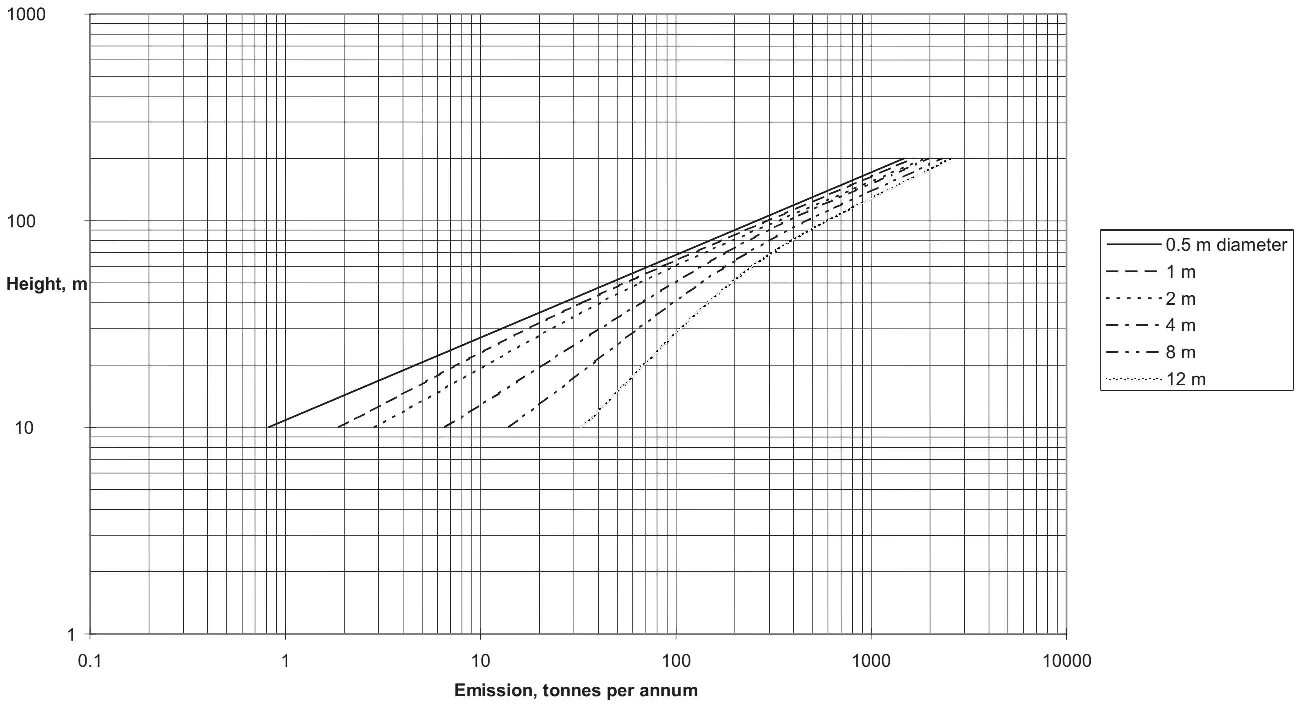


Figure 5.9: PM_{10} emissions (tonnes per annum) from that will give an annual mean ground-level concentration of 1 µg/m³ at receptor locations up to 2km from fugitive and low-level sources (stack <10m).

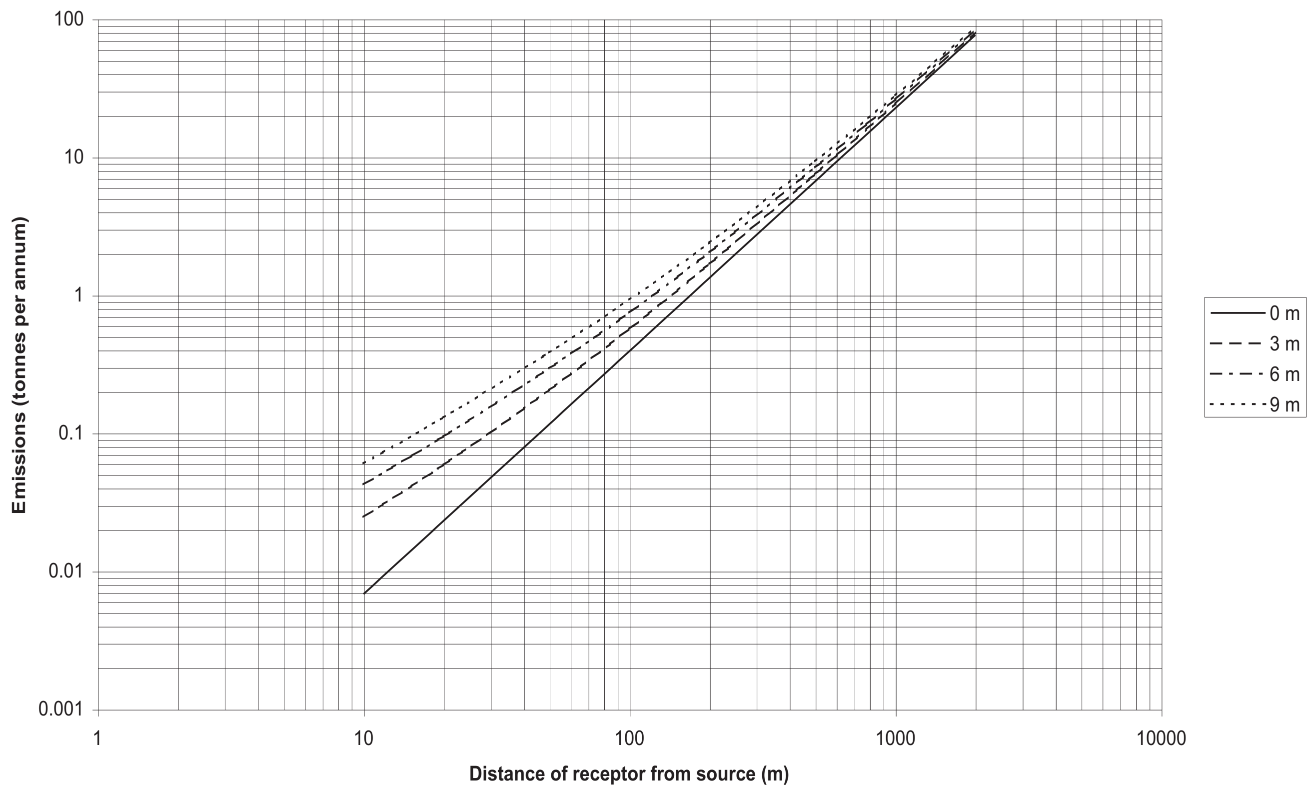


Figure 5.10: Emissions of lead (tonnes per annum) that will give rise to an annual mean ground-level concentration of 0.025 µg/m³ (stack > 10 metres).

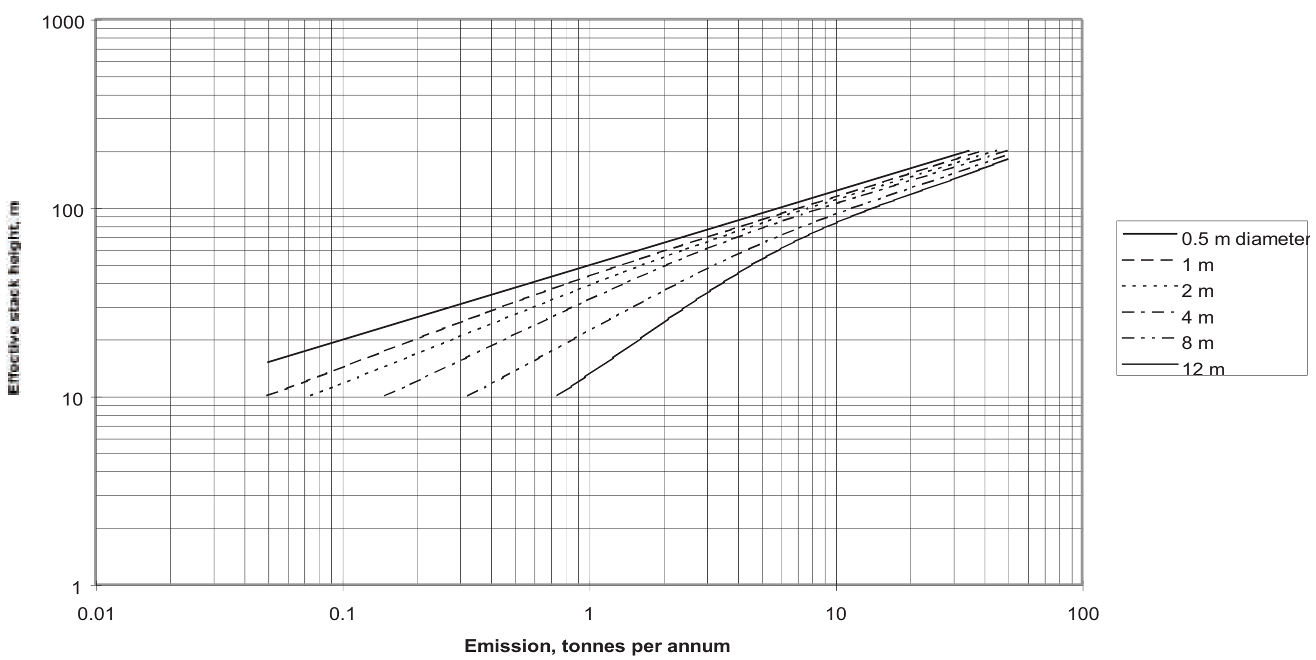


Figure 5.11: Emissions of lead (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.025 µg/m³ at receptor locations up to 2 km from fugitive and low-level sources (stack <10 metre).

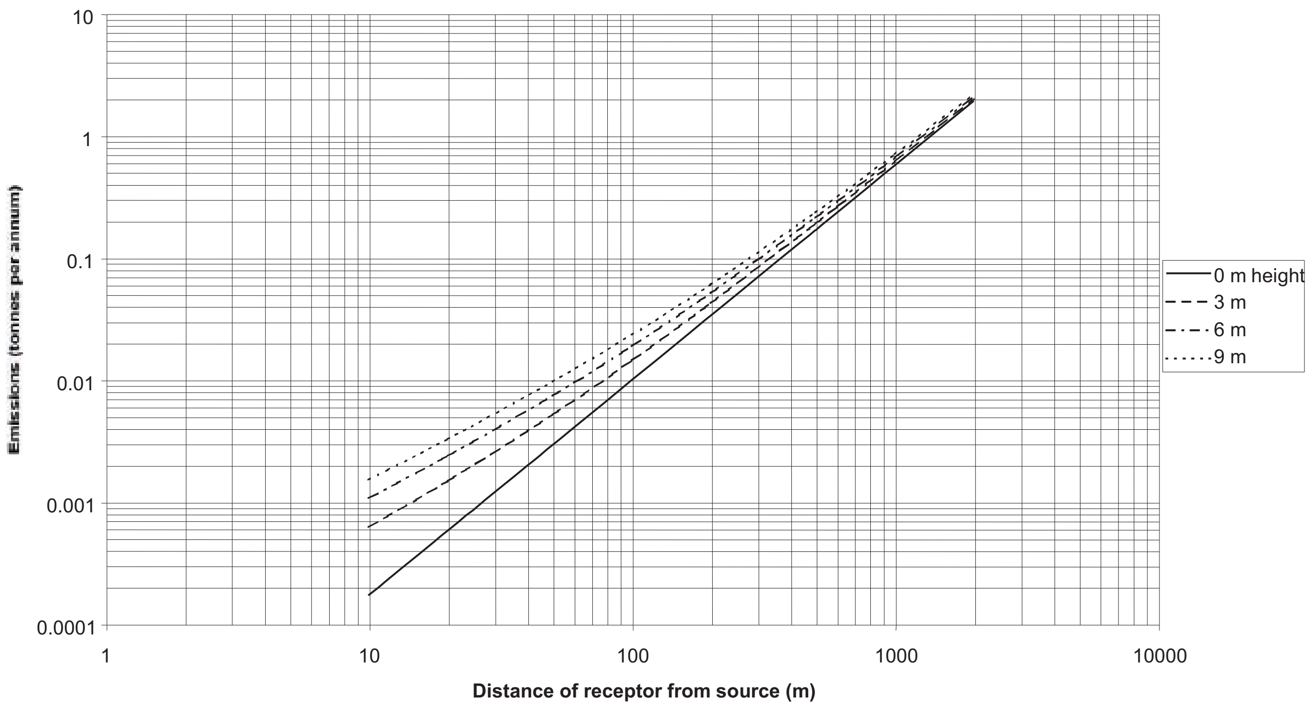


Figure 5.12: Emissions of sulphur dioxide which will give rise to a 99.9th percentile 15-minute ground-level mean concentration of 53.2 µg/m³.

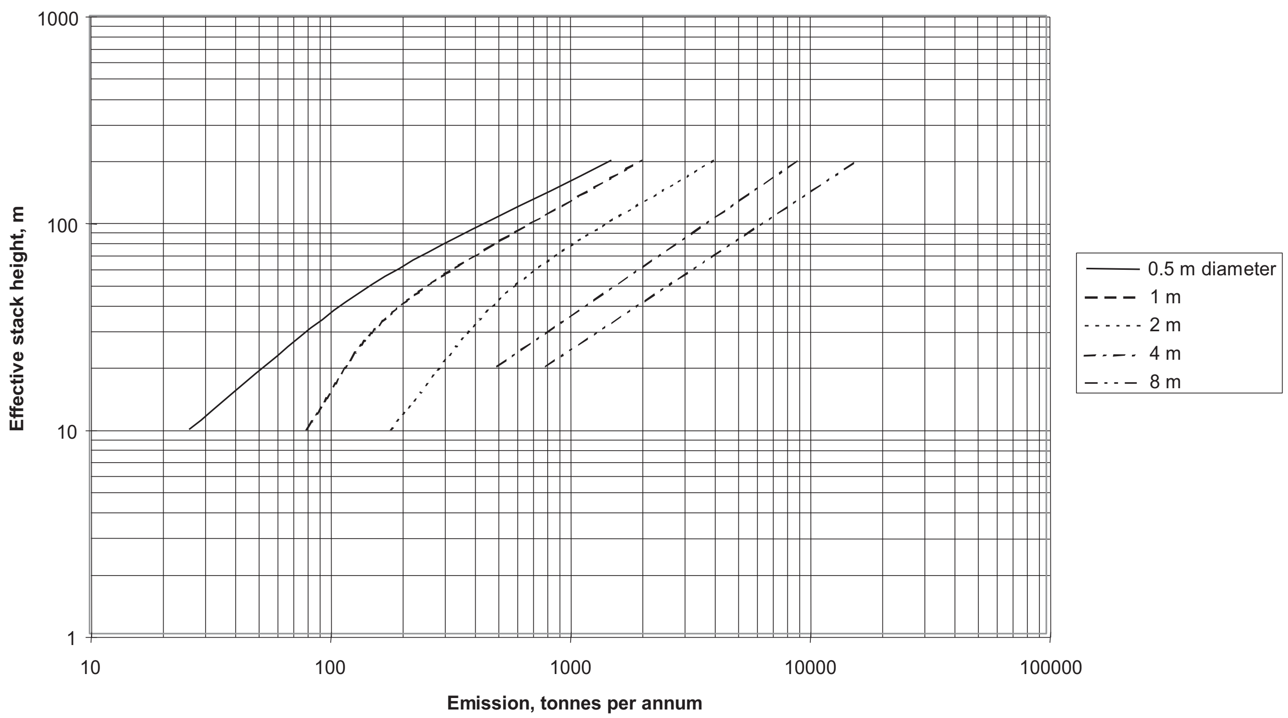


Figure 5.13: Emissions of benzene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 1.625 µg/m³ (stacks >10 metres).

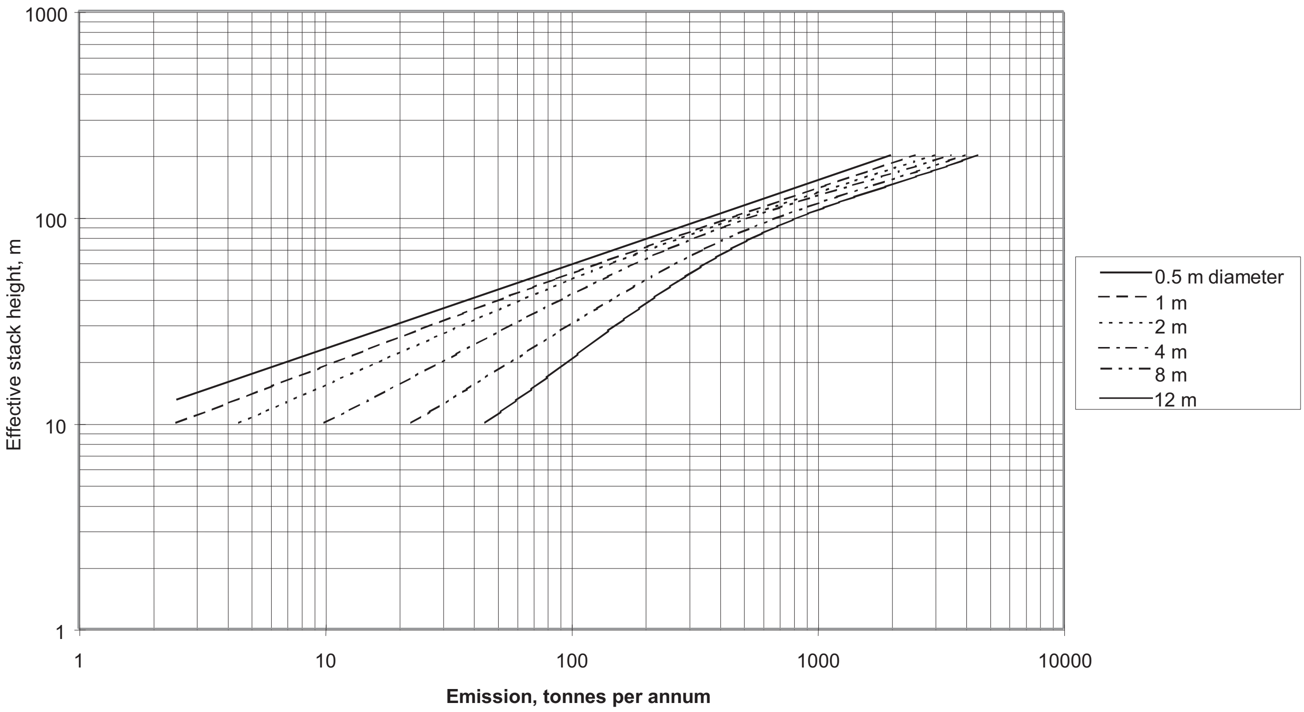


Figure 5.14: Emissions of benzene (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.22 µg/m³ (stacks >10 metres).

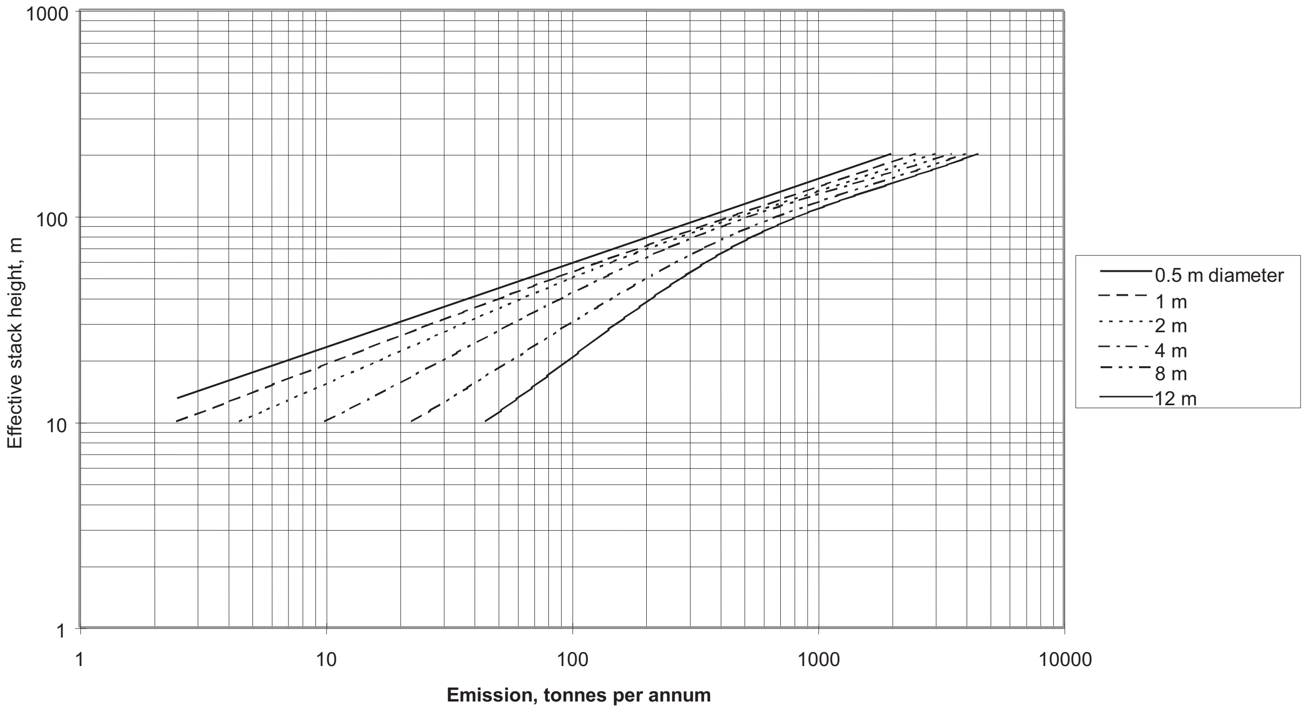


Figure 5.15: Emissions of benzene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 1.625 µg/m³ at receptors up to 2 km from fugitive and low-level sources (stack <10 metres).

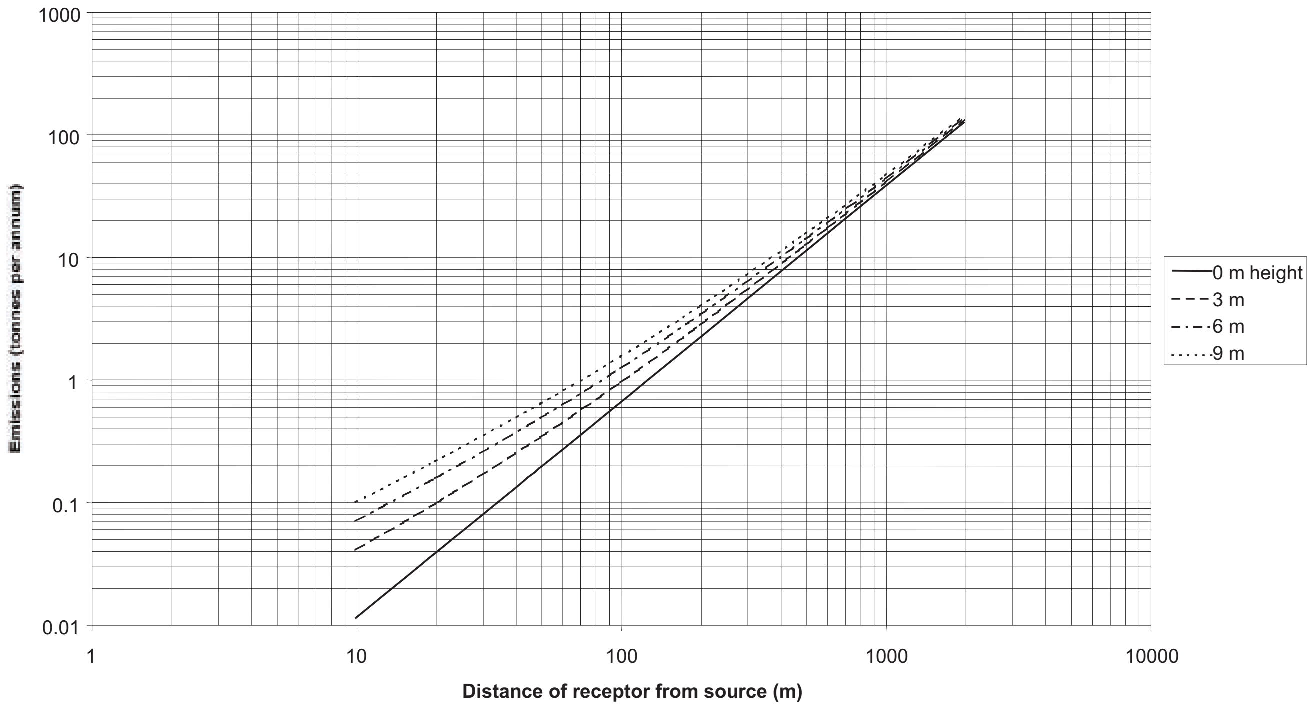


Figure 5.16: Emissions of benzene (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.22 g/m³ at receptors up to 2 km from fugitive and low-level sources (stack <10 metres).

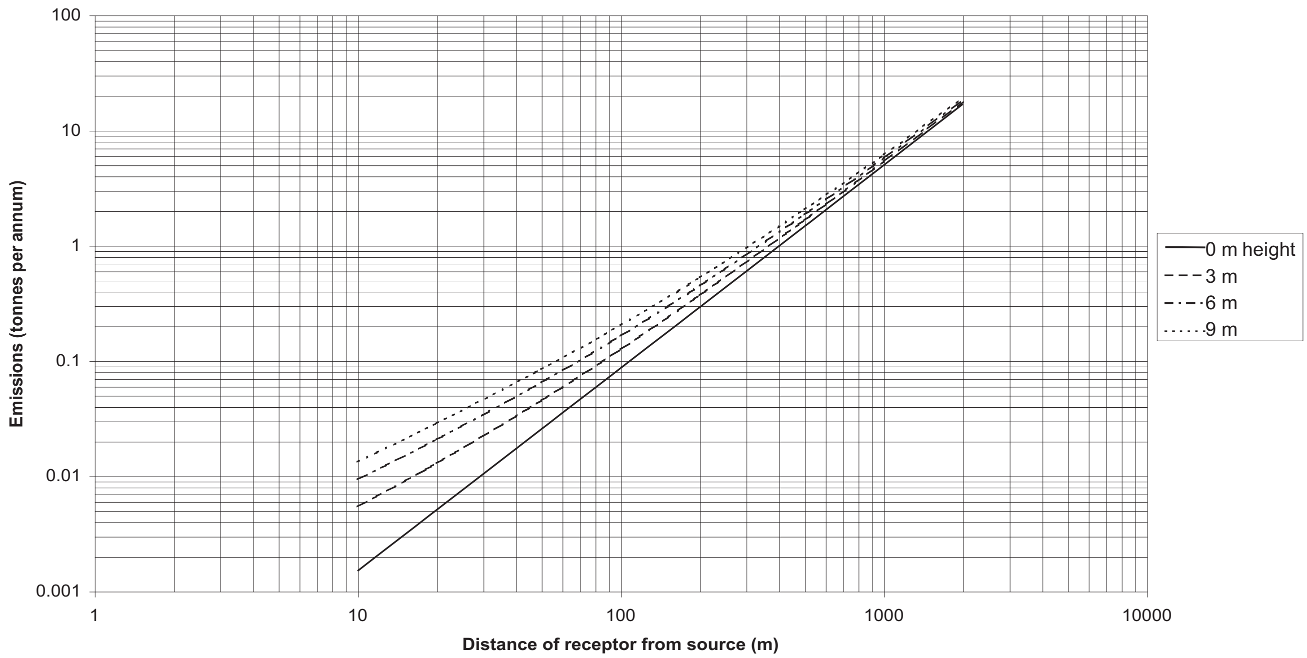


Figure 5.17: Emissions of 1,3 butadiene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 0.225 µg/m³ (stacks >10 metres).

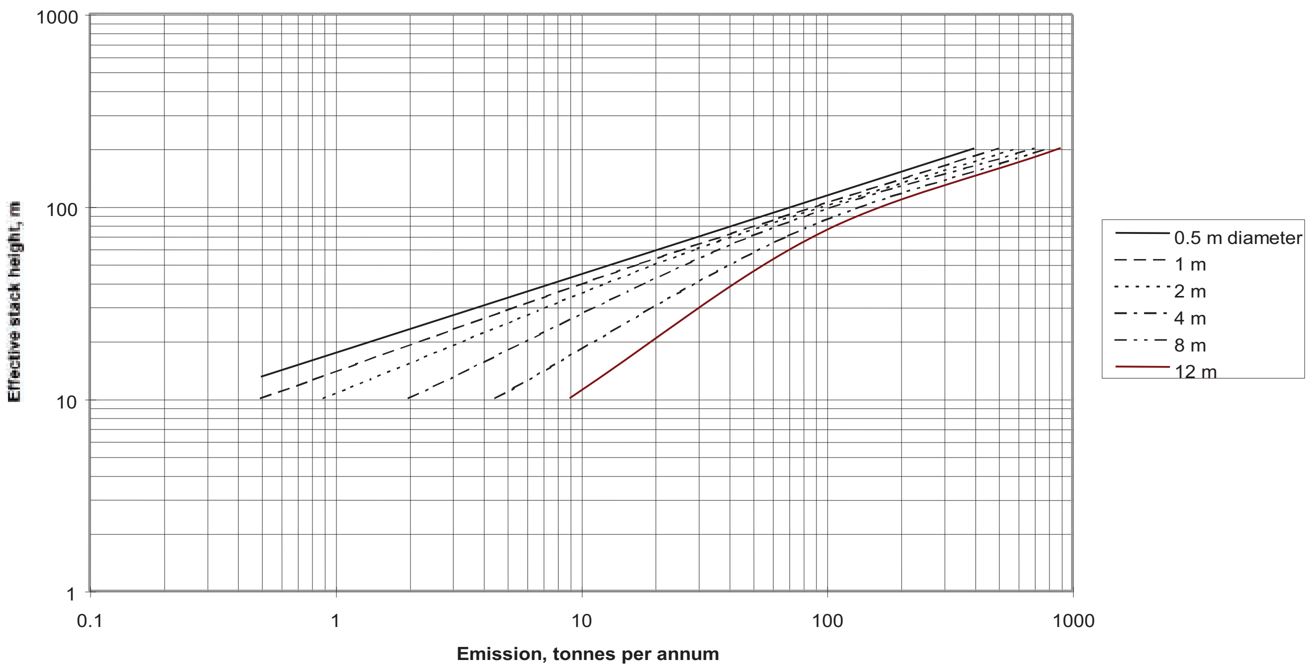


Figure 5.18: Emissions of 1,3 butadiene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 0.225 µg/m³ at receptors up to 2 km from fugitive and low-level sources (stack < 10 metres).

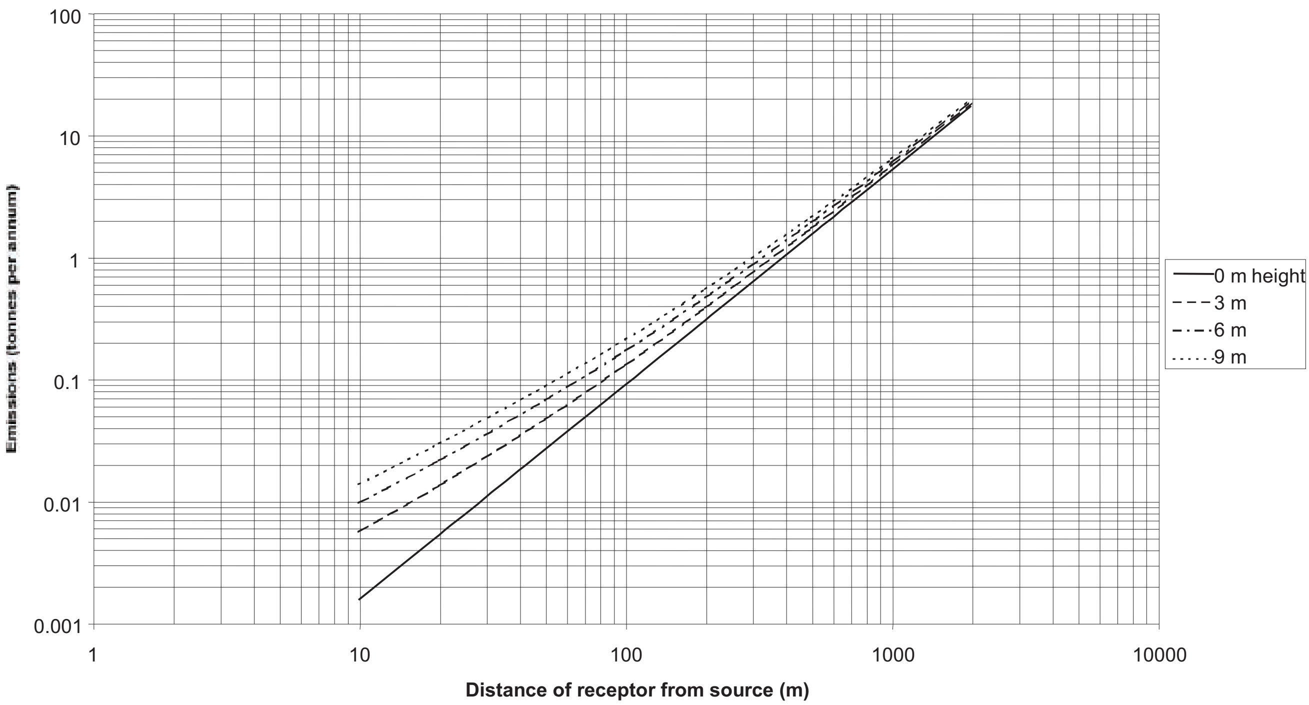


Figure 5.19: Particulate Matter emissions to give a 90th percentile of 24-hour mean ground-level PM_{10} concentrations of 1 μg/m³

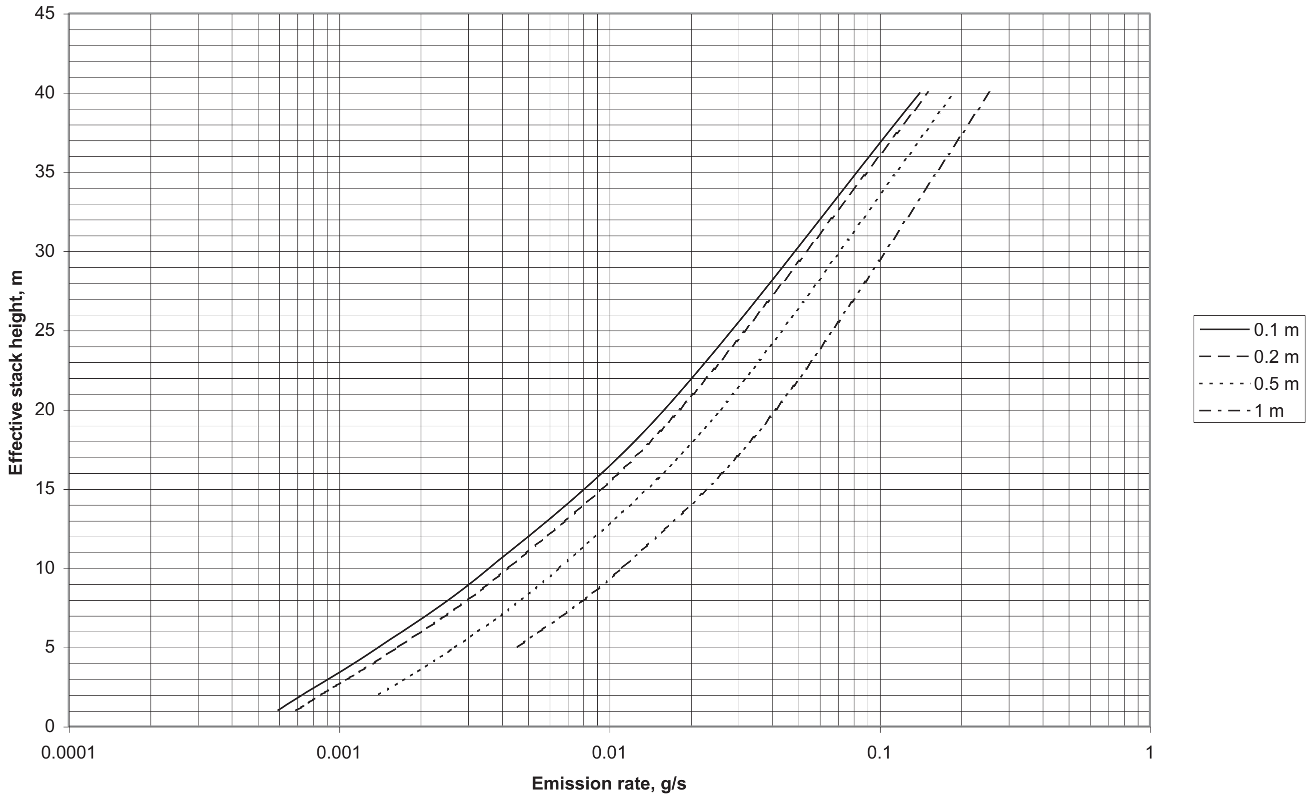


Figure 5.20: nitrogen dioxides emissions to give an annual mean ground-level nitrogen dioxides concentration of 1 μg/m³

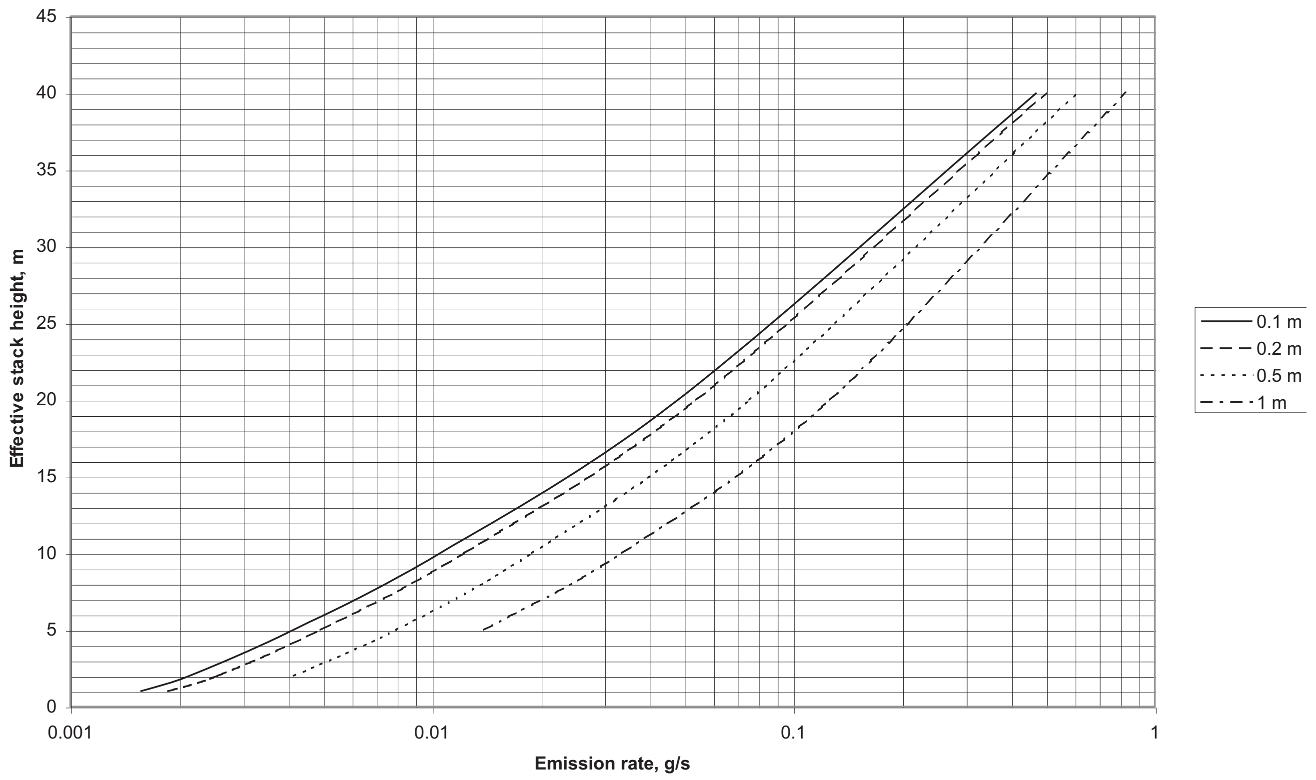


Figure 5.21: Emissions of nitrogen oxides that will give a 99.8th percentile of 1-hour nitrogen dioxide concentrations of 40 μg/m³

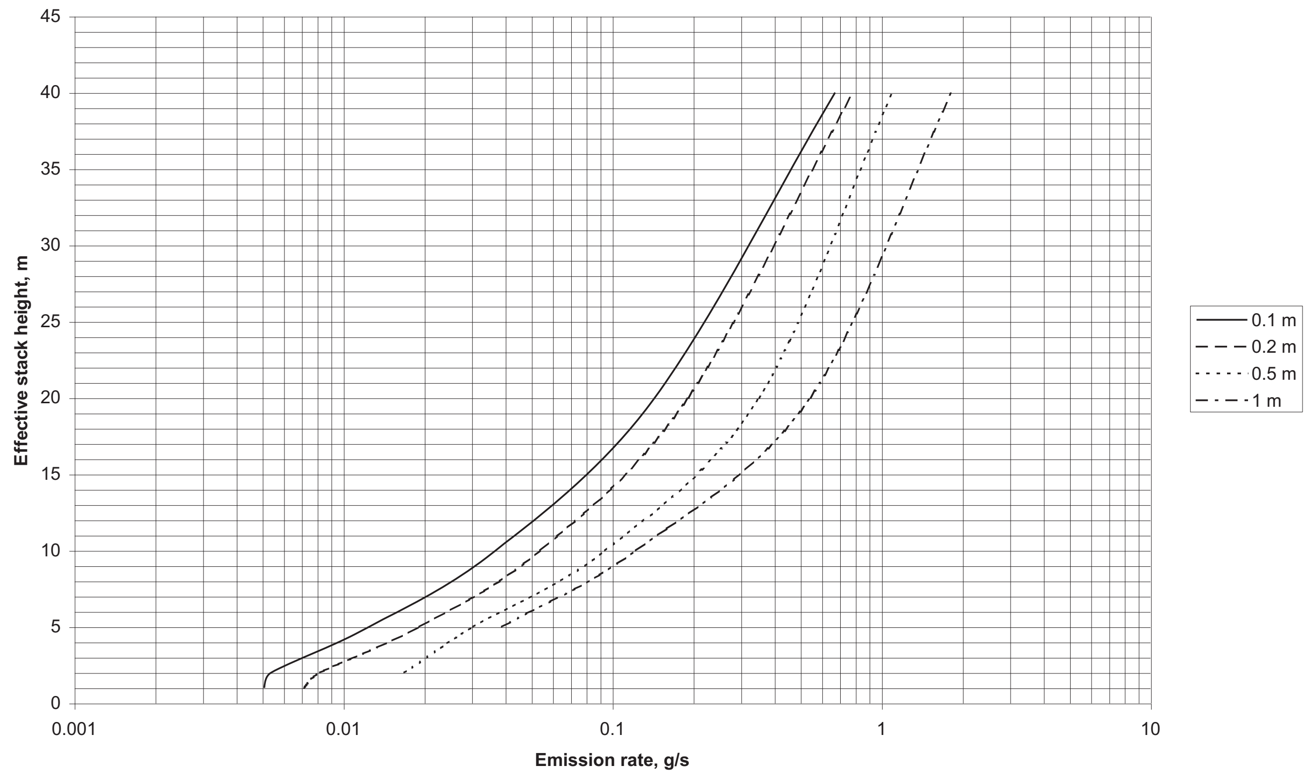


Figure 5.22: Threshold emissions density of emissions from a 500 m x 500 m area that may produce an exceedence of the daily mean objective for PM_{10}

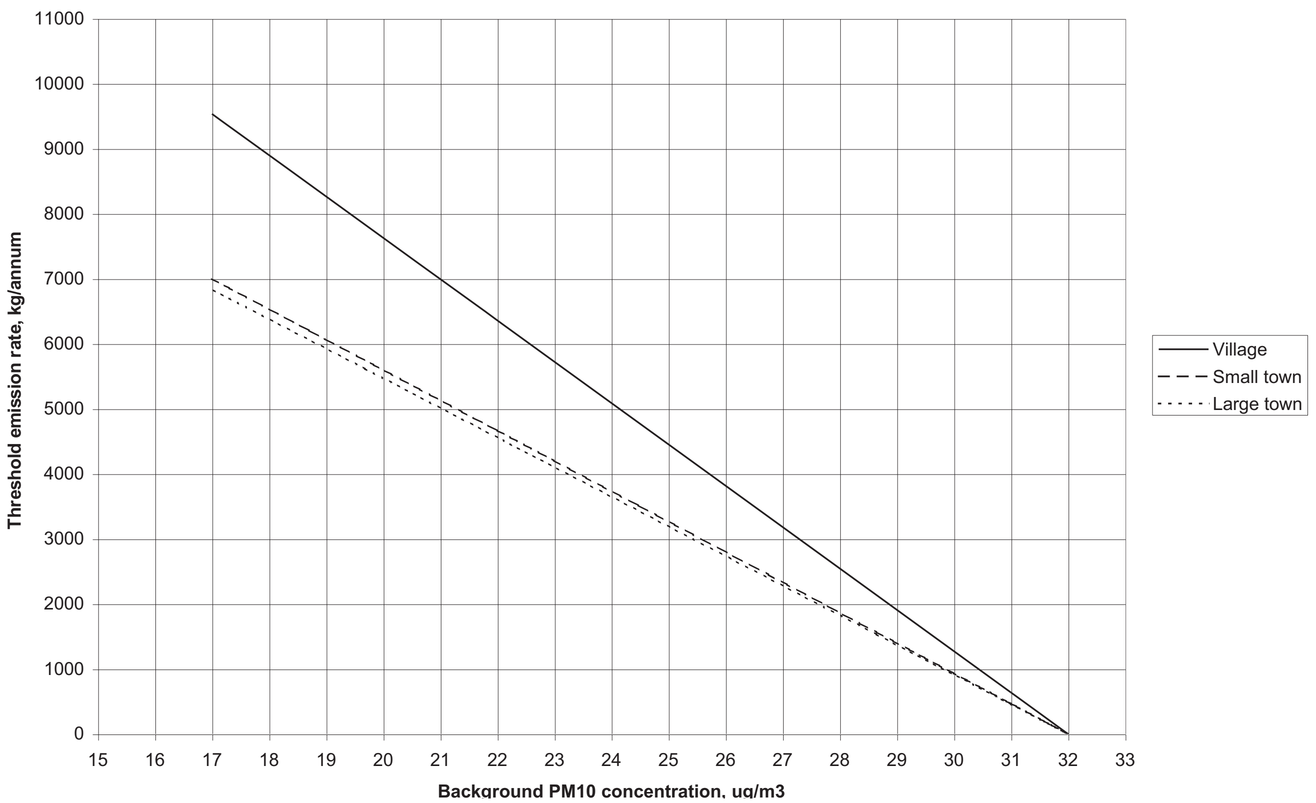
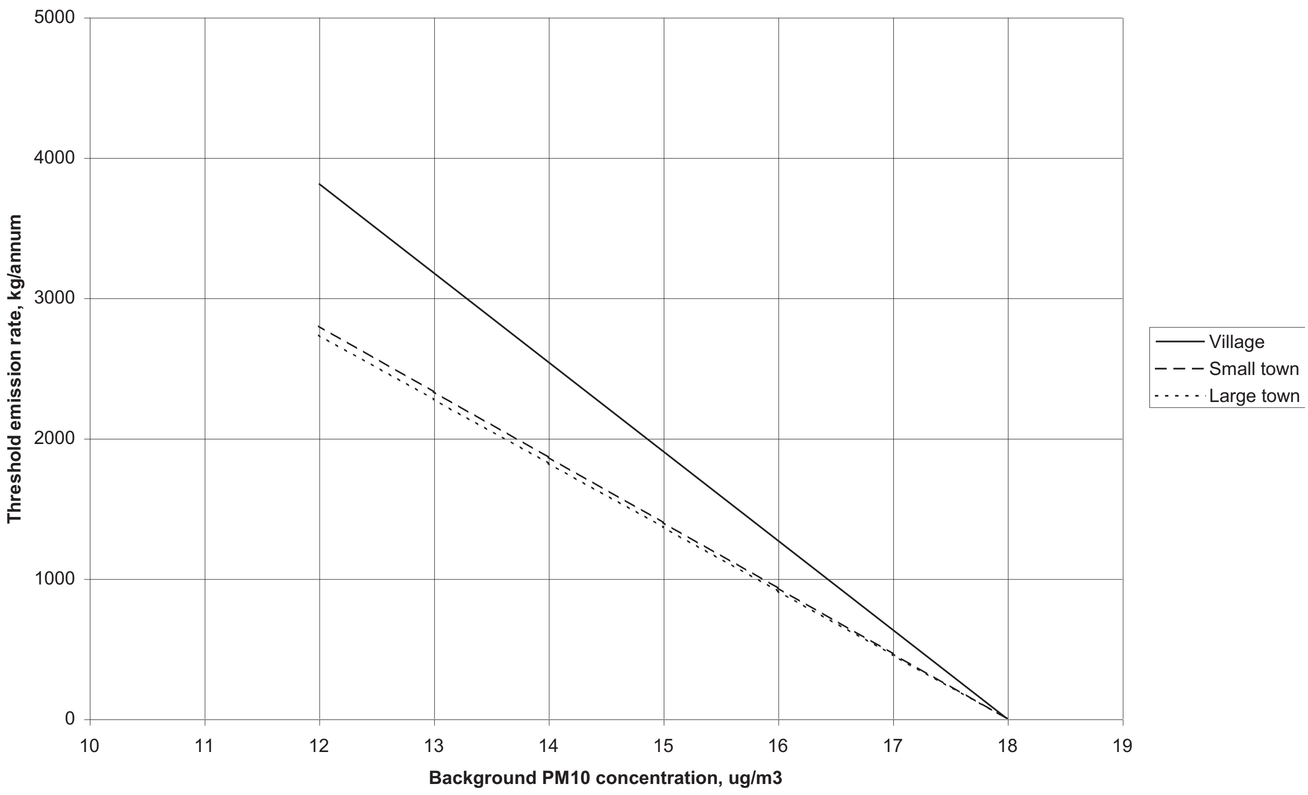


Figure 5.23: Threshold emissions density of emissions from a 500 m x 500 m area that may produce an exceedence of the annual average mean objective for PM_{10} in Scotland



CHAPTER 6: Detailed Assessments

Introduction

6.01 Where the Updating and Screening Assessment has indicated that there is a risk of the air quality objectives not being achieved, the authority will need to carry out a Detailed Assessment. A Detailed Assessment is also required in circumstances where an authority proposes to revoke or otherwise amend an existing Air Quality Management Area (AQMA).

6.02 The aim of the Detailed Assessment is to determine, with reasonable certainty, whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke/amend an AQMA. Where a likely exceedence of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent of the exceedence.

6.03 Because of the wide range of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the previous rounds of Review and Assessment have been drawn upon. It is also expected that authorities will make use of the Helpdesks (see Box 1.1).

6.04 Specific guidance related to monitoring, emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of these Annexes before commencing their work. Authorities should also check the most recent advice available on the Helpdesk websites (see Box 1.1), which is provided as answers to frequently asked questions (FAQs). Authorities are strongly encouraged to register with the Helpdesks in order to receive automatic notifications of new information and clarifications to guidance (see Para 1.15).

6.05 In undertaking the Detailed Assessment it is important to give consideration to the points of **maximum relevant public exposure** (ie, those locations where the highest concentrations are expected). It is **essential** that authorities take these potential "hot spots" into consideration within their Review and Assessment.

6.06 Authorities are also strongly encouraged to have regard to all existing sources of relevant information. For example, many planning applications for new developments are accompanied by air quality assessments. Provided that these assessments have been carried out to the standard of a Detailed Assessment (as set out below) then the authority may draw upon these conclusions within their reports. For installations that are regulated by the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), or the Northern Ireland Environment Agency (NIEA), authorities are advised to contact these agencies in the first instance to ascertain what previous studies may have been carried out.

Monitoring

6.07 As for the screening assessment, there is expected to be an increasing reliance on monitoring data as the "to be achieved by" dates of the objectives have now largely passed. In some circumstances, for example where the emissions arise from an unquantifiable fugitive source, the Detailed Assessment will need to rely predominantly on monitoring data.

6.08 Guidance on monitoring methods, monitoring strategies and suitable quality assurance and quality control (QA/QC) procedures, is set out in Chapter 3 and in further detail in Annex 1.

Modelling

6.09 For the Detailed Assessment, authorities will need to have confidence in their results. This is particularly the case where any exceedences of the objectives are solely reliant on modelled concentrations. Where exceedences are supported by measured concentrations, the modelling predictions will assist the authority to determine the geographical extent of the exceedence area, to determine the extent of the AQMA, and to estimate the population exposed to pollutant concentrations above the objectives (see Para 6.18).

6.10 Issues regarding model validation and verification are discussed in detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier or a regulatory agency (for example, United States Environmental Protection Agency (USEPA)). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

6.11 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured concentrations. Where there is a disparity between the predicted and the measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate adjustment factor that can be applied. For the Review and Assessment of road traffic and fugitive sources it is **essential** that model verification is carried out. For the Review and Assessment of point sources, verification of short-term concentrations may be more difficult to carry out. In this case, the use of an appropriate validated model will be sufficient, provided that the source emissions can be accurately quantified. However, in cases where there are local factors contributing to uncertainty, such as certain types of batch processes, complex topography etc, then local verification studies may be required, and/or an additional consideration of uncertainties taken into account.

6.12 Additional guidance related to the model verification for specific source types is set out below.

6.13 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the Review and Assessment report, and any adjustment factor applied should be **explicitly stated.**

Meteorological data

6.14 The choice of meteorological data for use in the dispersion model can affect the results. A detailed discussion on the selection of meteorological data is provided in Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In the case of annual mean concentrations, the choice of one year against another usually has only a small effect on modelled concentrations from local sources, and can largely be ignored. If possible, meteorological, background and emissions data should all be derived from the same year. Meteorological conditions generally have a more significant impact on background concentrations than local concentrations, especially in the case of particulate matter (PM), where an increase in easterly winds bringing air from northern Europe can significantly increase the background.

6.15 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years when defining exceedence areas. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc to either side of the predicted maxima, and properties lying within this arc should be considered. Where the authority decides to use multiple years (three or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

6.16 The importance of giving due consideration to potential "hot spots" has already been highlighted in Para 6.05. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. The same problem will arise in the case of models that provide concentrations averaged over a grid square. Such models are not suitable for modelling near to roads, where concentrations can fall off steeply over the first 20 m or so. A more detailed discussion on receptor spacing is provided in Annex 3.

6.17 In selecting specific receptors along roads, authorities are reminded to pay careful attention to the alignment of the road in their model[47]. Some models may describe curved sections of road as straight-line links. In some instances this may cause the distance from the road to the specific receptor to be significantly distorted (distances over the first 10 m or so from the kerbside are critical). Authorities are advised to ensure that road alignments in the model do not cause this type of problem.

Estimating population exposure

6.18 Within their Detailed Assessments local authorities are **required** to estimate the number of people exposed to pollutant concentrations above the objectives, and the maximum pollutant concentration (measured or modelled) at a relevant receptor location. This information is required to help Defra and the Devolved Administrations quantify the health benefits of improving air quality within the Local Air Quality Management (LAQM) regime.

6.19 Where the authority has modelled the area of exceedence, then this task should be relatively straightforward using Geographical Information Systems (GIS). All authorities have access to population data in GIS format for their administrative areas.

6.20 Where the exceedence area has not been modelled, for example where reliance is placed on monitoring data, then it should be possible to estimate the number of properties and hence the population exposed.

6.21 It should be noted that it is the population within the **exceedence area** that is of interest, and **not** the population within the AQMA. In many cases, authorities choose to designate the AQMA over a much wider area than the geographical extent of the exceedence.

[47] Some dispersion models allow the user to incorporate specific roadside receptors automatically, ie, to place receptors at a specified distance from the kerbside. Whilst this is an acceptable approach, authorities should document that this approach has been used, and ensure that distances used in the model are consistent with actual distances of the closest receptors to the road.

6.22 It is not feasible to take into account subtleties such as transient exposure (for example, at schools) or exposure at different heights within these assessments, and authorities should assume that the residential population is representative of exposure within the exceedence area.

Relationships between Nitrogen oxides and Nitrogen dioxide

6.23 The relationships between nitrogen oxides (NO_X) and nitrogen dioxide (NO_2) are set out within Chapter 2 of this guidance. For road traffic sources, a recommended approach, which may be used in Detailed Assessments, is described in Paras 2.22 to 2.27. The approach may also be applied for other source types within models representing wider urban areas, and where annual mean concentrations are the main focus. Other approaches, based on chemical reaction schemes are also applicable to Detailed Assessments. Where these are used, an adequate description of the methodology should be included in the report.

6.24 For the purpose of industrial and other point source emissions, where the emphasis is on the short-term objective, authorities may also use validated "chemistry modules" included in the model package to convert NO_X to NO_2. Where such modules are not available, a recommended approach is set out in Box 6.3a. Further guidance on adding industrial source contributions to the background, and the NO_X to NO_2 relationship, is provided in Annex 3.

Background concentrations

6.25 Background concentrations are an important component of models, frequently representing a larger contribution than local sources. Sometimes background concentrations are derived by modelling regional sources and adding a rural background from a monitoring station. One limitation of this approach is that there are few rural background locations, and it may be necessary to use results from a monitoring station many tens or even hundreds of kilometres from the study area. Where background concentrations are derived in this way, it is important that they are verified against local background data.

6.26 Background concentrations are more commonly taken from the national maps of background concentrations (see Chapter 2). These are available on a 1x1km grid for the whole country. It is important to use the results for the grid square in which the receptors are located. If a large area is being modelled, then it will be necessary to use different background values for different receptors. This approach to adding backgrounds is only suitable for calculating annual means. Modelled 24-hour mean concentrations, or 90th percentiles of 24-hour mean concentrations, should not be added to annual mean backgrounds, as this will give incorrect total concentrations. In these circumstances, the best approach is to use the annual mean to derive the number of exceedences of 50 $\mu g/m^3$ as a 24-hour concentration using the relationship presented in Chapter 2. The same constraint about not adding annual mean backgrounds applies to modelled 1-hour concentrations or 99.8th percentiles of 1-hour concentrations. An alternative approach is to model concentrations hour by hour and add them to the hour by hour results from an appropriate background monitoring station covering the same time period. If the local background is being modelled as well as the local source being investigated, then the results for a rural monitoring site would be used. If only the local source is being modelled then the results for a local urban background monitoring site would be used.

Road traffic sources

6.27 The Detailed Assessment of road traffic sources is likely to focus upon:

- a compilation of more detailed and accurate road traffic emissions data, including, if necessary, carrying out new traffic counts;
- a more detailed assessment of the road traffic contribution to NO_X and PM_{10} concentrations;
- a more accurate description of existing background levels; and
- additional roadside monitoring using an automatic monitor and/or an array of diffusion tubes in the case of NO_2.

6.28 Detailed guidance on how to estimate emissions and model road traffic sources is provided in Annexes 2 and 3, and includes consideration of:

- traffic patterns, variable speeds, traffic congestion;
- complex junctions;
- street canyons;
- car parks;
- bus and coach stations;
- road gradients and terrain; and
- non-exhaust PM emissions.

6.29 A number of dispersion models are suitable for the Detailed Assessment of road sources. Guidance on the use and selection of these models, and the types of input data required, is set out in Annex 3, and further advice may be sought from the Local Authority Air Quality Support Helpdesk (see Box 1.1).

6.30 The emissions of both NO_X and PM_{10} are strongly related to vehicle speeds, and it is recommended that more detailed information related to traffic flow and speeds is obtained. For example, it may prove useful to split roads up into much smaller sections, which will then allow a more accurate definition of changing vehicle speeds, for example, close to junctions. It may also prove important to take account of areas where cold-start emissions are particularly important, such as in the vicinity of long-term car parks. Emissions are also known to be affected by engine loading, for example when vehicles are climbing steep hills, and specific speeds and emission factors for these types of areas may need to be considered.

6.31 Where local traffic conditions are "unusual" (for example, streets with diesel taxis and bus-only access, heavy goods vehicles (HGVs) travelling up steep hills, etc), there may be some benefit in defining the vehicle types and operating conditions in more detail. Local emissions estimates may be refined using the methods in Annex 2, and advice may be sought from the Local Authority Air Quality Support Helpdesk (see Box 1.1).

Verification of road traffic models

6.32 As noted in Para 6.11 above, the verification of road traffic models forms an essential component of the Detailed Assessment. The verification involves a comparison between predicted and measured concentrations at one or more suitable local sites. In particular, the verification should specifically consider the predicted *versus* measured "road traffic contribution" to concentrations, so that the model performance can be adequately assessed. The process of model verification is discussed in more detail in Annex 3.

6.33 In the case of NO_2, authorities are also strongly recommended to verify their model predictions for NO_X as the initial step (see Box 6.2). This should be carried out separately for the background contribution (if modelled) and the source (ie, the road traffic contribution). Once the NO_X has been verified and adjusted as necessary, a final check should be made against the measured NO_2 concentrations.

Box 6.2: Importance of and approach to verifying modelled nitrogen dioxide concentrations from road traffic.

There are two important reasons why initial verification of the model output should be based on the source contribution to NO_X, rather than the total NO_X concentration (ie, source plus background NO_X) or the NO_2 concentration alone:

- The contribution of source NO_X to total NO_X (including the background NO_X) is often small. If the source and background NO_X values are added together, the effect will be to "smooth" the performance of the model, and any adjustment of the model output based on the verification study will be weighted towards the background assumptions.
- The annual mean NO_2: NO_X relationship is relatively flat in the principal region of interest (ie, around the 40 µg/m^3 objective). Relatively large changes in NO_X around this region may result in only small changes in predicted NO_2 levels. Once again, the effect is to "smooth" the model performance.

Example

The following example illustrates the reason why it is important to verify the modelled road contribution separately. A modelling study gives rise to an unadjusted annual mean NO_X contribution from a small road network **[$NO_{X(road)}$]** of 15 µg/m^3 at the monitoring site alongside the road. The annual mean background NO_X for this location is 60 µg/m^3, and annual mean background NO_2 is 34.5 µg/m^3. This gives rise to a calculated **total NO_2** of 39.2 µg/m^3.

The measured NO_2 concentration at the roadside monitor at the receptor location is 41.5 µg/m^3. Comparison of the predicted and measured NO_2 concentrations would indicate that the model is performing well, and under-predicting by only 6%. However, to achieve a predicted **[$NO_{X(total)}$]** concentration of 41.5 µg/m^3 requires the predicted **[$NO_{X(road)}$]** concentration to be increased from 15 to 23 µg/m^3. In reality the model is under-predicting the NO_X contribution from the road by 53%.

Non-exhaust emissions of particulate matter

6.34 The calculation of the "roadside enhancement" to the current or future background is of fundamental importance in predicting compliance with the objectives, and needs to be given detailed consideration at this stage. The roadside enhancement to PM_{10} concentrations comprises of several components:

- vehicle exhaust emissions;
- brake and tyre wear;
- entrainment ("resuspension") of material from the road surface.

6.35 Whilst vehicle exhaust emissions are confidently expected to decline in future years, emissions associated with both brake and tyre wear, and resuspension, are unlikely to reduce, unless traffic flows change substantially. These latter components will thus become more important in future years.

6.36 Brake and tyre wear emissions make a substantial contribution to road traffic PM emissions, and should be included in the assessment. Guidance on quantifying emissions from brake and tyre wear is provided in Annex 2 (Para A2.38 to A2.39).

6.37 Whilst the resuspension component is also widely considered to be significant, there are currently no conclusive data to indicate what emissions rates should be applied. For the purpose of Review and Assessment, authorities are currently advised to ignore resuspension. The Helpdesks (see Box 1.1) should be regularly checked to see whether this advice has changed.

Other transport sources

6.38 It is not considered likely that many authorities will need to proceed to a Detailed Assessment for non-road transport sources, including airports, ports and railways. Where such assessments are necessary, the authority is advised to contact the Review and Assessment Helpdesk prior to commencing the study. Some general guidance is provided below.

6.39 In all cases, it is emphasised that the road traffic emissions associated with these sources should be considered using the approaches set out in Para 6.27 to 6.38 above.

Airports

6.40 Only a limited number of airports in the UK operate at capacities above 10 million passengers per annum (mppa), which is the criterion set in Chapter 5. Where these airports do exist, air quality assessment reports will usually be available from the operator that take into account both monitoring and modelling data. There should therefore be no requirement for the authority to undertake any extensive additional work, beyond citing the conclusions of these previous assessments, once the authority has satisfied itself that appropriate methods have been used to carry out the assessment.

Shipping

6.41 Those authorities proceeding to a Detailed Assessment for shipping will need to calculate emissions arising from shipping movements. These emissions may then be input into an appropriate dispersion model.

6.42 The method used to determine ship emissions will vary considerably according to the data available. The port authority may be able to provide the necessary data on shipping movements at the port. Alternatively the Department for Transport Maritime Statistics has publicly available basic data or Lloyds Marine Intelligence Unit holds a database of very detailed information on ship movements, which is commercially available. Further details of these sources are provided in Annex 2.

6.43 Further information and detailed emission factors may be obtained from the European MEET or Entec studies detailed in Annex 2. A suggested outline of the steps that should be considered in creating an inventory of ship emissions are provided below. All the relationships and emissions factors necessary to follow these steps are provided in the MEET or Entec references.

- Determine the weight and type of cargo for each ship movement;
- Calculate the fuel consumption for each ship (dependent on ship type, ie, liquid bulk, solid bulk, general cargo, tugs etc) assuming engines are running at full power;
- Calculate the fuel consumption for each mode (ie, cruising, manoeuvring, hotelling, tanker offloading) for each ship using the fraction of maximum fuel consumption figures;
- Calculate the emissions from the auxiliary engines used during hotelling according to the power rating and percentage load;
- Calculate the emissions (determined from engine type) in each mode, for each ship, from the emissions factors (per ton of fuel used); and then
- Determine the overall emissions by combining the above emission factors with information on the time each ship spends in each mode.

6.44 If the port specific data available are not sufficient to consider the emissions in such detail, both the Entec and MEET reports contain average surveyed data on factors such as ship types, fuel consumption and time spent manoeuvring, hotelling and cruising etc. This information could be combined with the port-specific data to give an approximation of the emissions.

Railways

6.45 Those authorities proceeding to a Detailed Assessment for railways will need to calculate emissions arising from the locomotive(s). These emissions may then be input into a suitable dispersion model.

6.46 For coal-fired locomotives, information will be required on the sulphur content of coal and the amount used over a period of time. An estimate of efflux parameters is also required for dispersion modelling purposes.

6.47 In the case of diesel locomotives, information is available on emissions for different categories: freight, intercity and regional, within the National Atmospheric Emissions Inventory (NAEI) under the "Railways" category. It is based on the gas-oil consumption rates for moving locomotives. Information on emissions from stationary locomotives is harder to come by and the authority is advised to contact the Local Authority Air Quality Support Helpdesk (see Box 1.1).

6.48 Additional information on emissions and emission factors for locomotives is provided in Annex 2.

Domestic solid-fuel use

6.49 The Detailed Assessment of domestic solid-fuel use is likely to focus upon:

- an assessment of solid fuel use in the area to determine emissions;
- the application of detailed dispersion modelling; and
- local monitoring to confirm existing concentrations.

6.50 As a first step, it is recommended that authorities should undertake a Detailed Assessment of solid-fuel use within the area of concern, characterising the different fuels and combustion methods used in order to quantify more accurately the emissions. Guidance on emissions calculations is given in Annex 2, and additional advice may be obtained from the Local Authority Air Quality Support Helpdesk (see Box 1.1). These data may then be input to a suitable air quality dispersion model, in order to predict concentrations across the area of interest. Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Local Authority Air Quality Support Helpdesk (see Box 1.1).

6.51 In the absence of local monitoring data of suitable quality, it is recommended that a monitoring programme is carried out to provide a more accurate definition of current sulphur dioxide (SO_2) and/or PM_{10} concentrations in the area of concern. It is suggested that monitoring equipment is sited at relevant locations, where concentrations are expected to be highest. Ideally, monitoring should be carried out for a period of 12 months, although six winter months may also be suitable. As a minimum, the monitoring should cover the main solid fuel burning season, for example, November to February. It is not possible though to adjust such shorter periods to provide an estimate of concentrations over an annual period, using nearby monitoring sites that are not affected by domestic solid fuel use.

Industrial emissions

6.52 The Detailed Assessment associated with industrial installations is likely to focus upon:

- the quantification of the emissions;
- the application of detailed dispersion modelling; and
- the use of more detailed local monitoring to confirm existing concentrations.

6.53 There are a variety of dispersion models which can be used to assess the impact of emissions arising from elevated point sources (stacks), and other sources such as storage tanks etc. Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Local Authority Air Quality Support Helpdesk (see Box 1.1). Authorities are advised to consider the following issues:

- Accurate description of emissions – many installations operate well within their emissions limits, and actual emissions data should be used if at all possible. For certain types of installation, both seasonal and daily variations in emissions are significant, and should be considered wherever possible and input into the model;
- Elevated point sources will have little impact upon the annual mean concentration, and the assessment should focus upon an accurate prediction of the shorter-term (15-minute, 1-hour and 24-hour mean concentrations). The modelling approach should therefore ideally seek to predict hour-by-hour or day-by-day ground-level concentrations arising from the stack(s), which will then be added to suitable sequential hourly or daily background concentrations. Where this is not possible or practicable, alternative approaches to adding industrial installation and background contributions are summarised in Boxes 6.3a-c, and further detail is given in Annex 3.
- Where necessary, the modelling will need to take account of building downwash and/or local topography.

Box 6.3a: Approaches to adding industrial installation contributions to the background

Nitrogen dioxide

For the purposes of predicting NO_2 concentrations due to point sources the following approach is recommended in the first instance. Where this approach suggests that the predicted increase in the 99.8%ile above the background is more than 75% of the available headroom (the difference between the objective and background), then a more detailed approach will be required (see Annex 3):

The 99.8%ile of total NO_2 is equal to the ***minimum*** of either equation A or B:

A) 99.8%ile hourly background total oxidant + 0.05 x (99.8%ile process contribution NO_X). (Note: Table 5.1 gives the 99.8th percentile values of (ozone(O_3) + NO_2) at all national network sites in 2004, 2005 and 2006); or

B) the maximum of either:
B1) 99.8%ile installation contribution of NO_X + 2 x (annual mean background NO_2); or
B2) 99.8%ile hourly background NO_2 + 2 x (annual mean installation contribution of NO_X):

In equation A, the total oxidant is the sum of O_3 and NO_2 (as NO_2 equivalents) and should be based on summing the hour by hour concentrations from a suitable background monitoring site in order to derive the 99.8%ile.

Box 6.3b: Approaches to adding industrial installation contributions to the background

PM_{10}

For the purposes of predicting PM_{10} concentrations due to point sources the following approach is recommended in the first instance. Where this approach suggests that the predicted increase in the 98.1%ile above the background is more than 50% of the available headroom (the difference between the objective and background), then a more detailed approach will be required (see Annex 3):

- The 90.4%ile total 24-hour mean PM_{10} is equal to the maximum of either equation A or B below;
  A) 90.4%ile 24-hour mean background PM_{10} + annual mean installation contribution PM_{10}; or
  B) 90.4%ile 24-hour mean installation contribution + annual mean background PM_{10}
- The 98.1%ile total 24-hour mean PM_{10} (Scotland only) is equal to the maximum of either equation A or B below:
  A) 98.1%ile 24-hour mean background PM_{10} + (2 x annual mean installation contribution PM_{10}); or
  B) 98.1%ile 24-hour mean installation contribution + (2 x annual mean background PM_{10}).

Box 6.3c: Approaches to adding industrial installation contributions to the background

Sulphur dioxide

For the purposes of predicting SO_2 concentrations due to point sources the following approach is recommended in the first instance. Where this approach suggests that the concentrations exceed 75% (for example, if the total predicted 99.9%ile of 15-minute mean SO_2 concentrations is great than 200 µg/m^3) of the air quality objectives a more detailed approach will be required (see Annex 3):

- The 99.9%ile of total 15-minute mean SO_2 is equal to the ***maximum*** of either equation A or B below:
  A) 99.9%ile 15-minute mean background SO_2 + (2 x annual mean installation contribution SO_2); or
  B) 99.9% 15-minute mean installation contribution SO_2 + (2 x annual mean background contribution SO_2)
- The 99.73%ile of total 1-hour SO_2 is equal to the maximum of either equation A or B below;
  A) 99.73%ile hourly background SO_2 + (2 x annual mean installation contribution SO_2); or
  B) 99.73% hourly installation contribution SO_2 + (2 x annual mean background contribution SO_2)
- The 99.18%ile of total 24-hour mean SO_2 is equal to the maximum of either equation A or B below;
  A) 99.18%ile 24-hour mean background SO_2 + (2 x annual mean installation contribution SO_2); or
  B) 99.18% 24-hour installation contribution SO_2 + (2 x annual mean background contribution SO_2)

Poultry farms

6.54 Detailed Assessments for poultry farms are likely to be based on both monitoring and modelling studies. In many cases a suitable monitoring programme will need to be established to determine the impact of these sources. In addition to the general points set out in Paras 6.07 and 6.08 above, the following points should be borne in mind:

- Monitoring should be undertaken at relevant locations. Careful consideration should be given to the siting of monitors in relation to the emission source;
- Monitoring should focus upon those relevant locations where exposure to pollutant emissions is likely to be highest (generally downwind from the source, based on the prevailing wind direction);
- Ideally monitoring should be carried out for a period of at least 12 months. Where this is not possible, it is recommended that measurements should be carried out over the period when emissions are likely to be highest;
- In all cases, authorities are advised to compare the results of local monitoring programmes with data from national network sites, to assist with the interpretation of findings. This will focus on separating out regional episodes, to help identify the local impacts from the poultry farm.

6.55 Quantifying the PM_{10} emissions arising from a poultry farm is not straightforward. Where authorities need to quantify these emissions for input to a dispersion model, they are advised to contact the relevant regulatory authority and/or the Local Authority Air Quality Support Helpdesk (see Box 1.1).

Biomass boilers

6.56 Detailed Assessments for biomass boilers should treat these sources as any other industrial point-source emission, and the procedures set out in Paras 6.52 to 6.53 above should be used.

6.57 Wherever possible, authorities should seek to quantify emissions for the actual appliance in use, rather than using default factors. If necessary, authorities should contact the Local Authority Air Quality Support Helpdesk for advice (see Box 1.1).

Uncontrolled and fugitive emissions

6.58 Due to the uncertainties associated with defining emissions from uncontrolled and fugitive sources, it is likely that the Detailed Assessment will need to focus upon a detailed monitoring programme. Whilst emission factors are available for a variety of fugitive sources, for example those published within the *Compilation of Air Pollution Emission Factors (USEPA-42),* these factors are subject to a variable degree of uncertainty and frequently require default assumptions to be made. Their principal application lies in allowing predictions to be made for the impact of operations which are currently not in existence, or which are expected to undergo significant change in the future. If applicable, guidance on emissions data and dispersion models may be sought from the Local Authority Air Quality Support Helpdesk (see Box 1.1).

6.59 In many cases a suitable monitoring programme will need to be established to determine the impact of these uncontrolled sources. In addition to those issues discussed in Paras 6.07 and 6.08 above, the following points should be borne in mind:

- Monitoring should be undertaken at relevant locations. Careful consideration should be given to the siting of monitors in relation to the emission source(s);
- Monitoring should focus upon those relevant locations where exposure to pollutant emissions is likely to be highest (generally downwind from the source, based on the prevailing wind direction);
- Ideally monitoring should be carried out for a period of at least 12 months. Where this is not possible, it is recommended that measurements should be carried out over the period when emissions are likely to be highest;
- In all cases, authorities are advised to compare the results of local monitoring programmes with data from national network sites, to assist with the interpretation of findings. This will focus on separating out regional episodes, to help identify the local impacts from the fugitive source(s).

6.60 Where monitoring indicates that the objectives are likely to be exceeded, then it may be helpful to refine the monitoring strategy, in order to more clearly identify the source contributions. In such cases, authorities may find it useful to:

- Undertake monitoring of wind speed and direction to assist with the interpretation of results and any reported exceedences;
- Carry out monitoring at several locations, including an upwind site. This will allow a more accurate assessment of the contributions of the different sources to the measured values. Alternatively, “directional” monitoring equipment (which allows measurements to be collected only within a pre-defined wind direction) can be employed;
- Consider the use of various speciation and chemical analysis methods to assess the source contribution to the measured values.

CHAPTER 7: Further Assessments

Introduction

7.01 Section 84(1) of the Environment Act, and Part 3 of the Environment (Northern Ireland) Order 2002, requires authorities to complete a Further Assessment within 12 months of designating an Air Quality Management Area (AQMA). The main purpose of the Further Assessment is to provide authorities with an opportunity to supplement the information they have already gathered from their earlier Review and Assessment work.

7.02 The Further Assessment is intended to allow authorities to:

- confirm their original assessment, and thus ensure they were correct to designate an AQMA in the first place;
- calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA;
- refine their knowledge of sources of pollution, so that the air quality Action Plan may be appropriately targeted;
- take account of any new guidance issued by Defra and the Devolved Administrations, or any new policy developments that may have come to light since declaration of the AQMA;
- take account of any new local developments that were not fully considered within the earlier Review and Assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc, that were not committed or known of at the time of preparing the Detailed Assessment;
- Carry out additional monitoring to support the conclusion to declare the AQMA; Corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way; and
- Respond to any comments made by statutory consultees in respect of the Detailed Assessment.

What is required for the Further Assessment?

7.03 The Further Assessment is not intended to place an unnecessary burden on local authorities, but it is a statutory requirement and must be completed. In many cases it is envisaged that authorities will have completed a substantial part of the necessary work for the Further Assessment during the course of the Detailed Assessment and/or in the preparation of their Action Plans. Where this is the case, the authority is not expected to repeat the work, but is advised to simply reproduce or appropriately summarise and reference what has been done. The authority will, nevertheless, be expected to make a clear statement regarding each of the issues set out in Para 7.02, indicating that the relevant work has been completed within another report, and justifying why this work is relevant and does not need updating.

7.04 In some cases, the AQMA declaration may have been based upon a relatively short period of monitoring (adjusted to a calendar year using the procedures set out in Chapter 3). In other cases, the modelling assessment may have identified exceedence areas where monitoring data were limited. In either case, the Further Assessment represents an ideal opportunity for authorities to collect additional monitoring data to improve confidence in the declaration and geographical extent of the AQMA.

7.05 The Detailed Assessment is also likely to have been founded on many assumptions, for example traffic flows, speeds and vehicle mix on particular sections of roads, in some cases based on traffic models. The Further Assessment provides an opportunity to explore these assumptions, to make sure they are as accurate and as up to date as possible. This may include commissioning traffic counts to provide a better understanding of local emissions from traffic, and to improve modelling.

7.06 Wherever additional monitoring and/or modelling work is carried out, it is expected that this will conform to the same standards as those defined in Chapter 6 for the Detailed Assessment.

7.07 National and local policy developments may also have a bearing on AQMA declarations. At a national level, any specific developments or changes that impact on the Review and Assessment process will be reflected in FAQs posted onto the Helpdesk websites (see Box 1.1). Local authorities are therefore advised to register with the Helpdesks (thus ensuring they are automatically kept up to date with new information) or to check frequently as to whether new FAQs have been posted. At the local level, there may be changes to policies or plans, the granting or refusal of particular developments, or significant changes to local pollution sources such as the implementation of traffic management schemes or local industrial operations, which were not known or confirmed at the time of the Detailed Assessment. Where appropriate, these changes should be taken into account within the Further Assessment.

Link to Action Plan development

7.08 Defra and the Devolved Administrations envisage a close link between the preparation of the Further Assessment and the Action Plan, and expect that these would normally be taken forward in parallel following the declaration of the AQMA.

7.09 Work carried out within the Further Assessment will allow authorities to identify the extent to which different sources contribute to the air quality exceedences that have been identified i.e. by means of baseline "source apportionment". This will assist authorities to correctly target the most important sources, and to focus the principal measures within the Action Plan. The Further Assessment should also identify the reduction in pollutant emissions that is required to attain the objectives; this will assist authorities in identifying the scale of emissions reduction that needs to be addressed within the Action Plan.

7.10 The outcome of the Further Assessment can also be used to investigate the air quality effects of particular policy measures, ie how implementing measures would influence the baseline source apportionment. For example, the implementation of a local traffic management scheme etc would potentially reduce the contribution of one or more types of vehicle. This will assist authorities when preparing their Action Plans to show that they have adequately considered a range of measures, and have evaluated the cost-effectiveness and proportionality of their chosen approach. If this information is not reported within the Further Assessment it should be included within the Action Plan, together with the information on cost effectiveness of the measures considered.

Source apportionment

7.11 Source apportionment need not be carried out with absolute precision, but should be detailed enough to allow the authority to identify the predominant sources that contribute the air quality exceedences within its AQMA. An important initial separation, in most cases, will be into:

- **regional background**, which the authority is unable to influence;
- **local background**, which the authority should have some influence over;
- **local sources**, which will add to the background to give rise to the hotspot area of exceedences. These will be the principal sources for the local authority to control within the Action Plan.

7.12 Since the Action Plan will propose to influence emissions from local sources, it will also be important to separate these sources into:

- Stationary sources (if relevant) potentially dealing with each source separately;
- Vehicle type potentially split among cars, vans and lorries, taxis and buses and coaches. Potentially split by age or according to local or through traffic if these are significant issues;
- Vehicle emissions split between moving and stationary traffic, if congestion is a significant issue;
- Other relevant factors such a road gradients that give rise to excess emissions if these are significant.

7.13 Local authorities should rely on their local knowledge and exercise their judgment to identify significant factors related to local source emissions. They should then take steps to obtain available data that describe these factors and that can be used in the Further Assessment. For example, the AADT for links in the AQMA split by vehicle type, the age profile of bus fleets or the average queuing time and queue lengths at congested junctions.

7.14 The definition of regional and local background is a straightforward exercise using the national maps, by considering the different sector contributions as defined in Paras 2.06 and 2.07.

7.15 The preferred approach to apportionment of local sources is to use dispersion modelling, using the model to independently predict pollutant concentrations from each source in turn. Once a dispersion model has been set up, this is a relatively straightforward task to undertake. The results may be presented at a number of identified receptor locations, or as concentration isopleths.

7.16 Where a detailed modelling approach is not feasible, source apportionment may be undertaken using a simple spreadsheet approach. For example, where road traffic emissions are the principal concern, the percentage contribution to total nitrogen oxides (NO_X) emissions may be calculated using the appropriate emission factors. The level of detail will be dependant upon the road traffic data that are available.

7.17 Authorities are encouraged to consider an appropriate level of detail within the source apportionment study. For example, it may be appropriate to separately consider buses and Heavy Goods Vehicles (HGVs) within the assessment, if there is evidence to suggest that one or the other is having a disproportionate effect along a given stretch of road. Once again, this will provide useful evidence to support the proposed measures within the Action Plan. Without such evidence there is a risk that the Action Plan will be disproportionate in addressing emissions.

7.18 Apportionment for nitrogen dioxide (NO_2) is not as straightforward, due to the non-linear relationship between the emissions of NO_2 and NO_X. This is additionally complicated by the different proportions of NO_2 in the NO_X emission for different sources, for example, petrol cars or diesel cars.

7.19 The following advice therefore applies to NO_2 source apportionment:

- **background** contributions: the national maps will give the total background NO_2 concentration. This should be apportioned to regional and local background using the ratio of the background NO_X concentrations attributable to these two sources, which are also available in the national maps;
- **local** contributions: the local contribution to NO_2 is the difference between the total (measured or modelled) NO_2 and the total background NO_2. This is then apportioned to the local sources, for example, buses, HGVs, taxis, cars, using the relative contributions of these sources to the local NO_X concentration.

7.20 An example of how to carry out apportionment for NO_2 is set out in Box 7.1. Further examples are provided in Annex 3.

Required reduction in pollutant emissions

7.21 The required reduction in pollutant emissions to attain the objectives will allow the authority to judge the scale of effort that is required within the Action Plan.

7.22 In theory, this should be a simple calculation that can be derived from the Detailed Assessment by comparison of the objective with the maximum predicted pollutant concentration. Within the Further Assessment, authorities should confirm that the earlier assessment work had identified the locations at which the highest pollutant concentrations would occur (taking into account relevant exposure as set out in Box 1.1). It is also helpful to set out the reductions that would be required across several locations, so that the appropriate context is set.

7.23 In the case of NO_2 alongside roads, the required reduction should be stated as the $\mu g/m^3$ reduction in the NO_2 concentration, for example, a 5 $\mu g/m^3$ reduction from 45 to 40 $\mu g/m^3$. However, the required percentage reductions of local emissions should be expressed in terms of NO_X due to the local road traffic. This is because the primary emission is of NO_X and there is a non-linear relationship between NO_X concentrations and NO_2 concentrations.

7.24 Calculation of the NO_X reduction requires the current "road NO_X" concentration (*road NO_X-current*) to be calculated, ie, the difference between total NO_X (calculated or measured) and local background NO_X. The next step is to calculate the road NO_X concentration required to give a total NO_2 concentration of 40 $\mu g/m^3$ (*road NO_X-required*). This can be done using the NO_2 from NO_X calculator (see Paras 2.22-2.27), by entering a total NO_2 concentration of 40 $\mu g/m^3$, along with the local background NO_2 concentration. The ratio of "*road NO_X-required*" to "*road NO_X-current*" gives the required percentage reduction in local road NO_X emissions to achieve the objective. An example is presented in Box 7.2. Help with these calculations can be obtained from the Local Authority Air Quality Support Helpdesk (see Box 1.1).

Box 7.1: Example of source apportionment for nitrogen dioxide

The following is provided as an example of a source apportionment for NO_2 in a hot-spot near to a busy road. The highest annual mean NO_2 concentration **[T-NO_2]** at a relevant receptor, obtained from use of a verified model or from monitoring is **46 μg/m³**.

Step 1: From the national maps of background annual mean concentrations obtain the total background NO_2 for the grid square within which the hot-spot is located **[TB-NO_2] = 28 μg/m³** also the total background NO_X **[TB-NO_X] = 45 μg/m³** and regional background NO_X **[RB-NO_X] = 25 μg/m³.** From the total and regional background NO_X derive a local background NO_X:

[LB-NO_X] = [TB-NO_X] – [RB-NO_X] **= 20 μg/m³**

Step 2: Apportion the total background NO_2 into regional and local using the regional and local NO_X proportions:

[RB-NO_2] = [TB-NO_2] x ([RB-NO_X] / [TB-NO_X]) **= 15.6 μg/m³**

[LB-NO_2] = [TB-NO_2] x ([LB-NO_X] / [TB-NO_X]) **= 12.4 μg/m³**

Step 3: Calculate the local NO_2 contribution at the worst-case location **[L-NO_2]** from the total measured minus background:

[L-NO_2] = [T-NO_2] – [TB-NO_2] **= 18 μg/m³**

Step 4: Apportion the local contributions to total NO_2 concentration using the model concentrations or emission results for NO_X (see text for methodologies for this). In this example, it is shown that 44% of the NO_X at the worst-case relevant is from vans and lorries, 22% from buses and 34% from cars.

NO_2 vans and lorries = 44% x [L-NO_2] **= 7.9 μg/m³**

NO_2 buses = 22% x [L-NO_2] **= 4.0 μg/m³**

NO_2 cars = 34% x [L-NO_2] **= 6.1 μg/m³**

The final source apportionment of the worst-case NO_2 46 μg/m³ is thus

Regional background	**15.6 μg/m³ (34%)**
Local background	**12.4 μg/m³ (27%)**
Local traffic – vans and lorries	**7.9 μg/m³ (17%)**
buses	**4.0 μg/m³ (9%)**
cars	**6.1 μg/m³ (13%)**

By what date will the objectives be met?

7.25 As part of the Further Assessment, authorities should also provide an indication of the date by which the objectives are expected to be met. This can be achieved by adjusting monitoring data, using the approach described in Paras 2.10 – 2.14, or by modelling for future years.

Box 7.2: Example of calculated reduction in road nitrogen oxides emissions

The following is provided as an example of how to calculate the reduction in road NO_X emission required to meet the 40 µg/m^3 annual mean objective for NO_2. The measured or modelled NO_2 at the worst-case relevant exposure location is 45 µg/m^3. It is based on the required reduction in the road NO_X concentration at the worst-case relevant exposure location.

Step 1 Use the NO_X from NO_2 calculator (see Paras 2.22-2.27) to obtain the NO_X concentration that equates to the 45 µg/m^3 NO_2, which in this example is 99.0 µg/m^3.

Step 2 Obtain the local background concentrations of NO_X and NO_2 for the year of interest. For this example these are 39.8 and 28.8 µg/m^3 respectively, from the background maps (see Paras 2.02-2.09).

Step 3 Calculate the current "road NO_X" concentration (*road NO_X-current*), ie, the difference between total NO_X (calculated or measured) and local background NO_X. In this example *road NO_X-current* will be 59.2 µg/m^3 (99.0 minus 39.8 µg/m^3).

Step 4 Calculate the road NO_X concentration required to give a total NO_2 concentration of 40 µg/m^3 (*road NO_X-required*). This can be done using the NO_2 from NO_X calculator (see Paras 2.22-2.27) by entering a total NO_2 concentration of 40 µg/m^3 along with the local background NO_2 concentration. This gives the total NO_X concentration, from which the background NO_X concentration can be subtracted to give the *road NO_X-required*. In this example the *road NO_X-required* is 44.3 µg/m^3 (84.1 minus 39.8 µg/m^3).

Step 5 Calculate the road NO_X reduction to go from the *road NO_X-current* to the *road NO_X-required*. In this example the road NO_X reduction required is 54.7 µg/m^3 (99.0 minus 44.3 µg/m^3), which represents a 55% reduction in road NO_X (54.7/99.0 as a percentage).

Annex 1: Monitoring

Introduction

A1.01 This section describes monitoring procedures that can be used for the following pollutants covered by the original Air Quality Strategy for England, Scotland, Wales and Northern Ireland[48], and its 2007 update[49]:

- Carbon monoxide (CO)
- Benzene (C_6H_6)
- 1,3-butadiene ($CH_2CHCHCH_2$)
- Lead (Pb)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Particulate matter (PM_{10})

Whilst there is no obligation on local authorities to measure $PM_{2.5}$ concentrations, it is recognised that many authorities are currently undertaking, or are planning to undertake such monitoring, and informal advice is also provided.

A1.02 A summary of the main points to consider when setting up and operating a monitoring programme is given in this Annex. Further information is available from the Local Authority Air Quality Support Helpdesk, contact details as follows:

- telephone 0870 190 6050
- e-mail lasupport@aeat.co.uk
- web pages www.laqmsupport.org.uk/index.php

or via the Local Air Quality Management (LAQM) section of the Air Quality Archive web site at www.airquality.co.uk. Answers to Frequently Asked Questions (FAQs) on monitoring can also be viewed on the above websites.

A1.03 Monitoring fulfils a central role in the Review and Assessment process, providing the necessary sound scientific basis for assessment of compliance with the objectives of the Air Quality Strategy. Monitoring can assist in demonstrating whether or not there is a significant risk of a prescribed Air Quality Strategy objective being exceeded in a relevant location, enabling Air Quality Management Areas to be identified, and appropriate action taken.

A1.04 If monitoring is already being undertaken it is essential to establish whether the existing monitoring is sufficient for Review and Assessment purposes, or whether additional monitoring is necessary:

- Is the existing monitoring adequate – is it being made over a suitable time period and at the right location – and is the data capture sufficient?
- Are the methods and quality assurance and quality control (QA/QC) procedures adequate?

A1.05 Measurements made for the purpose of Review and Assessment often need to be used in conjunction with other objective assessment techniques. In particular, monitoring will be required to verify and calibrate air quality models to ensure that they are producing accurate and reliable estimates of pollutant concentrations. It is therefore crucial that monitoring is carried out as accurately as possible.

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[48] The Air Quality Strategy for England, Wales and Northern Ireland: CM 4548, HMSO Publications, 2000

[49] Defra: Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 17 July 2007, Cm 7169 NIA 61/06-07, PB 12654.

Overview of air pollution monitoring methods

A1.06 Air pollution monitoring methods can be divided into five main types, covering a wide range of costs and performance levels. The methods and their relative merits are shown in Table A1.1 and discussed in the following section. The use of a particular type of monitoring equipment may need to be justified in Review and Assessment reports and therefore should be chosen appropriately.

Table A1.1 Equipment available for Air Quality Monitoring

Method	Advantages	Disadvantages
Passive Sampling	Low cost – simple. Useful for Updating and Screening Assessment studies, and to supplement automatic monitoring for Detailed Assessments.	Indicative measurements only – inferior precision and accuracy to automatic methods. Laboratory analysis required. In general, only provide weekly or longer averages.
Photochemical and optical sensor systems	Can be used portably.	Sensitivity can be low. May only provide spot measurements.
Active (Semi-automatic) Sampling	Low cost – relatively easy to operate (although care must be taken with filter handling and conditioning).	Usually only provide daily averages. Some methods are labour intensive. Filter conditioning and weighing may be required. Laboratory analysis may be required.
Automatic Point Monitoring	Provide high resolution data. On-line data collection possible.	Relatively expensive. Trained operator required. Regular calibration required. Regular service and maintenance costs.
Remote Optical/Long-Path Monitoring	Provide path or range-resolved data. Useful near sources. Multi-component measurements possible.	Relatively expensive Trained operator required Regular calibration required. Data not readily comparable with point measurements.

A1.07 Since monitoring instrumentation covers a wide range of capital and running costs, it is usually advisable to choose the simplest method available to meet the specified monitoring objectives. Many baseline monitoring, spatial screening and indicative surveys can be served perfectly well by inexpensive passive or indicative sampling methods. Only proven and generally accepted measurement methods should be considered.

A1.08 ***Passive sampling methods (such as diffusion tubes)*** – These are simple, single-use sampling devices that absorb the pollutant directly from the ambient air and need no power supply. They are exposed at the monitoring location for a period of days or weeks, before being analysed by a laboratory. They are a simple and cost-effective ***indicative*** method of monitoring air quality in an area, to give a good general indication of average pollution concentrations. They are, therefore, particularly useful for assessment against annual mean objectives. The low cost per tube permits sampling at a number of points in the area of interest; this is useful in highlighting "hotspots" of high concentrations, such as alongside major roads. They are less useful for monitoring around point sources or near to industrial locations where greater temporal resolution is required for particular objectives. Diffusion tube surveys are simple to undertake and minimal operator training is required. Diffusion tubes are available for the following pollutants in the Air Quality Strategy:

- NO_2
- "BTEX" hydrocarbons, ie, benzene, toluene, ethylbenzene and xylenes.
- 1,3-butadiene
- SO_2 *(but these are unsuitable for Review and Assessment purposes.)*

A1.09 The tubes must be analysed by a laboratory that can offer suitable quality assurance and quality control measures to ensure the results meet the data quality objectives defined for the method. It is important to note that diffusive samplers are only considered an indicative method, and do not provide the same level of precision and accuracy as more expensive automatic methods. Another limitation is that diffusion tubes for NO_2 frequently exhibit "bias" (under-read or over-read compared to the reference method). When using NO_2 diffusion tubes for review and ssessment, it is important that any such bias is quantified, and the measured annual mean corrected if necessary. Details of QA/QC for diffusion tubes are provided in sections A1.181 – A1.211 of this annex.

A1.10 ***Active (semi-automatic) sampler methods*** – These methods collect pollutant samples either by physical or chemical means for subsequent analysis in a laboratory. Typically, a known volume of air is pumped through a collector such as a filter, absorbent or reagent solution for a known period of time, for subsequent laboratory analysis. The most relevant in the context of LAQM are pumped tube samplers for benzene, and gravimetric filter samplers for PM_{10} and lead. Sequential samplers with automatic filter changers are also available.

A1.11 Also included in this category are eight-port samplers which were historically used for monitoring smoke and SO_2: however, these are nowadays rarely used in LAQM, so are mentioned only briefly in this Annex. Active samplers are also available for NO_2, but as these are not used for LAQM, they are not included in this document.

A1.12 ***Automatic real-time point analyser methods*** – These produce high-resolution measurements (typically 15-minute or hourly averages) for oxides of nitrogen (NO_X), SO_2, CO and PM_{10}. Gas Chromatography (GC) analysers also provide high-resolution data on benzene and 1,3-butadiene. The sample is analysed on-line and in real-time. These samplers form the basis of the Automatic Urban and Rural Network (AURN), and are often the instrument of choice where a high degree of accuracy, precision and good time resolution are required. In order to ensure that the data produced are accurate and reliable, a high standard of maintenance, calibration, operational and QA/QC procedures is required. Instruments that have been certified by the Environment Agency's MCERTS scheme are available (see A1.74).

A1.13 Automatic analysers output a concentration every few seconds which is interrogated and stored by the data logger typically every 10 seconds. These 10 second values are then averaged up to the required interval. For some analysers, the data output or data logging interval may be greater than 10 seconds but the logging interval is not important as long as it is significantly less than the averaging period of the objective. Advice should be sought from the Local Authority Air Quality Support Helpdesk if required. Automatic analysers should be set to output average concentration data at least once per hour and preferably every 15 minutes. In the case of SO_2, 15-minute data are necessary for comparison with the 15-minute objective.

A1.14 **Remote optical/long-path analysers** – These are instruments that use a long-path spectroscopic technique to make real-time measurements of the concentration of a range of pollutants integrated along a path between a light source and a detector. MCERTS-certified instruments using the Differential Optical Absorption Spectroscopy (DOAS) principle are available for monitoring NO_2, SO_2, ozone (O_3) (not required in Review and Assessment) and benzene. The 2004 MCERTS certificate for one such remote sensing instrument advises, "The maximum path length for consistence with a point analyser is indicative only and will depend on the mode of application. Longer lengths can be expected at well-mixed background locations, whereas in street canyons greater inhomogeneity of concentrations will occur. For this reason site specific investigations are recommended for each application if the results are to be interpreted in terms of Air Quality Guidelines."

A1.15 In order to ensure that the data produced are accurate and reliable, a high standard of maintenance, calibration, operational and quality assurance and quality control procedures is required.

A1.16 ***Photochemical and Optical Sensor Systems*** – A range of relatively low-cost automatic analysers has been developed specifically for portable and personal exposure monitoring applications. These are battery or mains operated electrochemical or solid-state sensor based systems which can continuously monitor a range of pollutants (CO, NO_2, SO_2) with a time average of 15 minutes or less. These sensors are of low sensitivity and mostly suitable for identifying hotspots at roadsides and near point sources etc. Portable sensors using the light scattering principle are available for PM_{10} monitoring.

A1.17 The above is intended to be a broad overview of the various types of monitoring available. The following section provides more detail in relation to the methods which can be used for monitoring specific pollutants.

Which method to use?

A1.18 In this section, further information is provided on the monitoring methods available for the pollutants in the Air Quality Strategy, and guidance is given on the situations where they may be appropriate. A wide variety of equipment is commercially available for both sampler-based and automatic point monitoring. Several different analysers may be suitable for the job and there may not necessarily be an obvious best technical option.

A1.19 More details of the principles of operation of a range of analysers, together with detailed procedures for their calibration and operation, is provided in the Site Operator's Manual for the AURN which is available as a research report at www.laqmsupport.org.uk/empire/lsoman/lsoman.html.

Carbon monoxide

A1.20 It is unlikely that any Local Authorities will need to monitor CO as part of their LAQM duties. However, the relevant methods are as follows.

- Portable electro-chemical CO analysers. These are suitable for Updating and Screening Assessment studies. They are generally of low sensitivity and not suitable for routine ambient monitoring; however, they can provide indicative measurements in monitoring areas of high concentration. A version of this sensor is incorporated into commercially available roadside pollution monitoring systems.
- Automatic monitoring techniques. These use a continuous infra-red absorption analyser of the type employed in the AURN. These provide accurate measurement of ambient CO concentrations, with a 15-minute averaging period. This is the method that would be required in the unlikely event of carrying out a Detailed Assessment for CO.

A1.21 There is a CEN standard[50] for the measurement of CO; the uncertainty of the method is typically quoted as ± 15%. Diffusive samplers are *not* available for CO. For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

Benzene

A1.22 Benzene monitoring can be carried out using:

- BTEX diffusion tubes.
- Pumped tube samplers.
- Remote optical monitors (for example, DOAS type).
- Automatic monitoring systems are also available for ambient monitoring of a range of hydrocarbons. The instruments typically utilise an adsorption tube that is cooled to sub-ambient temperatures for sample collection. However, such instruments are expensive and the expense would in most cases not be justified in this context. They will therefore not be discussed in detail in this Annex.

More information on these samplers and their use is given below.

BTEX Diffusive samplers

A1.23 BTEX (sometimes called BTX) diffusion tubes (shown in Figure A1.1) are passive samplers which can be used to measure benzene, toluene, ethylbenzene and xylenes (hence the abbreviation BTEX). They consist of metal tubes, packed with a suitable absorbent and fitted at both ends with brass Swagelok fittings. A separate "diffusion cap" is supplied. Immediately before exposure, the Swagelok end fitting is replaced with the diffusion cap. The cap is removed after exposure, and is replaced with the Swagelok fitting. The exposure period is usually two weeks.

A1.24 The tube is then sent to a laboratory for analysis. During this process, the organic compounds are desorbed from the material inside the tube, then analysed using a gas chromatography system. The ambient concentration of benzene (and the other compounds) is calculated from the amount of pollutant absorbed. Diffusion tubes for benzene are available from a number of well-established laboratories.

A1.25 BTEX diffusion tubes are an indicative monitoring method. The typical accuracy for benzene measurement by BTEX diffusion tubes is ± 30%. The limit of detection varies, but is typically quoted as 0.2 μg/m^3. It should be noted that tube results that are less than ten times the limit of detection will have a higher level of uncertainty associated with them.

A1.26 BTEX diffusion tubes are very sensitive to interference by solvents, so it is important that they are protected from any such sources of contamination during storage, transport and deployment. Avoid use of solvent-based felt-tip marker pens on or near BTEX diffusion tubes.

A1.27 BTEX diffusion tubes on their own are suitable for Updating and Screening Assessment monitoring. For Detailed Assessments, BTEX tubes can still be used, but it is advisable to carry out a co-location study at a suitable site in either the UK Automatic or Non-Automatic Hydrocarbon Networks, against either a a gas chromatography analyser or pumped tube sampler. (BTEX diffusion tubes are not affected by the same sources of interference as NO_2 diffusion tubes, but can still exhibit bias, so their accuracy should still be established by means of a co-location study).

[50] EN 14625:2005 Ambient air quality - Standard method for the measurement of the concentration of carbon monoxide by IR absorption

Figure A1.1: Benzene (BTEX) Diffusion Tube

Pumped tube samplers for benzene

A1.28 This method was developed by NPL for use in the UK Non-Automatic Hydrocarbon Network[51]. It is defined within the EU as the standard method for monitoring ambient benzene concentrations. Pumped tube samplers consist of a small metal cartridge or tube, containing a proprietary sorbent material. A very low volume of air is drawn through the tubes, usually over a 2-week period. The tubes are then sent for analysis by GC at a suitable laboratory.

A1.29 Should it be necessary to carry out a Detailed Assessment for benzene, the usual approach recommended is to use BTEX tubes, but (as highlighted above) a co-location study should be carried out at a suitable site in the UK Automatic or Non-Automatic Hydrocarbon Networks, against either a gas chromatography analyser or a pumped tube sampler.

Remote optical monitors for benzene

A1.30 MCERTS-certified open-path monitors, using the DOAS principle, may be used for benzene monitoring in an Updating and Screening Assessment or a Detailed Assessment. As highlighted above, a high standard of maintenance, calibration, operational and quality assurance and quality control procedures is required in order to ensure that the data are fit for purpose.

[51] EN 14662-1:2005 Ambient air quality - Standard method for the measurement of benzene concentration.

1,3-butadiene

A1.31 It is unlikely that any Local Authorities will need to monitor 1,3-butadiene as part of their Review and Assessment. However, if this is necessary 1,3 butadiene may be sampled using the same techniques as benzene (above). Diffusive samplers are the most commonly used technique. The exposure period is usually two weeks. In the context of LAQM, diffusive samplers should be sufficient for either an Updating and Screening Assessment study or a Detailed Assessment.

Lead

A1.32 It is unlikely that any Local Authorities will need to monitor lead as part of their Review and Assessment. However, if this is necessary, the recommended method is to use a gravimetric PM sampler with PM_{10} size selective head, to capture fine ambient PM onto a suitable filter media for subsequent analysis. The reference method for lead monitoring is specified in the EC 1st Daughter Directive.[52] This specifies the criteria for techniques used to monitor ambient lead concentrations; these are recommended as the basis of lead monitoring against the air quality objective for lead.

A1.33 The sampling period is usually one week. Glass fibre or membrane filters are recommended. Analysis is by atomic absorption spectroscopy (AAS) or inductively coupled plasma mass spectrometry (ICPMS).

A1.34 It is important to note that there may be difficulties in using one sampler to measure both PM_{10} and lead. This is because some types of filters used for PM_{10} monitoring are not suitable for lead analysis - their background or blank lead levels are too high. Likewise, quartz filters which are suitable for monitoring lead may not give accurate results for gravimetric PM_{10}, as there can be difficulties in conditioning them (potentially leading to inaccuracy in weighing).

A1.35 An active sampler referred to as the "M-Type" sampler was frequently used in the past for lead monitoring, and may be used for Updating and Screening Assessment studies. However, this does not meet the equivalence criteria for the EC 1st Daughter Directive.

Nitrogen dioxide

Chemiluminescent Analysers

A1.36 Continuous monitoring of NO_X should be carried out using a chemiluminescent NO_X analyser as used in the AURN. This is defined by the EU as the reference method for NO_2, and is the recommended method where accurate NO_2 monitoring is necessary (for example, for a Detailed Assessment, Updating and Screening Assessment or in an Air Quality Management Area (AQMA)). There is a CEN standard[53] for the measurement of NO_X; the uncertainty of the method is typically quoted as ± 15%.

A1.37 For situations where NO_X and nitric acid (NO) concentrations fluctuate rapidly, for example at kerbside or roadside sites, enhanced instruments are available which incorporate modifications to avoid the potential problem of apparent negative NO_2 values being generated (an artefact which can occur when short-term fluctuations cause the NO concentration to exceed the NO_X signal). When purchasing a chemiluminescent analyser, Local Authorities should ensure they ascertain from the supplier whether the instrument is suitable for such locations.

[52] Council of the European Communities. Council Directive of 22 April 1999 relating to a limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (1999/30/.EC).

[53] EN 14211:2005 Ambient air quality - Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence

Diffusion Tubes for Nitrogen Dioxide

A1.38 Diffusive samplers (as described in Paras A1.08-A1.09 above) are widely used for indicative monitoring of ambient NO_2 in the context of Review and Assessment. Detailed guidance notes for suppliers and users of NO_2 diffusion tubes have been produced by AEA Energy & Environment, and are available on the Local Authority Air Quality Support website at www.airquality.co.uk/archive/reports/cat05/0802141004_NO_2_WG_PracticalGuidance_Issue1a.pdf. The reader is referred to this more detailed guidance.

A1.39 Diffusion tubes are particularly useful:

- when simple, indicative techniques will suffice;
- to give an indication of longer-term average NO_2 concentrations;
- for indicative comparison with the Air Quality Strategy Objectives based on the annual mean;
- for highlighting areas of high NO_2 concentration; and
- where installation of an automatic analyser is not feasible.

They are useful for identifying areas of high NO_2 concentration, particularly when dealing with sources such as traffic emissions, which do not change much from day to day.

A1.40 However, it should be remembered that diffusion tubes are an ***indicative*** monitoring technique. Whilst ideal for Updating and Screening Assessment surveys, for supplementing automatic monitoring, or for identifying locations where NO_2 concentrations are highest, they do not provide the same level of accuracy as automatic monitoring techniques. The uncertainty of diffusion tube measurements is typically quoted as around ± 25%. In particular, diffusion tubes are affected by several sources of interference which can affect accuracy – hence the need to quantify accuracy by co-location with a chemiluminescent analyser (see sections 3.24 – 3.30 and Box 3.3 of the main document, which deal with precision and accuracy of diffusion tubes, and bias adjustment).

A1.41 As the exposure period is typically several weeks, the results cannot be compared with air quality objectives based on shorter averaging periods such as the hourly mean. Diffusion tubes are therefore of limited use for monitoring ambient concentrations around specific emission sources such as industrial plant, as they cannot identify short-term changes in NO_2 such as may result from fluctuations in wind direction.

A1.42 **In view of the limitations of diffusion tubes, Local Authorities are advised not to rely upon diffusion tube data alone as the basis of a Detailed Assessment or declaration of an AQMA for NO_2. In particular, it is inadvisable to base a declaration on the results of a diffusion tube survey of short duration.** However, it is recognised that automatic monitoring is not always possible (there may, for example, be insufficient space for installation of an automatic analyser). In such cases, where diffusion tubes are the only practicable monitoring method, the local authority should ensure that:

- Monitoring should be carried out for a full year;
- Tubes should be deployed at several sites in the vicinity if possible (for example, at several points around a busy junction);
- The precision of the tubes used should be ascertained: a supplier should be selected whose tubes have demonstrated good precision; and
- The accuracy of the tubes should be quantified. An appropriate bias adjustment factor should be applied to the annual mean.

A1.43 It should be noted that diffusion tube bias has been observed to vary from year to year, (possibly due to changes in laboratory procedures, meteorological conditions at the co-location sites, and other factors). For this reason, bias adjustment factors should be calculated specifically for the calendar year being reviewed.

Remote Optical Sensors for Nitrogen dioxide

A1.44 Remote optical sensor systems such as DOAS can also be used to measure NO_2. The methodology is less established than that of the chemiluminescent analyser, although systems are available which have MCERTS approval. Particular attention must be paid to instrument calibration and quality assurance in order to obtain meaningful data from such systems.

Electrochemical Sensors for Nitrogen dioxide

A1.45 These sensors ***may*** be suitable for identifying NO_2 hotspots at roadsides and near point sources etc, in Updating and Screening Assessment studies only. The accuracy and precision of this equipment is uncertain and sensitivity can be low: the detection limits are often too high for such sensors to be useful. However, if monitoring with this type of analyser, it is advisable to carry out a co-location study with a fully calibrated chemiluminescent analyser (as is recommended for diffusion tubes) in order to validate the data.

Example A1.1 Monitoring Of Nitrogen Dioxide In A City Centre

Scenario: an Updating and Screening Assessment has predicted an annual mean NO_2 concentration above the Air Quality Strategy Objective of 40 μg/m^3 near a major road using the DMRB model. There are homes close to the road, hence relevant public exposure. In this case a typical monitoring strategy would be to make long-term measurements using a combination of automatic analysers and NO_2 diffusion tubes.

Automatic monitoring

A monitoring station with a chemiluminescent NO_X analyser is set up at the modelled point of maximum exposure, close to the nearest receptor (house or school etc). The site should ideally reflect the closest relevant public exposure to the road, but considerations such as power supply, site security and planning requirements may mean the site is further away.

At kerbside or roadside locations where NO_X and NO concentrations may change rapidly, the analyser must make simultaneous measurements of NO_X and NO or else be engineered to compensate for possible effects of sequential sampling. The equipment supplier is asked to demonstrate adequate performance of the analyser at kerbside locations.

A nearby automatic monitoring station at an urban background location, operated as part of a national or local network is used for comparative purposes in the Review and Assessment process.

Diffusion tube monitoring

Measurements from sites close to a busy road will only be representative over a very small area as NO_2 concentrations close to sources vary considerably, even over short distances. Therefore, NO_2 diffusion tubes for these site types are positioned at sites along all roads estimated as most likely to exceed the Air Quality Strategy objective. Tubes are also placed at sufficient background sites to obtain a representative background concentration for the area (three to four sites typically). Tubes are exposed for one month at a time at each of the sites selected, with triplicate tubes routinely exposed at a selected sub-set of the sites, in order to gather information on diffusion tube precision.

To validate the diffusion tube data, diffusion tubes are also exposed in triplicate at the automatic monitoring station, using the same monthly exposure periods as the other sites. The monthly averages from NO_2 tubes and the automatic analyser are compared, and at the end of the year a bias adjustment factor is calculated, and applied to the annual mean diffusion tube results from the other sites, to correct for any systematic bias. Details of the bias adjustment factor, and the adjusted and un-adjusted annual means, are all included in the review and assessment report. (Details of adjustment for bias in diffusion tube measurements is given in Chapter 3 of the main document).

When the diffusion tube and automatic data have been fully quality assured, they can then be used to identify exceedences of the air quality objectives, and also used to verify the modelling undertaken as part of the Review and Assessment.

The results of monitoring should take precedence over modelling: so, if the monitoring results do not indicate that there is likely to be an exceedence of the Air Quality Objective (taking into account the caveat set out in Chapter 3 of the main document, on site locations) there will be no need to declare an AQMA.

Sulphur dioxide

A1.46 The number of local authorities that should need to monitor SO_2 is relatively small: however, for those who have established a need for this, these are the methods available:

A1.47 For the purposes of Detailed Assessment, Updating and Screening Assessment or in an AQMA, automatic monitoring should be undertaken. Continuous SO_2 monitoring should be carried out preferably with an ultra-violet fluorescence (UVF) analyser as used in the AURN. This is the recommended method where accurate SO_2 monitoring is necessary. There is a CEN standard[54] for measurement of SO_2; the uncertainty of the method is quoted as ± 15%.

A1.48 As an alternative, the DOAS can be used to measure SO_2. As with all automatic techniques, careful attention needs to be paid, particularly to instrument calibration and quality assurance in order to obtain meaningful data. MCERTS-certified DOAS systems are available for SO_2.

A1.49 For monitoring in the context of an Updating and Screening Assessment, it ***may*** occasionally be possible to use a relatively inexpensive active sampling methodology. These work by drawing ambient air through a collecting medium (typically a solution of dilute acidified hydrogen peroxide in a liquid bubbler) for a specified time, typically a 24-hour period. The analytical methods are detailed in the GEMS/AIR methodology review handbook, volume 4[55]. The former UK Smoke and SO_2 Network, which ceased operation in 2005, used such "8-port" samplers. Analysis of the solutions was carried out using the net acidity method.

A1.50 However, active bubbler samplers for SO_2 have limitations. Firstly, their 24-hour sampling period makes them unsuitable for monitoring compliance with objectives relating to periods shorter than 24 hours, such as 1-hour and 15-minute means. Secondly, average SO_2 concentrations in the UK are now close to the limit of detection of the net acidity method. (More accurate results can be obtained using ion chromatographic analysis, but for daily samples the cost of this would be high.) Also, although the apparatus is inexpensive, the method is labour intensive, involving accurate preparation of reagents and titration of samples by a skilled operator.

A1.51 Therefore, there are likely to be few situations where active sampling for SO_2 using the net acidity (peroxide bubbler) method is the best option, and it is generally considered obsolete for the purposes of LAQM. Local Authorities considering using this option are advised to contact the Local Authority Air Quality Monitoring Support Helpdesk.

A1.52 **Diffusion tubes are available for SO_2 monitoring, but they are not suitable for use in LAQM.** This is because their averaging time is typically several weeks or one month. They are therefore:

- Unable to detect short-term changes in concentration attributed to emissions from point sources.
- Unable to monitor compliance with 24-hour, 1-hour and 15-minute Air Quality Strategy Objectives.

For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

[54] EN 14212:2005 Ambient air quality – Standard method for the measurement of the concentration of sulphur dioxide by UV fluorescence

[55] UNEP/WHO, 1994 GEMS/AIR Methodology Reviews Vol. 4: Passive and Active Sampling Methodologies for Measurement of Air Quality. WHOIEOS/94.4 UNEP/GEMS 94.A.S

Particulate Matter

A1.53 This section describes the various monitoring methods that are available for PM. The focus is on PM_{10} monitoring, as local authorities are required to Review and Assess against this pollutant. Informal advice is also provided with regard to $PM_{2.5}$ monitoring.

Methods Available

A1.54 The following methods are available for monitoring PM_{10}:

- Light scattering systems: these are portable instruments which use a light scattering method to measure ambient concentration of fine particles. They are considered suitable for use in Review and Assessment, but not for Detailed Assessments.
- Tapered Element Oscillating Microbalance (TEOM): In the TEOM, sampled ambient air passes at a constant flow rate through a filter, attached to a vibrating hollow tapered element. As PM is collected on the filter, the frequency of vibration of the element decreases. The mass of PM collected over a period of 15 minutes or one hour can thus be calculated. The TEOM can be used for continuous, on-line monitoring. The TEOM uses a heated sample inlet to prevent moisture from contaminating the filter: studies in recent years have shown that this results in the loss of volatile and semi-volatile components of PM_{10}, and until recently Defra advised applying a default correction factor (1.3) to take account of this. (This has been superseded; the current advice is to use the King's College London Volatile Correction Model (VCM), wherever possible, see Para A1.62).
- Filter Dynamics Measurement System (FDMS): The FDMS is a self-referencing airborne particulate monitor based on TEOM technology, measuring both core and volatile fractions of particles.
- Beta attenuation monitors (BAM): these devices draw sampled air at a constant flowrate through a section of paper tape, on which particles from the air are collected. At the beginning and end of the sampling period (one to 24 hours), transmission of beta particles through the tape (from a source inside the instrument) is measured. The difference between the two measurements, caused by the particulate matter collected on the tape, is used to determine the concentration. Beta attenuation monitors can be used for continuous, on-line monitoring. Some BAMs are combined with filter-based gravimetric samplers.
- Filter-based gravimetric methods: these samplers involve drawing a measured volume of air through a filter, which is weighed before and after the sampling period (this is usually 24 hours). Sequential instruments are available, which can operate unattended for several weeks. The European reference sampler is a filter-based gravimetric method; however, conditioning and accurate weighing of the filters is necessary if the results are to be valid. Also, because the filters must be weighed before and after exposure, this method cannot be used for continuous or on-line measurement.

Equivalence to the reference method for PM_{10} monitoring

A1.55 As set out above, PM_{10} concentrations can be measured using a range of sampler and analyser types, potentially giving very different results. In 2006, Defra and the Devolved Administrations published the results of a study investigating the equivalence of various samplers and instruments for measuring PM, in comparison with the European reference method (a gravimetric technique).

A1.56 The study involved the comparison of six automatic and gravimetric instruments with the European gravimetric reference sampler. The tests carried out were based on the Guidance for the Demonstration of Equivalence of Ambient Air Monitoring Methods issued by an EC

Working Group. The Guidance sets out an approach whereby it is possible to demonstrate whether an instrument is able to comply with the Data Quality Objective for overall uncertainty as defined within the relevant Air Quality Directive – in the case of PM_{10} this is ± 25%. The tests were conducted at four sites within the UK, over both summer and winter seasons. For further information, please refer to the "UK Particulate Monitoring Equipment Study" report by Bureau Veritas[56]. The outcome of the study is summarised below.

- Gravimetric samplers. The Partisol 2025 sequential gravimetric sampler, which is used at some sites in the AURN, met the equivalence criteria. If purchasing a gravimetric sampler, it is strongly recommended that it should be a sequential sampler, to avoid the need for daily filter changes, and to allow midnight-to-midnight sampling periods. If, however, you are using an older type of sampler without this capability, then samples should be exposed daily if possible or at least every alternate day (including weekend days). It is important to note that the ability of gravimetric methods to meet the Data Quality Objectives is highly dependent on correct filter handling, weighing and conditioning (see QA/QC section below).
- Beta Attenuation Monitor (Met-One). These analysers are available with both heated and non-heated sample inlets. The unheated Met-One BAM met the equivalence criteria with a correction factor for the gradient, ie, results should be divided by a factor of 1.21 (when the flow is measured at standard temperature and pressure conditions, as is the case for standard analysers supplied in the UK). The heated-inlet BAM was not tested: when using BAM analysers with heated inlets for LAQM purposes, the advice is to continue to multiply the results by a factor of 1.3 (in line with previous guidance).
- Filter Dynamics Measurement System. The FDMS (Model B) met the equivalence criteria in the above study. However, the "Model B" is no longer commercially available. A new "Model C" version is currently undergoing equivalence testing (see Para A1.57). A "Model C/B" version is also commercially available and is being installed into the national network.
- Tapered Element Oscillating Microbalance. The TEOM did ***not*** meet the equivalence criteria of the European reference method within the UK, even with application of the 1.3 correction factor (as advised in earlier guidance).
- Opsis SM200. The SM200 analyser is a combined beta attenuation / gravimetric sampler. The beta attenuation device met the equivalence criteria. The gravimetric device met the equivalence criteria with a correction factor for the gradient and intercept, ie, to subtract 1.29 $\mu g/m^3$ and divide by a factor of 0.819.

A1.57 Where possible, Local Authorities are encouraged to carry out PM_{10} monitoring using the European reference sampler or an instrument that has been demonstrated to be equivalent. However, as manufacturers are continually seeking to develop new methods, and improve on existing ones, the situation regarding equivalence of instruments is therefore subject to change. Defra and the Devolved Administrations are currently supporting the Environment Agency in a further programme of equivalence trials that are planned under the Agency's MCERTS programme. Local authorities should therefore contact the Local Authority Air Quality Support Helpdesk to seek the latest information on particulate matter monitoring, before purchasing equipment.

A1.58 Local authorities should ensure that they use the same operational set-up of instruments, model versions and filter media as used in equivalence trials. Changes in any of these parameters may mean that the instrument is not giving results equivalent to the reference method.

[56] Harrison D (2006) UK Equivalence Programme for Monitoring of Particulate Matter. Available at: www.airquality.co.uk/archive/reports/list.php.

Implications for Tapered Element Oscillating Microbalance users

A1.59 Tapered Element Oscillating Microbalance analysers are widely used in LAQM work. However, the outcome of the equivalence study means that TEOM analysers cannot strictly be used to measure PM_{10} concentrations for comparison with the air quality objectives (which are based on measurements using the European reference sampler).

A1.60 Defra and the Devolved Administrations' advice to local authorities using TEOMs is that it is generally not necessary to replace the instrument immediately, but when the time does come to replace it, the selected instrument should be a reference sampler, or one that meets the equivalence criteria. Suitable equipment will be noted by the suppliers as "Shown to meet equivalence criteria set out in the report on 'UK equivalence programme for monitoring of particulate matter'".

A1.61 The issue will be most critical where PM_{10} levels are slightly above or below the objectives, and local authorities are encouraged to have particular regard to those locations where this is the case. It is not possible to precisely define what "close to the objectives" means, but as an approximate guide it is likely to be in the range 30 to 40 days' exceedence of the 24-hour objective (or in case of the 2010 annual mean objective for Scotland, in the range 16 to 20 $\mu g/m^3$), as measured by the TEOM multiplied by 1.3. In such cases it may be possible to restructure local networks, for example by re-locating existing instruments.

A1.62 It is therefore considered appropriate that TEOM analysers should remain suitable for the purpose of Review and Assessment, but data should be corrected wherever possible using the King's College London Volatile Correction Model (VCM) for PM_{10} (rather than by the application of a 1.3 correction factor).

A1.63 The VCM Model allows TEOM measurements to be converted into gravimetric equivalent data by making use of FDMS volatile fraction data from a nearby monitoring station. There are some areas of the UK, particularly in Scotland, where the VCM approach cannot be currently used due to the lack of nearby FDMS analysers. In these cases local authorities should continue to use the approach as set out in previous guidance, as summarised in Paras 3.47 – 3.48 of the Main Document.

A1.64 Further details of the King's College London VCM can be found at the following website: www.airquality.co.uk/archive/reports/reports.php?report_id=490 and guidance on its application is provided in Box 3.4 of the main document. For further advice on the selection of monitors, please refer to the following FAQs:

UK Equivalence Tests for Particulate Monitors:
www.laqmsupport.org.uk/faqs.php?action=displaysubzone&sub_zone_id=8
www.uwe.ac.uk/aqm/review/mfaqpm.html#PM8a

Equipment Upgrade:
www.laqmsupport.org.uk/faqs.php?action=displaysubzone&sub_zone_id=8
www.uwe.ac.uk/aqm/review/mfaqpm.html#PM10

Choice of PM_{10} monitoring methods

A1.65 For **Updating and Screening Assessments,** local authorities may use any of the methods discussed above. However, if portable light scattering devices are used for indicative monitoring of PM_{10} (or $PM_{2.5}$) they should be size-selective, and properly calibrated. Calibration of light-scattering devices is normally carried out by measuring the mass of particles deposited on an in-line filter in order to obtain a local calibration factor. If a TEOM is used for the Updating and Screening Assessment, the results should be corrected wherever possible using the VCM.

A1.66 For **Detailed Assessments,** Defra and the Devolved Administrations encourage local authorities to use a reference sampler or a demonstrated equivalent method, wherever possible. The range of instruments meeting the equivalence criteria is however subject to change, and so local authorities should ensure they obtain up to date information before any purchase. Suitable equipment will be noted by the suppliers as "Shown to meet equivalence criteria set out in the report on 'UK equivalence programme for monitoring of particulate matter'". Tapered Element Oscillating Microbalance instruments are also suitable for Detailed Assessments but the data should be corrected using the VCM Model wherever possible. For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

A1.67 Example A1.2 below shows a typical example of a monitoring strategy in a situation where fugitive emissions of PM_{10} arise from a quarry.

Example A1.2 Monitoring Strategy for PM_{10} around a quarry

Scenario: fugitive dust emissions represent a potential problem around a quarry. In order to determine whether a Detailed Assessment is required, a monitoring survey is undertaken.

There are relevant receptors (houses, schools etc) within 400 m of the quarry, so detailed monitoring is necessary.

A suitable strategy is to set up PM_{10} samplers at three to four sites around the quarry source to make indicative measurements. Any type of PM_{10} sampler can be used: if power is not available at the sites then battery operated low volume gravimetric samplers or portable automatic monitors could be used. Wind speed and direction are also measured at one site. If manual samplers are used they should be set to operate from midnight to midnight. Samples are collected every other day over a three month period.

The samplers are located close to the nearest point of public exposure, for example, a house or school. For large quarries the receptor distance should be measured from the area of maximum activity during the survey period. The PM_{10} samplers are sited upwind and downwind of the quarry close to the nearest receptors.

This quarry is active during part of the year only. It is important that the timing of the survey is planned to coincide with a period of quarrying activity.

A nearby background site such as a national or local network site can be used as a reference, if available.

Daily average concentrations are compared to those from the national network site in order to determine the contribution to total PM_{10} concentration of background sources.

In order to further specify the source of the PM_{10} filters can be retained for scanning electron microscopic analysis to characterise the collected particles.

If no significant exceedences of the objectives are recorded during the three month period, then monitoring can be terminated. Otherwise a detailed monitoring study is undertaken.

$PM_{2.5}$

A1.68 There is no obligation upon local authorities to carry out monitoring of $PM_{2.5}$. Defra and the Devolved Administrations intend that the UK's monitoring requirements with respect to EU legislation will be fulfilled by data from national monitoring networks. However, any local authorities who wish to undertake $PM_{2.5}$ monitoring should ideally use instruments that meet the equivalence criteria, (and hence are compliant with the requirements of the EU Directive). Such equipment will be noted by the suppliers as "Shown to meet equivalence criteria set out in the report on 'UK equivalence programme for monitoring of particulate matter'" (www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf). This should be an important consideration when purchasing new instruments. As set out in Para A1.57 above, further equivalence trials using new $PM_{2.5}$ instruments are underway at the time of writing. Pending the outcome of these tests, authorities are advised to contact the Local Authority Air Quality Support Helpdesk.

A1.69 Where measurements of PM_{10} and $PM_{2.5}$ are required in a single location, it is strongly recommended that measurements are undertaken with identical instrument types. This will minimise any errors associated with differences between measurement methods and produce more reliable datasets.

Summary: selection of monitoring methods

A1.70 Table A1.2 gives a checklist to help when selecting monitoring techniques.

Table A1.2 Points to consider when choosing monitoring techniques

	Diffusion Tubes	Portable samplers	Continuous Samplers	Gravimetric Sampler
General	Indicative only. Tubes should be supplied and analysed by an accredited laboratory.	Suitable for screening but not for detailed monitoring. Data logging required.	Equipment should have independent type approval/designation. Span range must be suitable to monitor against objectives RS232/Voltage output or internal data logging system required	Accurate display/ measurement system for flow rate required.
CO	N/A	Available in roadside pollution monitors	Gas correlation infra-red units recommended	N/A
Benzene	Diffusion tubes suitable for indicative monitoring. Non-auto. Hydrocarbon Network uses pumped tube samplers.	N/A	Automatic BTX analysers available or full GC systems can be used.	N/A
1,3-butadiene	Diffusion tubes suitable for indicative monitoring.	N/A	Automatic BTX analyser or full GC systems can be used.	N/A
Lead	N/A	N/A	N/A	Gravimetric PM_{10} monitors can also be used for lead with suitable filters and exposure period.
NO_2	QA/QC important. May require bias adjustment. Indicative only.	Available in roadside pollution monitors	Fast cycling time and/or delay loops needed for roadside monitoring	N/A
SO_2	Not suitable	Not widely available	Time resolution must be suitable to measure against the 15-minute objective.	N/A
PM_{10}	N/A	Portable light-scattering devices may be used for indicative monitoring. They should have particle size-selection for the appropriate size fraction, and be properly calibrated.	Can be used for continuous, on-line monitoring. Seek latest guidance on which models meet the equivalence criteria: this situation is changing rapidly. TEOM does not meet equivalence criteria, but TEOM data corrected using VCM are considered acceptable by Defra and the Devolved Administrations for Review and Assessment. A designated PM_{10} inlet head must be used.	Both the EU reference sampler and equivalent samplers require that correct filter weighing and conditioning procedures are followed. These will require appropriate facilities. A designated PM_{10} inlet head must be used.

N/A = not available.

Planning, setting up and operating a monitoring campaign

Objectives

A1.71 Before embarking on a monitoring programme, it is important to have a clear understanding of what monitoring will achieve and how it will aid the Review and Assessment process. Box A1.1 lists some of the basic points to consider.

Box A1.1: Basic Considerations for Air Quality Monitoring:

- Which pollutants need to be monitored?
- What monitoring methods are appropriate?
- What monitoring equipment is needed?
- How much will it cost - to purchase and to operate?
- How long to monitor for?
- Where to monitor?
- How many monitoring sites are needed?
- What data quality is required?
- How to process and evaluate the data?

A1.72 It is important that the financial and other implications of embarking on a monitoring programme are fully understood before any action is taken. Local authorities are advised to seek assistance from the Local Authority Air Quality Support Helpdesk (contact details at the beginning of this Annex) if they are uncertain about the best way to proceed.

A1.73 When purchasing monitoring equipment, local authorities should work with their own purchasing departments to ensure that obligations regarding open competition etc are complied with.

Selecting monitoring equipment

A1.74 Equipment suppliers should be able to demonstrate that their analysers are “fit-for-purpose”. Monitoring equipment, particularly that used for Detailed Assessments should have some form of independent evaluation, for example, the ambient MCERTS scheme operated by SIRA, or the German TUV designation. Also, analysers will need to be able to monitor over the time period of the air quality objective, for example, 15-minute for SO_2.

A1.75 A list of equipment suppliers is available on the Air Quality Archive web site at www.airquality.co.uk/archive/reports/cat06/aqm_suppliers.pdf. Advice on monitoring equipment may be sought from the Local Authority Air Quality Support Helpdesk. Table A1.3 gives specifications of typical automatic monitoring equipment used in national networks. Concentrations are given in parts per billion (ppb), the “native” unit of most automatic analysers.

Table A1.3: Typical specifications for UK automatic network-standard analysers					
Pollutant measured by analyser		NO_2	SO_2	O_3	CO
Repeatability	Zero Span	1 ppb 3 ppb	1 ppb 3 ppb	1 ppb 3 ppb	<100 ppb <300 ppb
12 hour drift	Zero Span	2 ppb 6 ppb	2 ppb 6 ppb	2 ppb 6 ppb	600 ppb 100 ppb
Linearity Error (lack of fit, largest residual)*		<4%	<4%	<4%	<4%
95% Response Time (max)		180 secs	<180 secs	<180 secs	<180 secs

* Linearity is a measure of the relationship of analyser response with changing concentration. This relationship should be linear ie twice the concentration will produce twice the output signal etc.

Infrastructure and other equipment and services

A1.76 In addition to the analysers, other site infrastructure will be required to set up a fully automatic air quality monitoring station consisting of:

- equipment housing
- electrical systems
- air conditioning/heating
- telephone lines/modem
- cylinder storage facilities
- air sample inlet system
- autocalibration facilities
- data logging and acquisition facilities.
- security systems
- safety systems.

A1.77 Indicative techniques such as diffusion tubes, pumped tube samplers and electrochemical cell samplers usually require a much lower level of site infrastructure. However, access to appropriate analytical facilities at a central laboratory may be required.

A1.78 It is important to note that selecting, purchasing and commissioning the equipment for an automatic monitoring station can be a lengthy process (typically two to three months) and time should be allowed for this at the planning stage.

Monitoring enclosure

A1.79 If the equipment is to be self-contained rather than housed in an existing building then an enclosure will need to be purchased. Consideration needs to be given to the size, portability, and visual impact requirements of the enclosure. These criteria will need to satisfy the needs of the particular location, or overall programme if the site is to be frequently re-located (for example using a mobile monitoring station).

Air conditioning system

A1.80 In most cases if budget allows it is advisable to install monitoring equipment in an air-conditioned enclosure/room. Exceptions are if only one or two monitors are to be installed in a large enclosure, or if a room is particularly well insulated and ventilated. In general the problem is with over-heating of equipment in the summer so a cooling system is required. However, there may also be instances where the instruments themselves do not generate sufficient heat to warm the surroundings so a heating system may also be needed for winter months. Some monitors such as the infra-red absorption analyser for CO can be particularly susceptible to temperature change, leading to a risk of expensive instrument failure or severe data loss if not protected.

Sampling inlet

A1.81 Different sampling systems can be purchased depending on the amount of equipment to be installed and the location. There are two main types of sampling systems used in UK monitoring stations.

- Those that use the analyser to draw air through a narrow fluorocarbon tube which is passed through the monitoring enclosure to the ambient air. Typically this system is used where there are only one or two analysers at a site.
- Those that use a fan to draw ambient air at high speed down a wide manifold tube. The analysers are connected to the end of this manifold using short lengths of narrow fluorocarbon tubing, and this type of system is best suited to multi-pollutant sites.

Power supply

A1.82 The power supply to the monitoring enclosure/room must be of sufficient rating to support the equipment to be installed. A suitable trip is recommended in order to protect the equipment in the event of a power surge. In some cases such as roadside monitoring it is possible to arrange to draw power from a nearby facility (such as street lighting) without having to install significant lengths of underground or over-ground cables. However, not all such installations offer an uninterrupted power supply.

Telephone connection

A1.83 In order to ensure that analysers are operating satisfactorily, data should be downloaded remotely from monitoring stations on a daily basis. If a real-time public information system has been set up then data polling may be increased to every hour. In order to achieve this installation of a telephone line and modem, or mobile phone and GSM modem will be required. The type of system required will depend on location, cost of installation, and ongoing cost of calls and monthly rental. Most analysers can be connected directly to a broadband line with data then collected over the Internet.

Meteorological sensors

A1.84 In order to make the best use of the measured air quality monitoring data for dispersion modelling or source apportionment analysis, it is often useful to install meteorological sensors at the monitoring station. These will enable the local wind speed/direction/temperature/humidity data to be analysed to determine the conditions which lead to high pollution, and which are the most significant pollutant sources. Consideration will need to be given to the visual impact of installing a meteorological mast and whether overhanging vegetation or nearby buildings might interfere with the sensors. Meteorological measurements are usually most effective when the monitoring station is in a reasonably open location. The alternative is to purchase sequential meteorological data from the Met Office, but this may only be modelled or from a monitoring station many miles away.

Data logging

A1.85 Most automatic air quality monitors now have their own sophisticated controlling software and built-in data loggers which can store up to a month or more of 15-minute averaged data. If more than one analyser is to be installed then a code-activated-switch will be needed in order to allow remote polling to download data from each of the analysers in turn. An alternative is to install a dedicated PC or data logger at the site to store all the data and control operation of the analysers including calibration cycles. Consideration will also need to be given as to whether additional parameters such as meteorology and analyser status need to be recorded, where these values will be stored, and how they will be downloaded.

Service and maintenance contract

A1.86 Automatic air quality analysers are sophisticated and will require engineer support for repair and routine maintenance. Ideally, a contract should be set up to replace or repair any faulty equipment within 48 hours of call-out, ensure a minimum data capture level of 90% over the year or monitoring period, and to carry out routine servicing of the equipment every six months according to the manufacturers recommendation. It will be up to the operator to decide whether to take up a more expensive "all-inclusive" maintenance contract covering all eventualities, or to go for the cheaper but more risky option where individual (possibly expensive) items will have to be paid for in the event of breakdown.

A1.87 Maintenance schedules for the replacement of consumable parts, diagnostic checks and equipment overhaul should in all cases follow manufacturer's recommendations. Routine and non-routine service visits must be fully documented to describe in detail any adjustments, modification or repairs undertaken. The exact service schedule and level of documentation should be agreed as part of the service contract.

A1.88 A good service and maintenance contract on a well set-up, calibrated and maintained site should ideally ensure that any data loss is distributed evenly throughout the year. An example "model" contract (as used in the National monitoring network) is provided in the Site Operator's Manual of the AURN (Appendix F) at www.laqmsupport.org.uk/empire/lsoman/lsoman.html.

Data management software or services

A1.89 Data from the monitoring stations needs to be reviewed on a daily basis in order to:

- ensure that the equipment is still running satisfactorily;
- provide information on pollution alerts to the public; and
- backfill any data gaps if necessary.

A1.90 All or part of this service could be sub-contracted to a specialist consultant, with data linked in real-time to a web site for public information. However, if the local authority decides to carry out the task themselves then they will need to purchase the necessary software for:

- data download, functional review, editing and comparison with Air Quality Objectives, and
- reporting and uploading to a website if required.

A1.91 Most suppliers of air quality monitoring equipment will be able to provide software to the local authority for this purpose.

Site selection

A1.92 Monitoring sites can be classified according to the type of environment in which they are located, in order to permit more meaningful evaluation of data. The site description will generally reflect the influence of a particular pollutant source or of overall land use. Typical monitoring location types, as used in national automatic monitoring networks, are shown in Table A1.4.

A1.93 It should be noted that, at the time of writing, work is under way to agree a set of classification methods for air quality monitoring sites, to be used throughout Europe. These will use quantitative criteria based on the impact of emissions from various sources (traffic, domestic heating, industrial/ commercial processes), population, and local dispersion conditions to define site classification and area of representativeness. Guidance will be updated when the classification methods are finalised.

A1.94 It is important that detailed descriptions of all monitoring site locations used, including grid references, sampling heights, distance from kerbs etc, are given in the Review and Assessment reports.

Table A1.4 Monitoring locations

Site Type	Description
Urban centre	An urban location representative of typical population exposure in towns or city centres, for exampleg, pedestrian precincts and shopping areas.
Urban background	An urban location distanced from sources and therefore broadly representative of city-wide background conditions, eg, urban residential areas.
Suburban	A location type situated in a residential area on the outskirts of a town or city
Roadside	A site sampling typically within one to five metres of the kerb of a busy road (although distance can be upto 15 m from the kerb in some cases).
Kerbside	A site sampling within one metre of the kerb of a busy road.
Industrial	An area where industrial sources make an important contribution to the total pollution burden.
Rural	An open countryside location, in an area of low population density distanced as far as possible from roads, populated and industrial areas.
Other	Any special source-orientated or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels.

A1.95 In order to obtain useful air quality monitoring data for the purposes of Review and Assessment, the measurements made must be representative of the study area of interest. To achieve this, it is essential to choose the right site(s) for the monitoring equipment. A number of considerations need to be taken into account and it is worth investing reasonable effort in surveying possible sites before making a final choice. The approach taken to identify appropriate monitoring locations should be fully documented in the Review and Assessment report. The sites must be located where there is likely to be human exposure (see Box 1.4 of Main Document) over the relevant time period for each pollutant in the Air Quality Strategy or at least in a location representative of nearby exposure, for example the same distance from a section of road as the façade of nearby residential properties.

A1.96 The site selection process must take into account the spatial distribution and variability of gaseous pollutants. It is often not possible to find one site which is ideal for all pollutants: for example, concentrations of traffic pollutants such as NO_2 are highest at roadside locations, whereas SO_2 concentrations may be highest at urban background or rural locations as a result of emissions from a point source. In such circumstances, some degree of compromise may be required, or it may be necessary to set up separate sites for the different pollutants.

A1.97 Urban background monitoring is essential if there is a need to monitor long-term trends in pollutant concentration or population exposure. Urban background monitoring sites are less likely than roadside sites to be affected by very local factors, for example changes in traffic on a particular road.

Identifying relevant locations

A1.98 The initial process in Review and Assessment is to determine likely "hot spots", ie, relevant locations where air quality may not meet the prescribed objectives or exceedence of the relevant objective is possible. This can help refine the selection of suitable monitoring locations. The following information can be used when screening for potential areas of concern.

A1.99 ***Existing air quality data.*** A range of monitoring activities is currently undertaken by local authorities, and local data may be available to help assess future monitoring requirements. If monitoring has already been carried out in the area of interest, the data from previous studies may prove to be of use in targeting problem areas. Comprehensive monitoring of air quality is carried out on a national scale by Defra and the Devolved Administrations. Many of the sites have accumulated considerable historical data sets. All data are freely available to local authorities wishing to use this resource to assist in the appraisal of air quality in their area. Data from the national monitoring networks can be obtained from the Air Quality Archive at www.airquality.co.uk.

A1.100 Examples of the application of existing monitoring data include:

- Use of data from nearby national network sites or neighbouring local authority sites to verify data obtained from short term or indicative monitoring exercises.
- Use of data from long-term monitoring sites in estimating annual mean NO_2 concentrations from a short-term local study.

A1.101 ***Modelling.*** The results of dispersion modelling simulations can be used to predict pollutant dispersion and deposition patterns, thereby helping to identify areas where pollutant problems may occur. To be of real use, reliable emissions and meteorological data are needed, together with an appropriate model. The model should be validated against data measured in the location of its application. Details of dispersion modelling can be obtained from the Local Authority Air Quality Support Helpdesk at www.laqmsupport.org.uk .

A1.102 ***Sources and emissions.*** Compilations of emission data will help to identify the most polluted areas, as well as other location types where population exposure may be significant. If a full emissions inventory is not available, then surrogate statistics such as population density, location of industrial sources, traffic flows and fuel consumption may be of use in estimating likely pollution "hot spots". Advice on emissions can be obtained from the Local Air Quality Support Helpdesk at www.laqmsupport.org.uk. Emissions data collated on a national basis is provided in the National Atmospheric Emissions Inventory (NAEI), at www.naei.org.uk.

A1.103 Details of industrial processes in England and Wales authorised by the Environment Agency (EA) can be found on the EA website www.environment-agency.gov.uk under "What's in your backyard?". Details of industrial processes in Scotland can be obtained from the Scottish Environmental Protection Agency (SEPA), see www.scotland.gov.uk/Topics/Environment/Pollution/17314/Industrial-Pollution. Details of industrial processes in Northern Ireland can be obtained from the Environment and Heritage Service, see www.ni-environment.gov.uk.

A1.104 ***Meteorology and topography.*** The prevailing weather conditions and local topography will strongly influence the dispersion of air pollutants or, in the case of secondary pollutants, affect their production in the atmosphere. Meteorological measurements can be made on-site, or data purchased from the authorised agencies.

A1.105 ***Other information.*** Population and land-use information may be used to target locations representative of both baseline and worst-case exposure. Advice on siting for Review and Assessment can also be obtained from the Review and Assessment Helpdesk:

- Telephone 0117 328 3668
- e-mail: **aqm-review@uwe.ac.uk**
- Website: **www.uwe.ac.uk/aqm/review**

Local siting criteria

A1.106 It is recognised that it is very difficult to identify a "representative" site, particularly for automatic sites when taking into account factors such as visual impact and planning permission. However, in order to ensure meaningful comparisons of data between different areas, sites should be classified according to the scheme given in Table A1.4 above. In selecting site locations recognised siting criteria should be employed as far as possible (Box A1.2).

A1.107 The site should be located where relevant exposure is expected, or at least be representative of such exposure, for example at the same distance from a road as the façades of nearby residential properties. Details of site type and distance of nearby sources should be provided whenever results are reported. Details of the type and location of the monitoring sites used in the national monitoring networks are available on the AURN Site Information web pages at www.bv-aurnsiteinfo.co.uk.

A1.108 Local authorities often experience difficulties getting monitoring equipment installed at the preferred location. For automatic analyser enclosures, visual impact and planning permission are often major issues. Noise may also be a consideration. Practical problems such as power and telephone connection, access and security may also limit choice.

Siting issues specific to automatic monitoring sites

A1.109 In addition to the siting criteria listed in Box A1.2, a variety of practical considerations also apply when selecting monitoring sites for ***automatic*** stations.

- It should be practical for power and telephone connections to be made;
- The site should be accessible for a vehicle to deliver the housing;
- It should be reasonably easy for gas cylinders to be delivered close to the site and transferred to the housing without difficulty;
- There should be easy access to the site at all times;
- The site should be in an area where the risks of vandalism are minimal; and
- Account will need to be taken of visual impact and opportunities to "hide" the housing using pre-existing structures.

Box A1.2: Local Siting Criteria

- Sites should be in as open a setting as possible in relation to surrounding buildings.
- Immediately above should be open to the sky, with no overhanging trees, structures or buildings.
- To monitor human exposure, the sampling inlet should ideally be between 1.4 m and 4 m above local ground level. (2 m is usually the minimum practical to prevent tampering). Occasionally, it may be necessary to place the inlet at a greater height, for example to monitor exposure at heights above ground level.
- The site should not be close to local or point emissions sources, unless these have been specifically targeted for investigation.

For urban centre or background sites:

There should be no major sources of pollution (for example, a large multi-storey car park) within 50 m.

There should be no medium sized emission sources (for example, petrol stations, ventilation outlets to catering establishments etc) within 20 m.

Cars/vans/lorries should not normally or regularly stop with their engines idling within 5 m of the sample inlet.

An urban background site should ***not*** be within:

30 m of a very busy road (>30,000 vehicles/day)

20 m of a busy road (10,000-30,000 vehicles/day)

10 m of any other road (<10,000 vehicles/day)

To avoid disruption and allow long-term trends to be followed, no major redevelopment should be planned or expected in the surrounding area (within approximately 100 m of the site).

For traffic related sites:

Sites to be classified as "kerbside" should be within 1 m of the kerb.

Sites to be classified as "roadside" should usually be within 1-5 m of the kerb, although the distance can be upto 15 m in some circumstances.

For industrial sites

Where specific sources are being targeted, monitoring should be carried out at the point of maximum impact as determined by modelling.

A1.110 The analysers can be housed in a free-standing enclosure or in a suitable building. In either case, the inlet manifold should be positioned so that any buildings or structures do not impede the free flow of air around the sampling inlet. The housing should use air conditioning, or other means, to maintain a temperature of approximately 20°C ±5.

Planning permission

A1.111 Planning permission is often required for monitoring enclosures. This is normally obtained from the relevant local or district council or from the highways authority. It may also be necessary to obtain permission from the relevant utility provider to site diffusion tubes on street lamps and telegraph poles etc.

A1.112 ***In the specific case of Northern Ireland, a Street Works Licence is required to erect an air quality monitoring station.*** Under Planning, General Development Order NI 1993 No. 273, part 12, page 30; District Councils can erect the equipment under Permitted Development if:

1. it is used for a function of the Council ie environmental health;
2. it does not exceed 4 m in height;
3. it does not exceed 200 m^3 in capacity.

A1.113 .The placing of any apparatus in a street in Northern Ireland is subject to the provisions of the Street Works (Northern Ireland) Order 1995 (hereinafter referred to as "the Order") and the Regulations and Codes of Practice made or issued thereunder. Copies of the Order, Regulations and Codes of Practice are available from the Stationery Office. A Street Works Licence is required by any person or organisation who wishes to place or retain apparatus in a street, and thereafter inspect, maintain, adjust, repair, alter or renew the apparatus, change its position or remove it, unless the person or organisation has a statutory right to do so. Any person who carries out such works without a Street Works Licence or a statutory right is committing an offence and liable on summary conviction to a fine. The person granted a Street Works Licence, becomes an Undertaker for the purposes of the Order, and therefore attracts the relevant duties and responsibilities imposed by the Order and its associated Regulations and Codes of Practice. Under current legislation District Councils do not have a statutory right to erect air quality monitoring stations and therefore require a Street Works Licence. In order to obtain a Licence the Council should initially contact the local Roads Service Development Control Section to agree the siting of the station. Following agreement, the applicant should contact the local Roads Service Section Office to have a Licence issued. All applications should be submitted at least one month in advance of the commencement of the proposed works and should be accompanied by the relevant payment.

Siting and fixing of nitrogen dioxide diffusion tubes

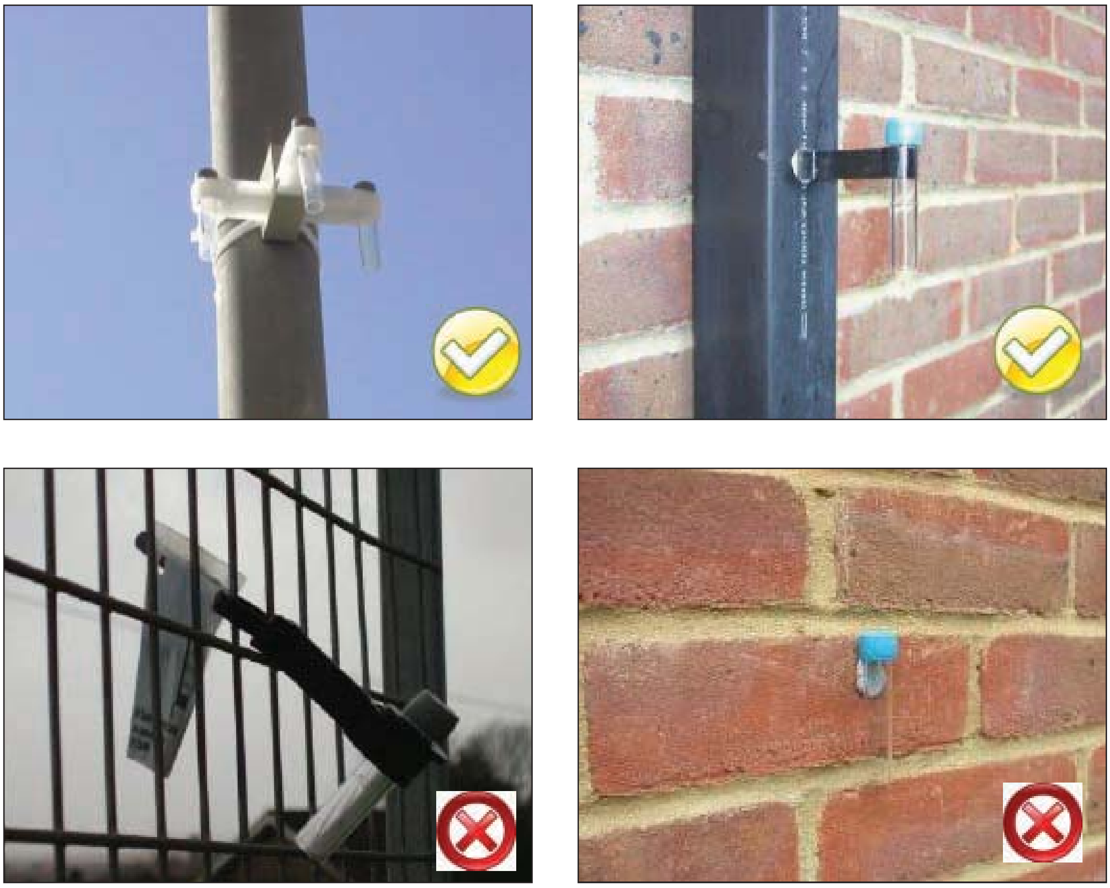
A1.114 The local siting criteria in Box A1.2 above are applicable to diffusion tubes as well as automatic sites. Although it is important to place diffusion tubes where there is free circulation of air around the tube, the opposite extreme should also be avoided, ie, areas of higher than usual turbulence. For this reason, the tube should not be located on the corner of a building. Care must be taken to avoid any very localised sources, or sinks of NO_2, or disturbances to the airflow. For example, close proximity (less than 10 m) to the following must be avoided:

- heater flues (particularly low level balanced flues);
- bushes or trees overhanging or surrounding the tube location;
- air conditioning outlets;
- extractor vents; or
- underground ventilation shafts.

The site should be open to the sky, with no overhanging vegetation or buildings.

A1.115 It is important that diffusion tubes are properly positioned. Some examples of right and wrong ways to fix diffusion tubes in place are shown in Figure A1.2. The tube must be vertical, with the open end downwards. It is important that the open end of the tube is exposed to free circulation of air. Avoid placing diffusion tubes in any form of recess. A permanent clip (for example Terry clip or plastic clip) should be mounted so that the tubes can be changed easily. Also, certain surfaces may act as absorbers for NO_2, leading to a thin layer of reduced atmospheric concentrations immediately adjacent to the surface. For these reasons tubes must not be fixed ***directly*** to walls etc, even when the objective is to monitor at a building façade. A spacer block of at least 5 cm may be used between the surface and the tube. This may be of wood or plastic, and the open end of the tube must be located below its lower surface.

Figure A1.2: Examples of right and wrong ways to expose diffusion tubes



A1.116 It is not common practice in the UK to expose diffusion tubes inside any kind of box or shelter, although such shelters are used in some other European countries. If shelters are used, they should be used at ***all*** sites in the survey (including any co-located with automatic analysers). The findings of any such co-location studies, in terms of diffusion tube precision and accuracy compared to the automatic analyser, may not be applicable to cases where shelters are not used.

Site numbers

A1.117 Monitoring is normally undertaken in order to evaluate pollutant behaviour in both space and time. A good programme design should therefore seek to optimise both spatial and temporal coverage, within available resource constraints. The number and distribution of monitoring sites and samplers required for reviewing and assessing air quality depends on the degree of public exposure in the area to be covered, the spatial variability of the pollutants being measured and the required data usage. In general, automatic monitoring will only need to be carried out at one or two strategically located sites. This monitoring can be supported by the use of diffusive or other indicative samplers distributed over a wide area around the automatic site. Particularly in the case of NO_2, it is recommended that diffusion tubes are co-located (in triplicate if possible) with the automatic monitors, to quantify any bias in the diffusion tube measurements. The most important locations are those at which concentrations are expected to be high, and where the public may be exposed over the averaging times specified in the prescribed objectives.

Frequently Asked Questions on monitoring locations

Where should I try to locate my monitors to measure urban background concentrations?

A1.118 At urban locations distanced from major sources (typically greater than 50 m) and therefore broadly representative of city-wide background conditions, for example, parks, pedestrianised areas and urban residential areas.

Where should I try to locate my monitors for investigating road traffic emissions?

A1.119 Firstly look for areas with relevant public exposure (see Box A1.2). Initially, you could carry out a survey using passive or active samplers and/or portable monitors over a variety of roadside locations. For a more detailed study you would ideally monitor at roadside and background locations using automatic techniques, supplemented by indicative measurements such as passive samplers or portable monitoring. Try to site the monitors as near to the point of public exposure as possible, for example at the building façade for residential housing. It is important (for model validation in particular) to cover a range of urban background and roadside or kerbside sites if possible. Highest concentrations are likely to be recorded near busy roads, along congested streets or at congested traffic junctions.

Where should I try to locate my monitors for investigating emissions from point sources?

A1.120 Firstly, look for areas where public exposure to air pollution takes place over the relevant averaging period for the pollutants of concern (see Box A1.2). Initially you could carry out a survey using indicative techniques (for example, passive samplers or portable monitors), over a variety of locations including the point of modelled maximum impact. Then you would ideally look at the modelled point of maximum impact with automatic monitors in conjunction with ongoing sampler and portable monitoring. It will be difficult to ensure that you monitor at the point of maximum impact, as this is likely to move from year to year, and is unlikely to be identified accurately by modelling.

Once I've identified a suitable area for monitoring, what do I need to take into consideration when locating a specific site?

A1.121 For automatic analyser enclosures, visual impact or intrusion and noise may be a consideration. Practical problems such as power and telephone connection, access and security may also limit your choice. Assuming that these concerns are satisfied, a monitoring site will be representative if not enclosed by surrounding buildings or covered by overhanging vegetation. Ideally, sampling air at a height of between 1.4 m and 4 m is recommended. Monitoring close to local or point source emissions, unless these have been specifically targeted for investigation, is not recommended.

Duration of monitoring survey

A1.122 Concentrations of some pollutants exhibit seasonal patterns, so all surveys should ideally be carried out for a minimum of six consecutive months (three in summer and three in winter, for example January to June or July to December), to ensure they are representative of the full year. However, for practical or economic reasons it may in some cases only be possible to carry out a three-month survey. These still provide very useful information, especially if long-term datasets are available for comparison, from one or more nearby urban background monitoring sites.

A1.123 Figure A1.3 shows an examination of the ratio between short-term means and annual mean NO_2 concentrations, based on data from 2001 – 2006, measured at five automatic urban background sites in the AURN (London Brent, West London, Bournemouth, Portsmouth and Walsall Alumwell). This shows that for NO_2 it is better to start a six-month survey in January or July. A three-month survey is best started in March, or failing that, August or September.

A1.124 Figure A1.4 shows the same analysis, for PM_{10}. Again, the data used are from 2001- 2006, measured at five urban background sites in the AURN (London North Kensington, Northampton, Portsmouth, Preston and Southend on Sea). The seasonality is less pronounced, with the 3-month mean consistently within 5% of the annual mean, and the 6-month mean consistently within 3% of the annual mean. The choice of start month is therefore much less critical in the case of PM_{10}.

A1.125 Please note that the seasonal patterns may be different for roadside sites, or those affected by specific emission sources. Therefore, the above analyses may not be applicable for such sites.

Figure A1.3: Ratio of short-term mean to annual mean Nitrogen dioxide concentrations for urban non-roadside sites

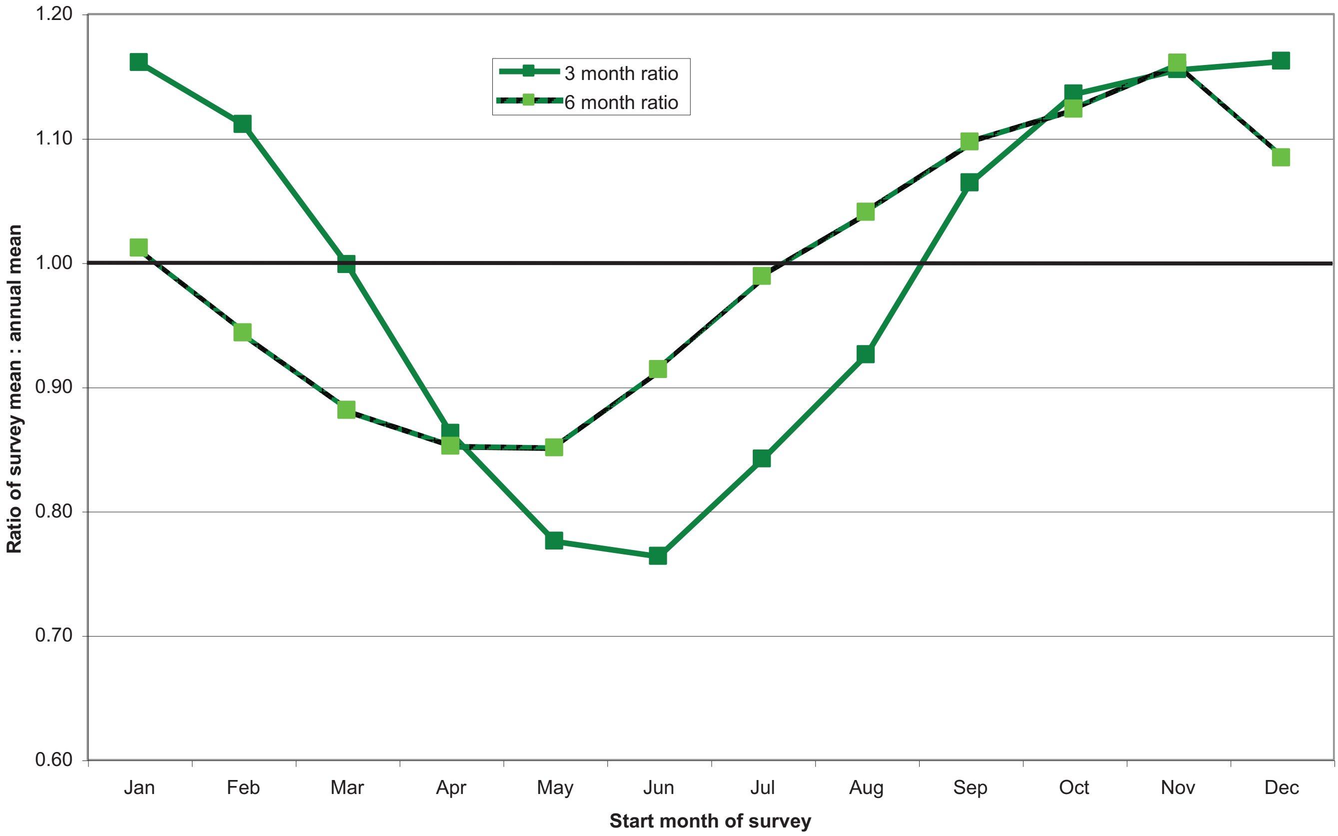
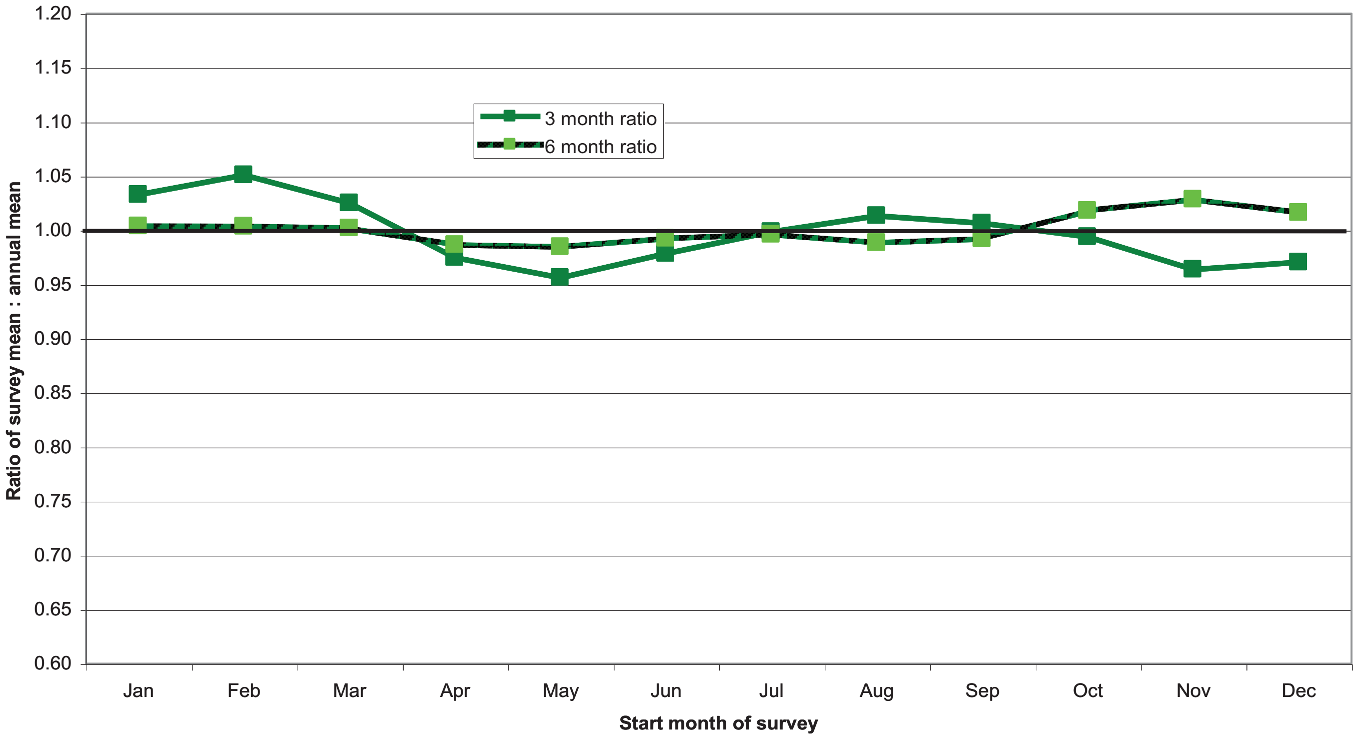


Figure A1.4: Ratio of short-term mean to annual mean PM_{10} concentration for urban non-roadside sites



A1.126 The length of a survey may also depend on the Air Quality Objective with which the data are to be compared. For comparison with the annual mean NO_2 or PM_{10} objective for example, a three month survey may be sufficient, whereas for objectives based on peak concentrations (for example the 99.9th percentile of 15-minute mean SO_2 concentrations, then ideally the survey duration should be a full year. Also, it may become apparent after three months or six months that concentrations are well below the relevant objective, at which point it may be judged that sufficient data have been obtained to establish that an exceedence is very unlikely.

A1.127 If long-term datasets are available from one or more nearby monitoring sites (ideally, ones within the AURN), it is possible to estimate annual mean concentrations from a short-term dataset. An example of how to do this is shown in Box 3.2 of the Main Document. However, it should be noted that such estimates should be used for indicative purposes only, as they can be subject to considerable uncertainty. The shorter the short-term study, the more uncertainty there is likely to be. It is recommended that the procedure in Box 3.2 should only be used with short-term surveys of at least three months.

A1.128 For NO_2 diffusion tubes, an earlier examination[57] of the ratio of short-term average to annual mean concentrations, as measured by NO_2 diffusion tubes at urban background sites, showed that it is best to start a six-month survey in January or July, and a three-month survey in February or July. Six-month means showed an average variation from the annual mean of up to 20%, while three-month means showed an average variation from the annual mean of upto 30%.

[57] D Laxen, P Wilson "Compilation of Diffusion Tube Collocation Studies Carried out by Local Authorities" Report prepared by Air Quality consultants on behalf of Defra and the Devolved Administrations, Nov 2002.

Monitoring for Updating and Screening Assessment

A1.129 In the context of Updating and Screening Assessments, wide-scale screening using simple monitoring techniques may be undertaken. Integrating measurement methods such as passive samplers, although fundamentally limited in their time resolution, are useful for a variety of area-screening, exposure assessment, and network design functions. Site numbers and distribution should be selected so as to maximise data on the spatial distribution of pollutant concentrations.

A1.130 The sites selected may need to target both source-oriented monitoring locations (often synonymous with worst-case or "hot-spot" locations) and background locations optimised for quantifying general population exposure. Depending on the pollutants under assessment, data from a wide variety of location types may be necessary to build up a reasonably complete picture of ambient exposure patterns. The general siting criteria given in Box A1.2 should be applied to the siting of individual samplers.

Use of mobile monitoring stations

A1.131 Automatic monitoring instruments may be installed in a mobile vehicle or other portable monitoring facility and deployed for short-term monitoring campaigns at a range of locations. The main application for mobile monitoring is for screening studies and to locate "hot-spots". This type of study is particularly effective when carried out in conjunction with permanent fixed-site automatic monitoring studies. In practice in can be difficult to move the mobile station to a range of locations for short periods unless the necessary services (for example electricity and telephone) are in place. The data require careful interpretation since very short-term monitoring can give a poor representation of longer-term averages.

Use of portable monitors

A1.132 To help select suitable monitoring locations, portable hand-held monitors can be used to obtain a "snapshot" of pollution concentrations over a wide area. They are particularly useful for estimating impacts at sites of likely high concentration, for example kerbsides and industrial point sources. Such monitors can be linked to Global Positioning Systems (GPS) and Geographical Information Systems (GIS) to provide further enhanced information.

Monitoring for Detailed or Further Assessments

A1.133 If an Updating and Screening monitoring programme indicates that pollutant concentrations may exceed the Air Quality Objectives, then the Detailed or Further Assessment monitoring must be carried out using methods which are capable of time resolution consistent with the pollutant averaging times specified in the objectives.

A1.134 Continuously operating automatic analysers may be used to make assessments against short or long-term objectives. Screening assessments should provide information on the likely locations where the air quality objective for the pollutant of concern may be exceeded. This information can be used to select a monitoring site for detailed studies using automatic monitors.

A1.135 Please also refer to Para A1.109, for practical siting issues specifically relating to automatic monitoring sites.

Routine site operations

A1.136 An on-going programme of routine site operations for automatic stations will include regular site visits to:

- carry out site checks on equipment, sampling systems, safety and security
- perform manual equipment calibrations if necessary
- carry out routine equipment maintenance and repair where necessary
- change diffusion tubes or sampler solutions.

A1.137 The frequency and type of field calibrations required for automatic analysers should be defined in a Quality Assurance Programme for the site or network. A comprehensive calibration record and instrument checklist should be completed after each site visit and retained for subsequent QA/QC auditing. Details of calibration procedures and examples of suitable calibration sheets are available in the Automatic Urban Network Site Operator's Manual which is found at www.laqmsupport.org.uk/empire/lsoman/lsoman.html.

Typical monitoring costs

A1.138 As well as purchase of equipment there are other costs associated with a monitoring programme including:

- ***Staff costs - site operation.*** Frequent documented site visits are an essential component of air monitoring. The frequency of visits required will depend on the type of monitor being used. For instance, certain older types of gravimetric PM_{10} monitor may require daily site visits (although newer versions incorporate automatic filter exchange mechanisms which allow the instrument to operate unattended for upto two weeks.) Filter changing and filter weighing for gravimetric samplers can involve a lot of staff time. Nitrogen dioxide diffusion tubes are usually changed on a monthly basis and returned to a laboratory for analysis: other types of passive samplers may need to be replaced at 1,2 or 4 weekly intervals. For automatic analysers, telemetry systems can provide an efficient and cost-effective method for data acquisition, but do not obviate the need for regular visits by operators. These should, in fact, be performed as frequently as operational needs, geographical constraints and available manpower permit. The national Automatic Urban Network sites are visited routinely every two weeks.
- ***Staff costs - data processing.*** Automatic analysers produce large quantities of data, which need to be collected efficiently and stored for subsequent analysis. Although passive and active sampler methods produce much less data than automatic continuous methods, large monitoring surveys can soon accumulate large datasets which become unmanageable if not efficiently processed and archived.
- ***Equipment maintenance.***To ensure optimal performance from monitoring sites, all equipment should be fully serviced, preferably at six-monthly intervals, according to the instrument manufacturer's recommendations. In addition to routine servicing, provision should be made for emergency "call out" breakdown or repair visits from the service unit, in order to minimise equipment down-time.

A1.139 Ultimately, the cost of an automated air quality monitoring programme will depend on many different factors, including location, range of pollutants monitored and of course the duration of the programme. Table A1.5 shows a range of scenarios with approximate costs (at the time of writing).

Quality Assurance and Quality Control

A1.140 A documented quality assurance and control programme must be followed in order to ensure robust and reliable measurements. Typical QA/QC programmes include an established schedule of regular site calibrations, validation of data, and documentation of all procedures. Details of site quality assurance procedures are given in the AURN Site Operator's Manual at www.laqmsupport.org.uk/empire/lsoman/lsoman.html

Collection, ratification and reporting

A1.141 An ongoing resource commitment to QA/QC is required in any monitoring survey, to ensure that measurements fully comply with the requirements of the Review and Assessment process and are therefore fit for purpose.

Table A1.5 Approximate Costs of Monitoring Activities

Project Task	Estimated Cost
Six-month to one year monitoring survey contracted "all-inclusive" to specialist consultancy.	**£10k – £25k** depending on duration, reporting requirements and number of pollutants.
Purchase and installation of single gas-analyser in existing building with power and phone line already available.	**£10k – £15k**
Purchase and installation of multi-pollutant site including PM_{10} in purpose-built enclosure. Power and phone to be connected, calibration gases to be purchased, data collection software to be purchased.	**£50k – £75k**
Annual "all-inclusive" service and maintenance costs.	**£3 – 8k** per site
Annual data management and QA/QC costs.	**£5 – 10k** per site
Annual staff costs for site visits.	**£5 – 10k** per site
Annual cost of electricity/phone.	**£2 – 3k** per site
Web site commissioning costs.	**£3 – 10k** depending on sophistication.
Annual software and web site maintenance fees.	**£1 – 2k**
Annual filter weighing costs for gravimetric PM_{10} monitoring.	**£3 – 10k** per year depending on number of filters, reporting requirements, source apportionment analysis.

A1.142 The fundamental aims of a QA/QC programme are as follows:

- Data should be representative of ambient concentrations in the area under investigation.
- Measurements need to be sufficiently accurate and precise to meet the defined monitoring requirements.
- Data must be intercomparable and reproducible. Results from multi-site networks need to be internally consistent and comparable with national, international or other acceptable standards.
- Measurements should be consistent over time, particularly if long-term trend analysis is to be undertaken.

Data Quality Objectives

A1.143 Proper QA/QC practice is necessary to ensure data integrity and guarantee the data quality required for meeting the overall monitoring objectives. Fundamental data requirements are:

- accuracy;
- precision;
- data capture;
- traceability to national/international metrology standards; and
- long-term consistency.

A1.144 Accuracy and precision may be defined as follows.

- **Accuracy** is "the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value".
- **Precision** is the "closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions".

A1.145 The overall uncertainty in any air quality measurement is the combination of accuracy and precision errors. Since accuracy is expressed as a percentage error, its significance for overall uncertainty increases at higher concentrations. At very low concentrations, close to the instrument baseline, the contribution of accuracy errors to total uncertainty is reduced and the overall uncertainty estimate is dominated by the precision error, which is constant at all concentrations.

A1.146 Data quality objectives for specific pollutants – taken from EC Directives – are provided in Table A1.6 to help assess the overall confidence in the conclusions of any Review and Assessment. They are intended to indicate the degree of confidence that can be placed in any particular monitoring result if the quality assurance and quality control procedures for the method are properly undertaken. (Local authorities are not required to calculate accuracy levels.) The accuracy percentages in Table A1.6 relate to twice the standard deviation of the mean of the individual measurements, averaged over the period of the relevant air quality objective.

Table A1.6 Data quality objectives

Pollutant	Accuracy %
Benzene	±25
1,3-butadiene	±25
Carbon Monoxide	±15
Lead	±25
Nitrogen dioxide	±15
PM_{10}	±25
Sulphur dioxide	±15

A1.147 For indicative monitoring techniques (such as diffusion tubes for NO_2 and benzene), the EC Directives set an accuracy objective of ±25%.

Quality Assurance and Quality Control of automatic monitoring data

A1.148 The overall uncertainty of a given measurement is calculated from the individual uncertainties for various aspects of the monitoring method. For an automatic monitoring method these include:

- precision of the analyser;
- linearity errors of the analyser;
- uncertainty of the gas standards; and
- stability of the output signal.

A1.149 In order to minimise measurement uncertainty of monitoring programmes it is important to apply stringent QA/QC procedures, such as those laid down for the UK automatic monitoring networks.

A1.150 For gaseous pollutants (CO, NO_2, SO_2) the analysers should ideally be housed in an air-conditioned room, hut or trailer, and operated according to the manufacturers' instructions and the requirements of the appropriate CEN standard. The analysers should be calibrated at least once every two weeks for kerbside and roadside sites, four-weekly for all others. The calibration should be performed with zero air from a zero air cylinder or chemical scrubber, and standard gas mixtures from certificated gas cylinders. The 15-minute averaged data should be collected and scaled using the best available calibration factors. Independent audit checks on monitors, gas standards and site operational procedures may be beneficial when using these highly complex analysers.

Calibration methods

A1.151 Automatic instruments generate electrical response signals corresponding to the concentration of pollutants in the air. In order to correctly scale the analyser response, it is necessary to calibrate it using a gas mixture of known concentration. Calibrations can be conducted at a number of levels:

- daily "automatic" calibration;
- frequent (weekly/fortnightly/monthly) manual calibrations;
- periodic (for example three to six monthly) reference calibrations.

Calibration Standards

A1.152 In order to ensure reproducible data quality, automatic monitoring instruments must be properly calibrated using reliable and traceable calibration standards. Gas mixtures at near-ambient concentrations should be used for on-site or remote calibrations of point source monitoring equipment. These mixtures should be verified independently by a suitable calibration laboratory. The manufacturers' certificates may not always offer the accuracy and traceability required for the calibration of automatic monitoring instruments. Gas cylinders provide a convenient means for calibrating NO, NO_2, SO_2 and CO instruments and are commercially available from a number of established suppliers. Dilution systems can be used with high concentration gas cylinders. A list of gas standard suppliers is available from the Local Authority Air Quality Support Helpdesk.

A1.153 All calibration gases and analytical techniques applied to monitoring methods should be accredited to a recognised standard, for example, UKAS or EN 45001. Box A1.3 shows some examples of convenient calibration gas mixtures.

A1.154 Low-concentration gas mixtures in cylinders cannot be guaranteed to be stable over the long-term. Hence, It is recommended that the concentration of these gases are checked by independent audit every six months, as in the UK national monitoring networks.

Box A1.3: Convenient calibration gas mixtures for urban monitoring sites:

0.5 ppm (parts per million by volume) NO in N_2

0.5 ppm NO_2 in air

0.5 ppm SO_2 in air

20 ppm CO in air

Equipment service and maintenance

A1.155 To obtain meaningful long-term average measurements, it is important to ensure that a high level of data capture is obtained. Any data loss should, where possible, be evenly distributed throughout the year. For this reason, equipment service engineers must undertake any necessary repairs promptly. Any sophisticated automatic monitoring system will require an adequate programme of equipment maintenance and support. Maintenance schedules for the replacement of consumable parts, diagnostic checks and equipment overhaul should in all cases follow manufacturer's recommendations. Routine and non-routine service visits must be fully documented to describe in detail any adjustments, modification or repairs undertaken. The exact service schedule and level of documentation should be agreed as part of the service contract. An example of a service contract specification for an automatic monitoring station can be found in the AURN Local Site Operator's Manual at www.laqmsupport.org.uk/empire/lsoman/lsoman.html.

A1.156 Results of the analyser tests or calibrations performed during the service should be recorded. For active samplers, pumps, meters and valves etc need to be regularly calibrated and maintained. Routine service and maintenance activities should be scheduled outside periods when high pollutant concentrations may be expected. More details on equipment support are given in the subsequent sections of this Annex.

Data capture

A1.157 Only if acceptable data quality and high capture rates are achieved can the performance be regarded as fully satisfactory. A data capture rate of 90% for ratified (ie, usable) data is specified in the relevant EC Directives and is recommended as a target for automatic monitoring. These data capture rates do not include losses due to regular calibration or maintenance of the instrument. Any down-time for the samplers should be evenly spaced through the monitoring period to ensure maximum temporal coverage.

A1.158 Although some data loss due to analyser failure is unavoidable (short of deploying backup instruments), most other failure modes can be minimised by use of the correct procedures (Box A1.4).

Box A1.4: Procedures to minimise data loss

- Deployment of proven analyser types
- Proven site infrastructure and system backup
- Experienced site operators
- Comprehensive and documented site operational protocols
- Regular application of these protocols
- Efficient data telemetry (enabling on-site problems to be identified rapidly)
- Backup data storage media on-site
- Rapid servicing, maintenance and repair

Data processing

A1.159 ***Data processing - Sampler systems*** For diffusion tube and passive sampler systems, data processing is heavily dependent on manual recording of data on exposure times and sampling volumes. It is, therefore, important that the operators involved are properly trained and accurately record the necessary information.

A1.160 ***Data processing - Automatic systems*** Automatic analysers record the concentration of pollutants as a continuous analogue voltage or digital output signals. The signal is averaged over a certain time period (for example, 15-minutes or hourly averages). This averaging process can be implemented by a data logger which may be built into the analyser or as a free-standing unit. The data stored on the logger can then be downloaded directly onto a computer or collected via a modem and telephone line.

A1.161 Once automatic data have been collected, they have to be converted from raw values to more useful pollutant concentrations. This may be carried out either automatically on site or after collection of data from the monitoring station. The conversion is achieved using zero and span "calibration factors". Calibration factors are estimated from the regular calibrations carried out by the site operator. The two-point calibration will quantify the analyser "zero" and "span" response.

A1.162 The zero response, Vz, is the response in measurement units of the analyser when the pollutant species being measured is not present in the sample airstream. The span response, Vs, is the response of the analyser to an accurately known concentration, c, in ppb, (volume parts per billion) of the pollutant species. Both the zero and span responses will be taken on the concentration range at which the instrument normally operates. Instrument zero and span factors are then calculated using these data as follows:

- Instrument zero = Vz
- Instrument sensitivity, F = c/(Vs-Vz)

Ambient pollution data are then calculated by applying these factors to logged output signals as follows:

- Pollutant concentration (ppb) = F(Va-Vz)

- where Va is the recorded signal from the analyser sampling ambient air. Application of calibration data in this way assumes that the instrument response is linear over the whole concentration/voltage range in use. For comparison with the objectives, concentrations should be converted to the appropriate units using the factors in Box A1.5.

Box A1.5: Conversion Factors for Gaseous Pollutants at 20°C and 101.3 kPa	
Carbon monoxide (CO)	1ppm = 1.16 mg/m^3
Benzene	1ppb = 3.25 µg/m^3
1,3-Butadiene	1ppb = 2.25 µg/m^3
Nitric Oxide (NO)	1ppb = 1.25 µg/m^3
Nitrogen Dioxide (NO_2)*	1ppb = 1.91 µg/m^3
Sulphur Dioxide (SO_2)	1ppb = 2.66 µg/m^3
Ozone (O_3)	1ppb = 2.00 µg/m^3

* Oxides of nitrogen (NO_X) are expressed as NO_2, ie NO ppb + NO_2 ppb x 1.91 = NO_X µg/m^3

A1.163 The conversion factors are given at a temperature of 20°C and pressure of 101.3 kPa (1 atmosphere), as the Air Quality Strategy Objectives, and the EC Limit Values from which many of them are derived, require mass concentrations to be reported at these conditions.

Data validation and Ratification

A1.164 ***Data validation*** After applying the calibration factors, it is essential to screen the data, by visual examination, to see if they contain spurious and unusual measurements: this is how equipment faults or episodes of exceptionally high pollution are detected. Errors in the data may occur as a result of equipment failure, human error, power failures, interference or other disturbances. Any suspicious data, such as large spikes or spurious high concentrations can be "flagged" or marked to be investigated more fully. this process is known as validation. It is important to retain the original "raw" data-set in case it is necessary to re-examine the original measurements at a later date.

A1.165 ***Data ratification*** Data validation must be followed by more thorough checking at three or six month intervals to ensure that they are reliable and consistent. This latter process is called data "ratification". Essentially, the data ratification procedure involves a critical review of all information relating to a particular data set, in order to verify, amend or reject the data. A wide range of inputs need to be considered in the ratification process (Box A1.6). When the data have been ratified, they represent the final data set to be used in the Review and Assessment process. It is therefore important that the ratification process is undertaken very carefully. Steps in the ratification process include:

- Examination of calibration records to ensure correct application of calibration factors;
- Examination of data for other pollutants and monitoring sites to highlight any anomalies;
- Deletion of data shown from chart or other records to be spurious, for example, spikes generated by the analyser;
- Correction of any baseline drift as indicated by examination of daily automatic calibration records;
- Examination of any local scale changes to the site environment, for example, roadworks to account for any unexpected variations in concentration;
- Application of correction factors from QA/QC audits, for example, cylinder concentration changes.

A1.166 Figure A1.5 presents a time series of 15 minute SO_2 data as raw millivolts from an urban site which shows a large zero baseline offset and step changes in concentration following calibration visits. After correction has been made for these at the data ratification stage the data are usable for comparison with the Air Quality Strategy objective (Figure A1.6).

Box A1.6 Factors to be taken into consideration during data ratification:

Instrument history and characteristics. Has the equipment malfunctioned in this way before?

Calibration factors and drift. Rapid or excessive response drift can make data questionable.

Negative or out of-range data. Are the data correctly scaled?

Rapid excursions or "spikes". Are such sudden changes in pollution concentrations likely?

Characteristics of the monitoring site. Is the station near a local pollution sink or source which could give rise to these results?

Effects of meteorology. Are such measurements likely under these weather conditions?

Time of day and year. Are such readings likely at this time of day/week/year?

The relationship between different pollutants. Some pollutant concentrations may rise and fall together (for example, from the same source). **Figure A1.7** shows a time series of data for a range of pollutants for CO, NO_X, SO_2, O_3 and PM_{10} measured at an urban centre site. The patterns are generally consistent for CO, NO_X and PM_{10} which would be expected, for these vehicle derived pollutants.

Results from other sites in the network. These may indicate whether observations made at a particular site are exceptional or questionable. Data from national network or other sites in the area can be compared for a given period to determine if measurements from a particular station are consistent with general pollution concentrations. If any high concentrations are identified (seen as spikes) at the local site, further examination is required. **Figure A1.8** shows a comparison of PM_{10} concentrations measured in the London area in November 1998. The plots show that the pollution profile is generally consistent but occasional peaks are site specific.

QA Audit and Service reports These will highlight any instrumental problems and determine if any correction of the data is necessary for long-term drift etc.

Figure A1.5: Raw unratified data set

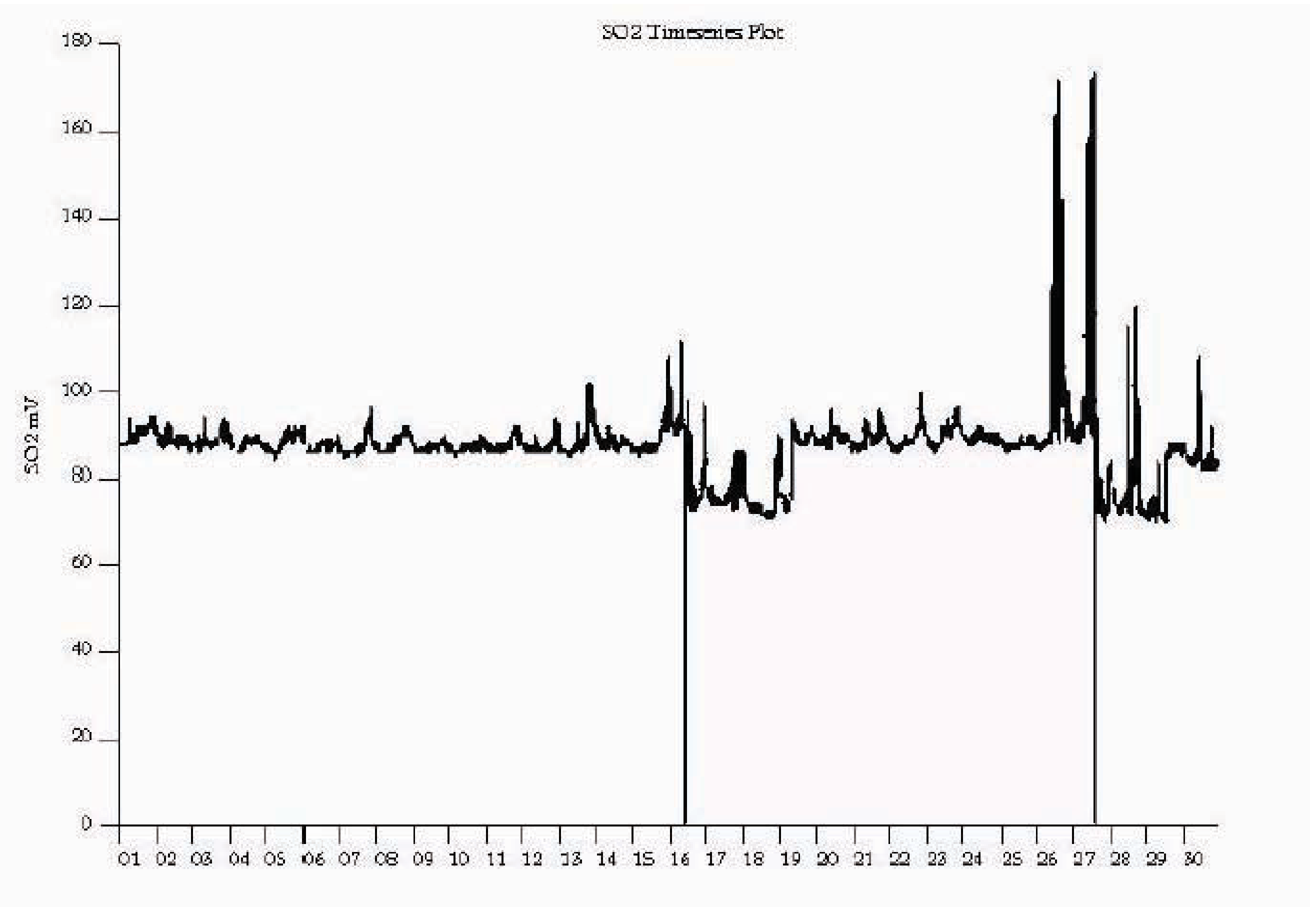


Figure A1.6: Fully ratified data

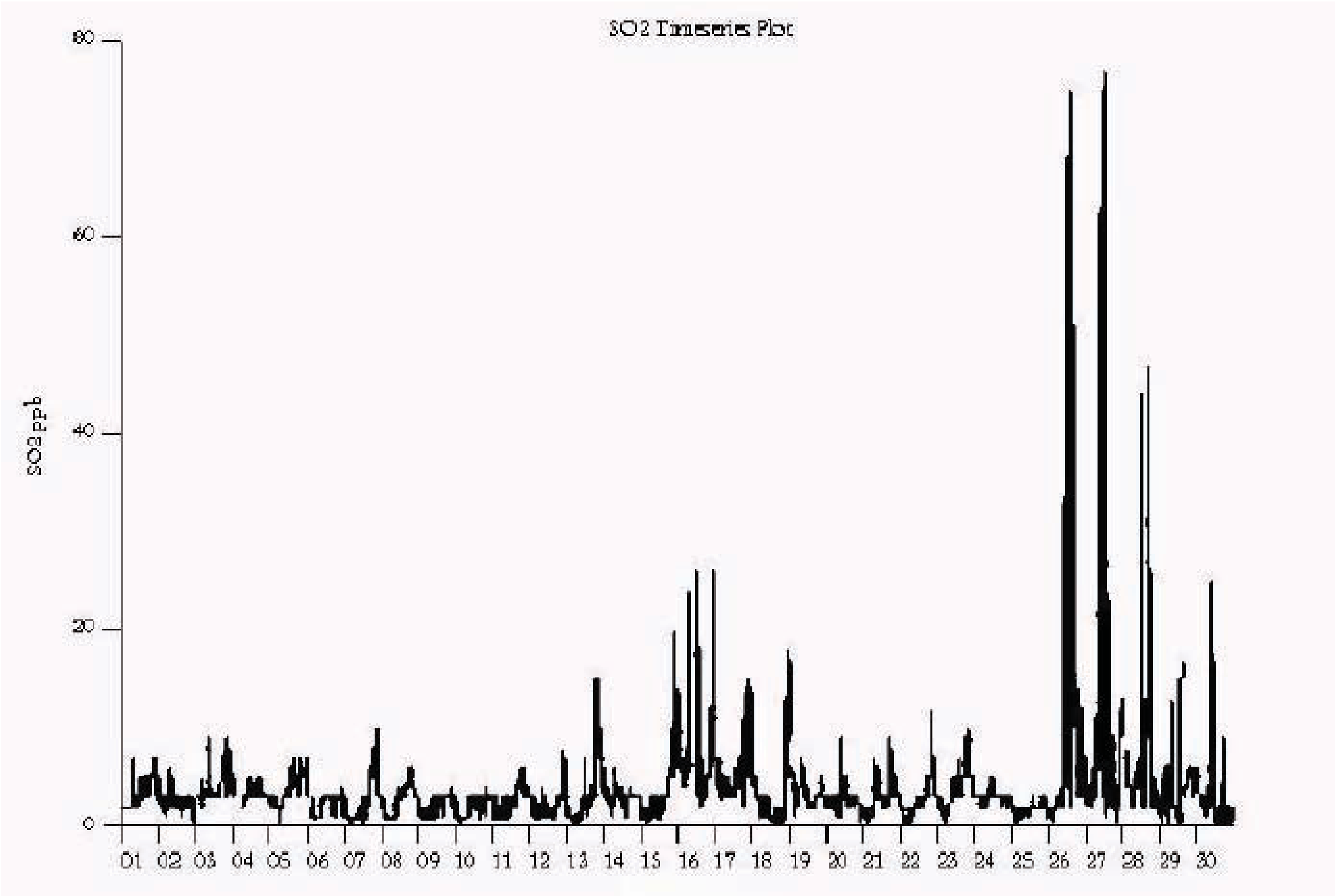


Figure A1.7: Pollutants measured at an urban centre site; illustration of comparing patterns for different pollutants at the same site

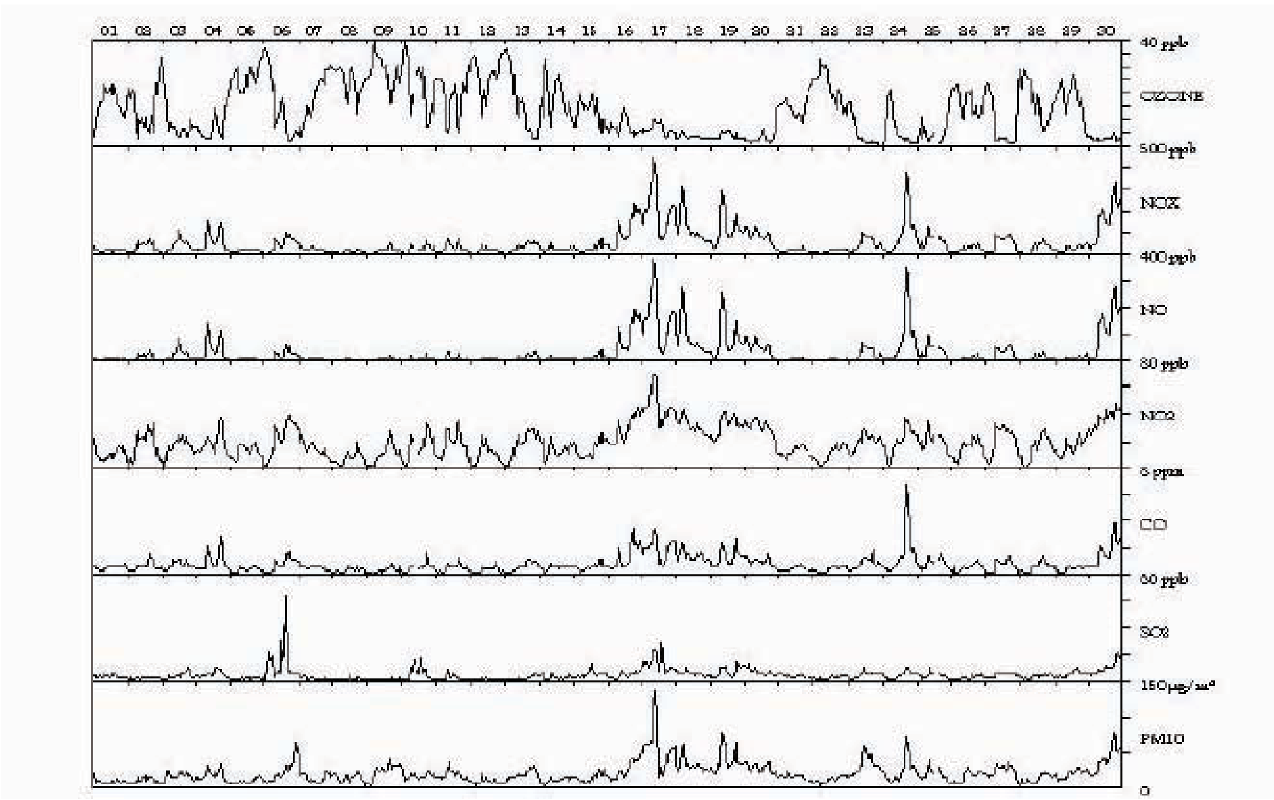
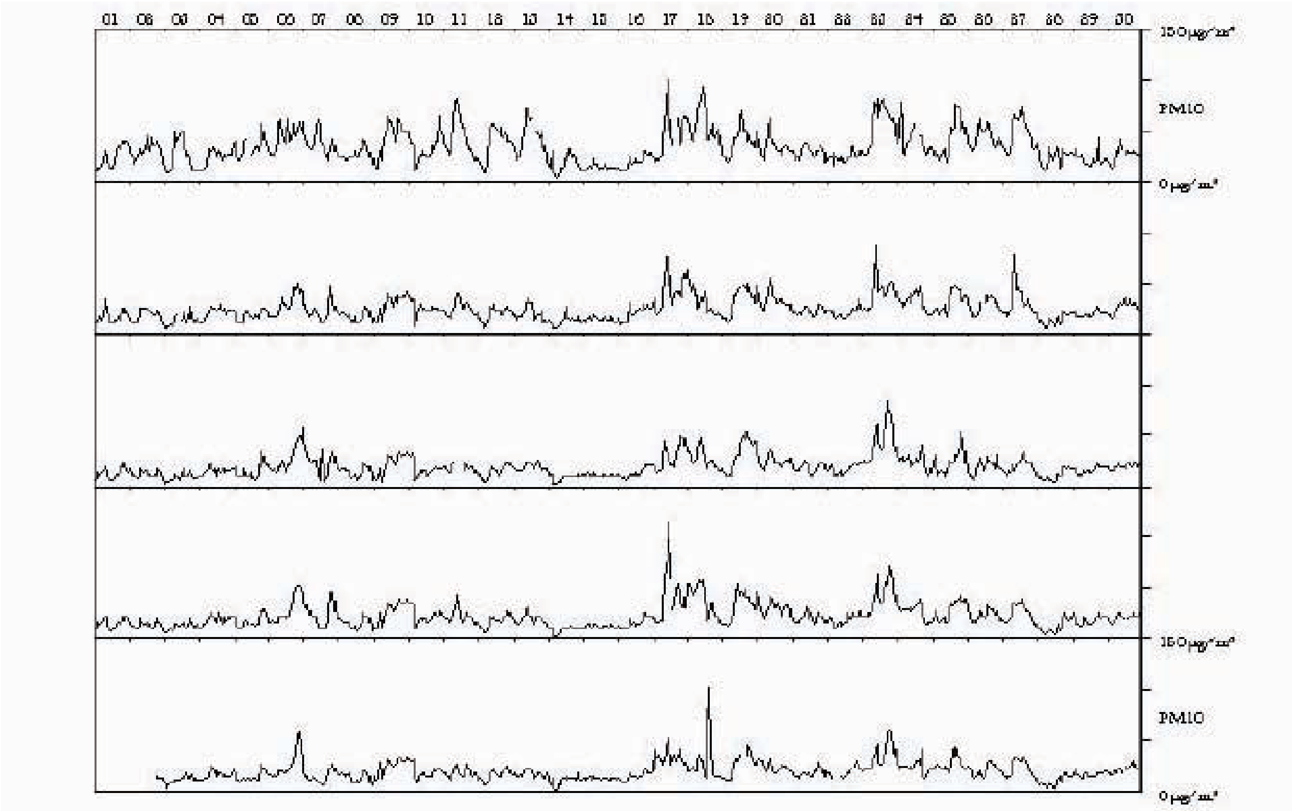


Figure A1.8: PM10 measurements at a range of automatic sites; illustration of comparing patterns for a given pollutant at several sites in the same region.



A1.167 Records of calibration and services visits should be used to aid interpretation if anomalous peaks are seen. Records of daily automatic calibrations, if available, can be used to identify any long-term drift in the output of the instrument and correction factors applied as appropriate.

A1.168 Ratification is an important data management process, ensuring measurements are credible, reliable and for the purpose of Review and Assessment or any other monitoring objectives. The effort and skill level required for data ratification should not be under estimated. Several environmental consultancies can assist with this process, under contract, if required.

Quality Assurance and Quality Control for Particulate Matter monitoring

Quality Assurance and Quality Control procedures for automatic PM_{10} monitoring

A1.169 The analysers should be operated in accordance with the manual for the equipment utilised. The sampling heads should be cleaned regularly and sample flow rates measured as recommended in the manual. Suitable calibration factors need to be calculated for some monitors such as light scattering devices. Data from some analysers may also need to be re-scaled in order to compare with the objectives of the Air Quality Strategy. The Local Authority Air Quality Support or Review and Assessment Helpdesks should be contacted for more information.

A1.170 For operators of the Partisol 2025 gravimetric sampler, the Met-One BAM and the FDMS, further guidance can be found in the Site Operators' Manual, produced by Defra for the operators of AURN sites. This can be found at www.laqmsupport.org.uk/empire/lsoman/lsoman.html.

Quality Assurance and Quality Control procedures for gravimetric PM_{10} monitoring

Filter Materials

A1.171 There are a number of materials used for filters in gravimetric samplers, for example, PTFE, quartz fibre and PTFE-coated glass fibre. While the present CEN standard EN12341 specifies quartz filters, current drafts of the new PM_{10} CEN standard (which is to replace it) do not recommend any specific filter material. Detailed comparison exercises undertaken by NPL have shown that different types of filters differ from each other in their collection efficiencies and in their water absorption characteristics. These differences will affect reported measurements from any gravimentric sampler. NPL's study, published in 2005, concluded that PTFE-bonded glass fibres (Emfab) performed best and were therefore most suitable for monitoring ambient particulate matter[58]. Whichever filter material is selected, it is recommended that operators use the same type of filter consistently throughout any monitoring survey.

Filter Conditioning and Weighing

A1.172 Filter conditioning and weighing should be carried out to BS-EN12341, which includes control of the weighing room atmosphere to temperature of 20 ± 1°C and a relative humidity of 50 ± 5%.

A1.173 Filters will need to be pre-conditioned for at least 48 hours (much longer for some types) before the initial weighing, in open dust protected sieve trays, in the air conditioned weighing room (temperature and relative humidity conditions as specified above). After exposure, filters must be re-conditioned for at least 72 hours under the same conditions, before re-weighing.

A1.174 Before weighing a filter, it should be examined for pinholes and other imperfections by backlighting with an area light source similar to a x-ray film viewer.

A1.175 Balances used for this purpose should have a resolution of 10 µg. They are to be calibrated annually, using calibration weights that are traceable to national standards. In addition to the full annual calibration, regular routine checks should also be carried out, to ensure no substantial deviation from the expected settings. This is done using a check weight at the start of each weighing session (as a minimum), or better still, before every set of filters weighed within a session, and at intervals throughout. Blank filters should also be weighed at the start and end of each batch of clean and exposed filters.

A1.176 Not all local authorities will have adequate in-house facilities for filter conditioning and weighing. In this case it will be necessary to contract these activities out to a suitable external laboratory.

Sampler Operation

A1.177 The samplers should be operated in accordance with the manual for the sampler utilised. The sampling heads should be cleaned regularly and sample flow rates measured as recommended in the manual. The filter exposure period and total sample flow must be recorded at each filter change. Ambient temperature and pressure may need to be recorded if the sampler does not make automatic corrections.

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[58] Andrew S. Brown, Rachel E. Yardley, Paul G. Quincey and David M. Butterfield "Ambient Air Particulate Matter: Quantifying Errors in Gravimetric Measurements." NPL REPORT DQL-AS 015, Jan 2005.

A1.178 Many gravimetric samplers are equipped with sophisticated data logging systems to record ther operating status of the analyser during filter exposure. Typically, this includes: filter exposure times, flow through filter, temperature and pressure measurements, errors occuring during sampling, filter ID information and date of exposure. This daily information should be recorded and used during the process of ratification. It is recommended that a minimum of 18 hours valid sampling is required for a valid 24 hour mean or daily mean.

Field Blanks

A1.179 In any gravimetric particulate monitoring programme, field blanks should be included as a matter of course and in a systematic way. Field blanks are filters which are placed in the gravimetric monitor with the filters to be exposed (in the case of a sequential sampler, in the filter canister), but are not exposed. Like the exposed filters, they are conditioned and weighed before and after going to the site. The field blank mass (which should be close to zero) is subsequently subtracted from the exposed filter masses, for all filters in the same batch.

A1.180 Long-term records should be kept of field blank measurements, and any changes (upward or downward trends in field blank mass, or step changes) should be investigated.

Quality Assurance and Quality Control for nitrogen dioxide diffusion tubes

A1.181 Palmes-type NO_2 diffusion tubes are widely used in LAQM. Although relatively simple to use, careful attention must be paid to quality assurance and quality control procedures to ensure that the data obtained are of defined and adequate quality.

A1.182 Guidance for suppliers and users of diffusion tubes is provided in a separate document, *"Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users",* available from www.airquality.co.uk/archive/reports/cat05/0802141004_NO_2_WG_PracticalGuidance_Issue1a.pdf. Information on diffusion tube QA/QC is also available on the Local Authority Air Quality Support web pages at www.laqmsupport.org.uk/no2qaqc.php. Users of diffusion tubes are referred to this document: however, the main points are summarised below.

A1.183 It must be borne in mind that NO_2 diffusion tubes are an indicative monitoring technique: although ideal for screening studies and for identifying areas of high concentration, they do not offer the same precision and accuracy as the automatic chemiluminescent analyser (which is defined by the European Union as the reference method of measurement for this pollutant). In particular, NO_2 diffusion tubes are affected by several mechanisms, which may cause them to exhibit positive bias (over-read), or negative bias (under-read) relative to the reference technique.

Handling and use of Nitrogen dioxide Diffusion Tubes

A1.184 The Practical Guidance document referred to above includes guidance on storage, handling and exposure of diffusion tubes. This is summarised in Box A1.7 below.

Duration of Exposure

A1.185 Nitrogen dioxide diffusion tubes should be exposed for a minimum of one week and a maximum of five weeks. They are commonly exposed monthly, and an annual calendar of exposure periods is provided by Defra under the Local Authority Air Quality Support contract, at www.airquality.co.uk/archive/NO_2admintools/no2cal08.doc It is recommended that these exposure periods are used for LAQM monitoring.

Travel blanks

A1.186 The purpose of travel (or "transport") blanks is to identify possible contamination of diffusion tubes while in transit or in storage by the user. Travel blanks are sent out with the tubes for exposure. They go everywhere the exposed tubes go, but are not themselves exposed. They are taken to the site when the tubes are put out, but returned to the user's refrigerator (in their sealed bag) for the duration of the exposure period. They are taken to the site again when the tubes are collected after exposure, and sent to the laboratory for analysis along with the exposed tubes. (Note: the results of travel blanks are not meant to be routinely subtracted from those of the exposed tubes: rather, their purpose is to highlight any contamination issues.)

A1.187 It is recommended that travel blanks are budgeted for, and included in the survey.

Box A1.7: Instructions for Exposing Nitrogen dioxide Diffusion Tubes

The procedures below should be followed when deploying diffusion tubes:

- Diffusion tubes should be stored in a cool, dark place (preferably a fridge), in a sealed plastic container, before and after exposure.
- Remove tubes from the refrigerator on the day that they are to be put out, and ensure each one is clearly labelled with an identification number (if this hasn't already been done by the supplying laboratory). The labelling must be weatherproof!
- Take tubes to the site in a snap-seal bag or sealable plastic box. Travel blanks should be identified and their code numbers noted on the exposure details form provided by your laboratory.
- At each site, select a tube. Record its ID number, and the site at which it is to be exposed, on the exposure details form.
- Remove the clear or white end cap, and position the tube is positioned vertically in its holder, with its open end downwards.
- Record the date and time of the start of the exposure period on the exposure details form, and make a note of any site irregularities (for example building/road works, traffic diversions).
- Keep the end caps in the bag, for use when the exposure period is completed.
- When collecting the exposed tubes, at each site, remove the exposed tube from the sample holder and replace the end cap tightly. (Any uncapped tubes will be rejected by the analyst).
- Record the time and date of the end of the exposure period on the exposure details form, against the appropriate tube number. Again, make a note of any site irregularities or anything which might affect, or even invalidate, the tube's results (for example, the tube found on the ground, insects, dirt, or liquid inside the tube).
- Tubes that are damaged or have splits in the end-caps should not be used.
- Keep the exposed tubes in a sealed container, in a cool place (a fridge is best) until they can be returned to the laboratory for analysis, which should happen as soon as possible.
- Ensure that the tubes are used and analysed within the specified "use by" date – typically within three months of preparation.

When visiting sites, it is recommended that the operator takes some spare tube end caps, also some spare mounting clips and spacer blocks to replace any missing or damaged.

Co-location Studies for Nitrogen dioxide Diffusion Tubes

A1.188 As highlighted above, diffusion tube measurements may exhibit substantial under- or over-estimation compared to the reference method. This is due to factors affecting the performance of diffusion tubes in the field, for example wind-induced shortening of the effective diffusive path length, that are not related to the laboratory's preparation or analysis of the tubes.

A1.189 Clearly, any such under- or over-estimation is a problem in any situation where diffusion tube results are to be compared with air quality objectives. As a result, local authorities making use of NO_2 diffusion tubes in their Review and Assessment should carry out their own investigation of diffusion tube accuracy (often referred to as "bias") and apply an adjustment factor to the annual mean if required.

A1.190 This should be done by a co-location study: that is, by exposing diffusion tubes alongside an automatic chemiluminescence analyser, and comparing the results of the two techniques. When carrying out a co-location study:

- Diffusion tubes should be placed within 1 m of the automatic analyser inlet, but care should be taken that they do not block the inlet in any way;
- If the co-location study is being carried out at a roadside monitoring station, ensure that the tubes are the same distance from the road as the analyser inlet;
- The co-located diffusion tubes should be exposed in triplicate (ie, groups of three) if possible. Ideally tubes should be spaced at least 10 cm apart;
- The duration of the study should be at least nine months;
- Exclude data from any months when the automatic analyser does not achieve at least 90% data capture;
- It is of paramount importance to ensure that the data from the analyser are of good quality, so good QA/QC procedures must be applied to the automatic monitoring; and
- The co-located diffusion tubes should be prepared, handled and analysed in exactly the same way as those from the other (non co-located) monitoring sites in the survey. Exposure periods should be the same, to within +/- two days.

A1.191 For local authorities with their own co-location studies, a spreadsheet is available on the "LAQM tools" section of the Air Quality Archive at www.airquality.co.uk/archive/laqm/laqm.php, which can be used to calculate the precision and accuracy of co-located diffusion tubes. The spreadsheet provides a bias adjustment factor (with a 95% confidence interval as an estimate of its uncertainty).

A1.192 It is not necessary, or indeed feasible, for every local authority to do its own co-location study. Instead, results from studies carried out by other local authorities, or the tube supplier/analyst, can be used. A database of bias adjustment factors, from co-location studies carried out by UK local authorities in recent years is available on the Review and Assessment Helpdesk website at www.uwe.ac.uk/aqm/review.

Triplicate or Multi-tube Exposure of Diffusion Tubes

A1.193 Even if you do not carry out a co-location study, it is useful to expose diffusion tubes in triplicate at one or more monitoring sites, as this allows you to keep an ongoing check on your tube **precision.** To do this, calculate the coefficient of variation (CV) of each triplet of tubes (the coefficient of variation, also called the relative standard deviation or RSD, is the standard deviation expressed as a percentage of the mean). This can be done using the spreadsheet-based tool described above.

A1.194 As a rough guide, the CV of diffusion tube triplicates is considered satisfactory when the CV of eight or more periods out of any twelve is less than 20%, and the average CV of all twelve monitoring periods is less than 10%.

A1.195 There may also be other situations where triplicate tube exposure is desirable, for example when a more precise measurement is required, but operational or other factors rule out the use of an automatic analyser.

Quality Assurance and Quality Control requirements for analytical laboratories

A1.196 When selecting a laboratory for the supply and analysis if diffusive samplers, it is important to ensure they follow correct QA/QC procedures. Good laboratory practice and high standards of cleanliness are required for accurate analysis. A regime of system blank and calibration runs must be incorporated into the analysis of exposed tubes. The laboratories should maintain quality control charts of calibration records.

A1.197 However, it is clearly difficult for the operators to verify all these points themselves. Local authorities should ensure that their diffusion tubes are supplied and analysed by a laboratory that has demonstrated satisfactory performance, over the past year, in two centralised QA/QC activities:

- The independent WASP quality assurance scheme, managed by the Health and Safety Laboratory. This tests each laboratory's analytical proficiency on a quarterly basis, using diffusion tubes artificially spiked with a known amount of nitrite; and
- The monthly field intercomparison exercise operated by AEA Energy & Environment This measures the precision and accuracy of each laboratory's diffusion tubes, by exposing them in triplicate alongside a chemiluminescence analyser (which is defined as the reference method for NO_2.)

A1.198 It is also recommended to use analytical laboratories that are accredited to a recognised standard, for example, UKAS or equivalent.

A1.199 As part of their contract to Defra and the Devolved Administrations for air quality support to local authorities, AEA prepare regular summaries of all laboratories' performance in both the WASP scheme and Field Intercomparison, comparing each laboratory's performance with predefined performance criteria. To find out whether a particular laboratory has achieved the Defra performance criteria in the past year, please contact the laboratory, or the Local Authority Air Quality Support Helpdesk.

A1.200 Those local authorities who analyse diffusion tubes in their own in-house laboratories are referred to the guidance provided in *"Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users"*, available from www.airquality.co.uk/archive/reports/cat05/0802141004_NO_2_WG_PracticalGuidance_Issue1a.pdf. The document sets out procedures to be followed by all laboratories preparing and analysing NO_2 diffusion tubes to be used for LAQM.

A1.201 When presenting diffusion tube results in a Review and Assessment report, the local authority should include:

- the name of the laboratory that prepared and analysed the tubes;
- whether it has any formal accreditation to BS or UKAS standards for the analytical method;
- confirmation that the laboratory has met the agreed performance criteria in the inter-laboratory QA/QC exercises above;
- type of tube used, and preparation technique;
- monitoring site locations, with site category and grid reference;
- annual mean concentrations (or period mean if less than full year), both bias adjusted (where necessary) and unadjusted; and
- the source of any bias adjustment factor used.

When To Reject Diffusion Tube Results

A1.202 Sometimes, a diffusion tube result may be much higher or lower than usual results from the site. The first step should be to check with the analyst, to ensure that the result has been correctly calculated and reported. Have details such as the exposure period been correctly reported?

A1.203 Having ruled out calculation or reporting errors, it will be necessary to decide whether the value should be rejected. Some general guidelines are as follows:

- Low concentrations (3 µg/m^3 or less) are rare at urban background or roadside sites in built up areas. If such a low concentration is measured at an urban site, where measured NO_2 concentrations are usually much higher, it is unlikely to be genuine, and more likely due to a faulty diffusion tube. (Of course, this does not apply at rural sites, where such low concentrations may well be typical).
- High concentrations: unless there is a reason why the result is likely to be spurious, it is best to err on the side of including high values rather than rejecting them.

A1.204 The exposure records should be checked for any possible explanations (for example nearby bonfires during exposure, insects or foreign objects in the tube, or evidence of tampering), which may lead the operator to conclude that the result is not valid.

Identifying Outlying Values From Triplets

A1.205 Where groups of three or more diffusion tubes are exposed together, occasions may arise where one or more of the results differs substantially from the others, and may be considered suspect.

A1.206 If four or more diffusion tubes are exposed together, it is possible to use a statistical test (such as Grubb's test or Dixon's test) to identify an outlying value. However, in the more usual case of triplicate exposures, these tests are not valid. Instead, it is possible to use the following "common sense" approach to help identify and exclude an outlying value:

1. Calculate the CV, sometimes also called the RSD, of all the triplets in your survey. This is the ratio of the standard deviation to the arithmetic mean, expressed as a percentage.
2. The CV of the "suspect" triplet should be compared with those of the rest of the survey. If it is substantially higher, this may indicate a problem with one or more of the three results.
3. In some cases, there may be one result that is clearly much higher or lower than the other two, and this can confidently be rejected.

A1.207 However, on other occasions there may be considerable "spread" in the three results, but with no clear outlier. From experience with Palmes type NO_2 diffusion tubes, a CV of around 10% or less would be expected. A CV of more than 20% would indicate that the precision of the triplet of results is relatively poor. In such cases, where it is not possible to identify any one value as an outlier, a judgement must be made on whether to accept or reject all three results.

Application of Bias Adjustment Factors

A1.208 Having calculated the bias adjustment factor (see Box 3.3 in the Main Document) this should be applied to the annual mean concentration. Some points to remember when using bias adjustment factors are as follows:

- Apply a bias adjustment factor to the annual mean NO_2 concentration only, not to individual monthly results. Performance of diffusion tubes can vary from month to month depending on meteorological and other factors, so it is not valid to adjust monthly values in this way;
- The performance of diffusion tubes can vary over time, so it is not valid to apply a bias adjustment factor obtained from a recent study to previous years' data; and
- When using a bias adjustment factor in Review and Assessment reports, always report the unadjusted annual means as well. In the accompanying text, give details of how the bias adjustment factor was obtained.

A1.209 One frequently asked question is whether it is better to use a locally-derived bias adjustment factor, or one based on results from several studies at different sites. The answer to this question depends on several factors, and this issue is dealt with fully in Box 3.3 in Chapter 3 of the Main Document, and as an FAQ on the Review and Assessment Helpdesk site, at www.uwe.ac.uk/aqm/review.

A1.210 Before using the results of a co-location study carried out by another organisation, it is important to ensure that:

- the tubes are identical, being prepared and analysed by the same laboratory, using the same materials and techniques;
- the exposure period is the same as in your own survey; and
- the duration of the co-location study is at least nine months.

A1.211 Finally, although the chemiluminescence analyser is defined as the reference technique for NO_2, it should be remembered that it, too, has a certain amount of uncertainty associated with the results: typically around 10-15% for the annual mean (although at present, local authorities are not required to take this into account in Review and Assessment).

Reporting of monitoring data

A1.212 Even the simplest air monitoring programme can quickly produce a large amount of data. Statistical summaries are therefore required to obtain a clear overall picture and to minimise the amount of information needed to describe the pollution situation. These statistical summaries form the basis of calculations to compare measured results with the objective.

A1.213 The type of information required may include:

- hourly, daily, monthly, seasonal and annual mean concentrations of pollutants;
- exceedences of specified threshold or limit values;
- hourly, daily, monthly maximum values;
- variation of concentration with wind direction, and other meteorological factors;
- trends over time; and
- mapped concentrations (of area diffusion tube surveys).

A1.214 A selection of different ways to analyse and present air pollution data is given in Box A1.8.

A1.215 When handling and reporting data, account must be taken of the twice-yearly change between Greenwich Mean Time (GMT) and British Summer Time (BST). It is generally advised that all data are collected, stored and analysed in GMT. However this means that anyone carrying out analysis of the data needs to be aware that (for example) rush hour peak are an hour out in the summer. Also, when investigating or plotting diurnal patterns over a full year, the BST/GMT correction needs to be made, otherwise the diurnal patterns will be incorrect.

Box A1.8 Methods for analysis and reporting of air quality data

Tables

Data are presented in the form of lists, for example, tables of measured pollutant concentrations for different intervals of time at selected measurement sites. Tables provide the largest sets of data for general analysis at minimal expense.

Time series

A time series plot of concentrations against specified time intervals provides a very useful way to quickly visualise a large dataset. These can be used to identify possible data anomalies, to compare data from different monitoring sites or fluctuations of different pollutants at the same site. Diurnal or seasonal variations in pollutant concentrations can also be readily viewed.

Trend Analysis

By performing a regression analysis on statistics such as annual mean and 98th percentile concentrations, it is possible to assess how air quality compares to previous years and identify whether pollution concentrations are changing over time. Statistically significant trends, or even a reasonable overview of how concentrations are changing, usually only become meaningful when complete data records extend over five years or more.

Mapping

Mapping of concentration data or statistics, often using GIS systems, is invaluable in assessing spatial patterns of pollution and exposure, identifying "hot spots" and assisting in monitoring network design. This technique is particularly appropriate for area surveys with diffusion tube samples.

Wind/Pollution Roses

These can be useful in determining the source of a given pollutant. The wind velocity rose indicates average wind speed for wind directions recorded in each various sectors and the wind direction rose indicates the percentage of time wind was recorded from each particular direction. The pollution rose plots relate air pollution measurements to wind direction. These plots show the average pollutant concentrations during periods when the wind was recorded in each of the sectors.

Calculation of exceedence statistics

A1.216 Specific statistics need to be calculated from the ratified data for comparison with the Air Quality Strategy objectives. The following definitions are commonly used:

- *15-minute mean* – 15-minute mean is a mean calculated every 15 minutes for the preceding 15 minutes, ie, from 00.00 to 00:14, 00:15 to 00:29, 00:30 to 00:44, 00:45 to 00:59 and so on.
- *Hourly mean* – An hourly mean is the mean concentration for the following hour, ie, the mean for 11:00 will be the mean for the period 11:00 to 11:59. If the hourly mean is calculated from 15-minute means then at least three valid 15-minute means are required to produce a valid hourly mean.
- *Running 8-hour mean* – A running 8-hour mean is a mean which is calculated from hourly average concentrations. The running 8-hour mean for a particular hour is the mean of the hourly average concentrations for that hour and the preceding seven hours. The averaging period is stepped forward by one hour for each value, so running mean values are given for the periods 00:00 -07:59, 01:00 - 08:59 etc. There are, therefore, 24 possible 8-hour means in a day (calculated from hourly data). In order for a running mean to be valid, 75% data capture is required, ie, six hourly averages out of every eight must be valid. The maximum daily 8-hour running mean is the maximum 8-hour running mean measured on any one day, ie, between 00:00 and 23:59 hours.

- *24-Hour mean* – A 24-hour mean is the mean concentration for the preceding 24 hours. If the 24-hour mean is calculated from hourly means then at least 18 valid hourly means are required to produce a valid 24-hour mean. A daily mean specifically refers to a 24-hour mean calculated for the period between 00:00 and 23:59 hours.
- *Annual Mean* – An annual mean is a mean that is calculated from hourly average concentrations over a year, yielding one annual mean per calendar year, for automatic data. The annual mean for non-automatic data is the mean of the relevant sampling periods over a year. Annual means are based on 365 days (366 days for leap years) and 90% data capture is required.
- *Running Annual Mean* – A running annual mean is a mean which is calculated each hour from hourly average concentrations over a year. The running annual mean is the mean of the hourly average concentration for that hour and the preceding 8759 hours (365 days). For leap years annual means are based on 366 days.
- *Percentile* – A value that is the rank at a particular point in a collection of data. For instance, a 98th percentile of values for a year is the value that 98% of all the data in the year fall below, or equal. Calculation of percentiles is described in Para A1.218.

A1.217 Commercial software, often available from the equipment suppliers, can be used to produce standard reporting formats. **In reporting data it is important to clearly specify what concentration units have been used.**

Calculating percentiles

A1.218 An explanation of percentiles can be found in any statistics textbook or on the internet (for example, on Wikipedia at en.wikipedia.org/wiki/Percentile). Percentiles can easily be calculated using Excel or a similar spreadsheet. For example, to calculate the 99.8th percentile of the hourly NO_2 concentrations measured over one year:

Step 1. Load the hourly average concentrations for the year into a spreadsheet

Step 2. Sort them into ascending order of concentration

Step 3. Calculate 99.8 percent of the total number of concentration values

Step 4. Round this number to the nearest integer

Step 5. The concentration in the row equivalent to this number is then the 99.8th percentile.

A1.219 Thus, if in a calendar year there are 8760 values measured 99.8 % of 8760 = 8742.48 = 8742. The concentration at row 8742 in the spreadsheet is then the 99.8th percentile.

A1.220 The above example is included for illustrative purposes: however, in practice it is usually quicker to use the following Excel spreadsheet function:

percentile(address of first cell:address of final cell, 0.XXX)

- where 0.XXX is the required percentile, for example the 99.8th percentile = 0.998

Box A1.9: Summary of Procedures for Ratifying and Reporting of Automatic air quality monitoring data

Validation – Screen the data, by visual examination, to see if they contain spurious and unusual measurements: this is how equipment faults or episodes of exceptionally high pollution are detected.

Ratification – This initial data validation must be followed by more thorough checking at three or six month intervals to ensure that they are reliable and consistent. This latter process is called data "ratification". Essentially, the data ratification procedure involves a critical review of all information relating to a particular data set, in order to verify, amend or reject the data. When the data have been ratified, they represent the final data set to be used in the Review and Assessment process.

Reporting – The data reported should include

- Simple statistics such as data capture, arithmetic and geometric mean of hourly values, maximum hour, and 24-hour,
- Comparison of the results with relevant standards and objectives of the Air Quality Strategy
- Site and equipment information

It is import to record the measurements units that have been used and any correction factors which have been applied to the data.

Annex 2: Estimating emissions

Introduction

A2.01 This guidance is not intended to provide a single outline to compiling a complete emissions inventory. Review and Assessment is about assessing the potential for air quality exceedences and therefore is about identifying and understanding the significant sources contributing to poor air quality.

A2.02 These significant sources will be different for different local authorities and even for different areas within a local authority. In the majority of cases, road transport and stationary large point sources are likely to be the most common problems. In addition but probably in more isolated cases, residential areas burning coal or solid fuel, large ship ports or airports may need Detailed Assessments. In many cases a complete inventory is inappropriate and time consuming. However, where exceedences are likely to result as a cumulative result of a large number of different sources, then a more complete inventory is recommended.

A2.03 It is recommended that the significant sectors are assessed in detail first and then if necessary (ie, there is more than one significant sector) a combined assessment is undertaken.

A2.04 The emissions data necessary for a combined assessment should include the data gathered for the sector specific assessments as detailed in the guidance below. In addition, background emissions data can be used to account for sectors not specifically assessed in the detailed studies. This data can be obtained from the National Atmospheric Emissions Inventory (NAEI) data warehouse www.naei.org.uk/data_warehouse.php and will include:

- non point source commercial, industrial and residential emission maps;
- road transport emission maps including major roads, minor roads, cold start, hot soak and brake and tyre wear; and
- and other transport emissions such as those arising at ports and airports.

A2.05 Information for London is available from the London Atmospheric Emissions Inventory (LAEI) www.london.gov.uk/mayor/environment/air_quality/research/emissions-inventory.jsp.

A2.06 In addition, point source and traffic data are available as background input for areas outside the local authority boundary. These data can be obtained from the UK air quality archive www.airquality.co.uk. Further detail on both the NAEI data warehouse and the UK air quality archive is included in Appendix D.

Road transport

Design Manual for Roads and Bridges Screening Model assessment data

A2.07 The Design Manual for Roads and Bridges (DMRB) Screening Model is provided by the Highways Agency. The latest version to use and the data requirements and procedures for its use are described on the Local Authority Air Quality Support Helpdesk website[59].

[59] www.airquality.co.uk/archive/laqm/tools.php

Detailed Assessment data

A2.08 A Detailed Assessment will involve some form of modelling, requiring high quality traffic flow, speed and link location information. Each link will require at least a location (grid reference) for each end of the link so that its location in relation to the nearby population can be accurately assessed. In cases where the road link is not simply a straight line between the two points, additional spatial data will be required. Detailed centrelines and accurate road widths will also need to be collected for each link. The local authority Planning Department should have this information. The possible approaches and tools for modelling are discussed in Annex 3. Try to avoid using average or aggregate factors for flow or traffic composition and where possible, incorporate slow speeds during congestion and the likely impact of steep hills. Further details on how to treat these are provided in Paras A2.15 to A2.30. Paras A2.11 to A2.14 provide information about calculating suitable speeds to use in the Detailed Assessment.

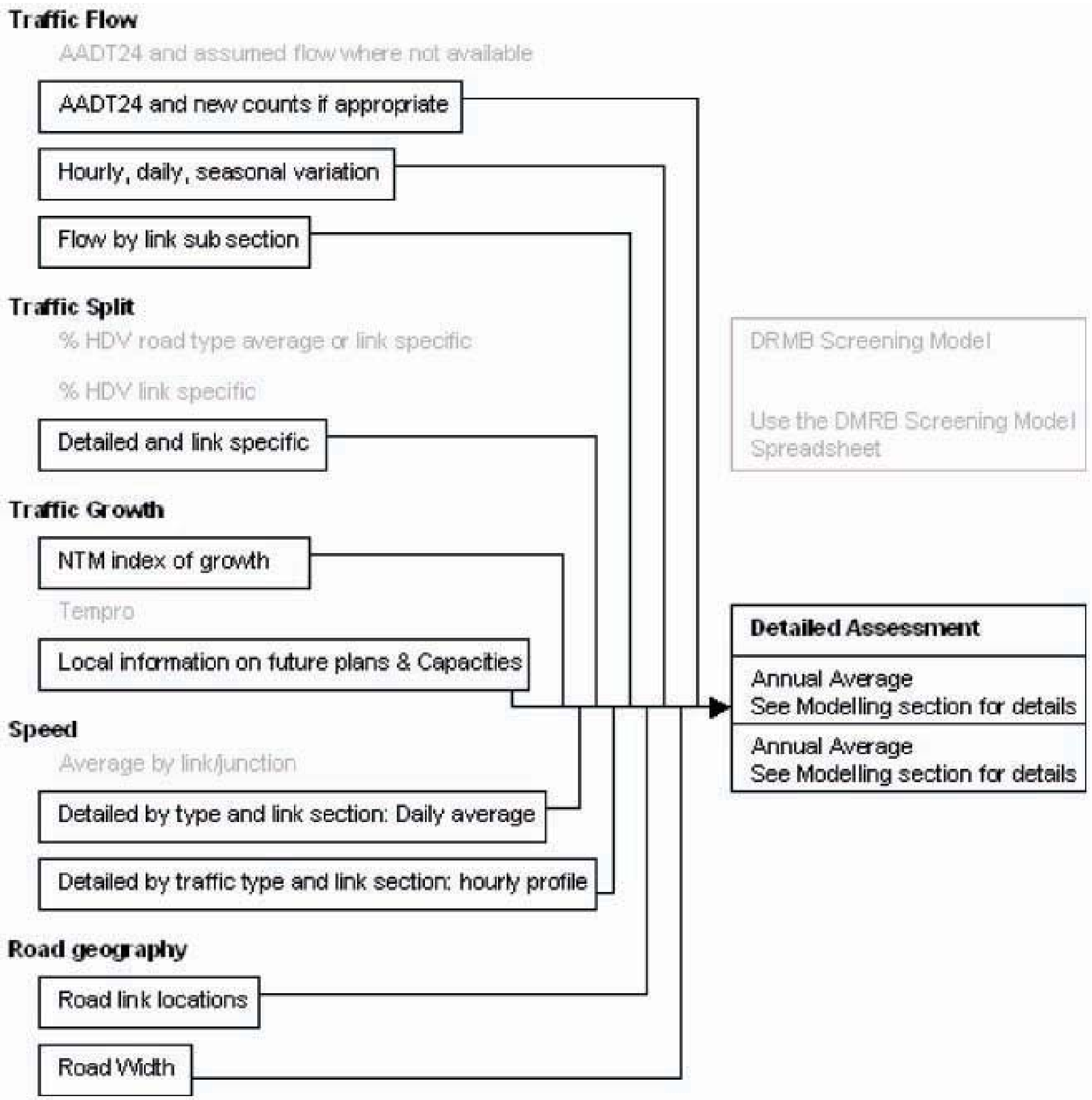
A2.09 The emissions for each link can be calculated using the Emission Factor Toolkit (EFT) (see Chapter 2 of Main Document). The EFT requires link specific input data of speed, traffic composition and road type. From this input data, emission factors (EFs) for each specific link being assessed will be calculated and can be applied to the geographic map of the roads and their Annual Average Daily Traffic (AADT24) traffic flow. Alternatively, if not using the EFT then the raw EF data are available from the NAEI website at www.naei.org.uk/data_warehouse.php

A2.10 The road transport EFs in the NAEI data warehouse are being updated at the time of writing. This follows a review undertaken by the Transport Research Laboratory (TRL). The proposed new factors have a more detailed vehicle classification than that currently used in the NAEI. The main enhancements will be:

- The provision of factors for Euro 3, 4, 5, 6 factors for Light Duty Vehicles (LDVs) and Euro III, IV, V and VI factors for Heavy Duty Vehicles (HDVs). In the NAEI, factors for stages higher than Euro 3 (III) are based on scaling factors relative to Euro 2 (II) on the basis of Type Approval limit values. Note that vehicles meeting Euro 5 (V) and 6 (VI) standards are not yet in service;
- The provision of factors for three different weight classes of Light Goods Vehicles (LGVs);
- The addition of factors for LDVs running on LPG;
- The inclusion of taxi (black cabs) as a separate category;
- The sub-division of rigid Heavy Goods Vehicles (HGVs), articulated HGVs, buses and coaches by weight band; and
- The sub-division of motorcycles by engine size band.

A2.11 The data necessary for the Detailed Assessment are illustrated in Figure A2.1 and described in more detail below.

Figure A2.1: Illustration of the data requirements for Detailed Modelling Assessment



A2.12 The following information is required:

- **Traffic flows:** for Detailed Assessments it is important to get accurate counts or estimates of traffic flow. The traffic flow data should be AADT24 but also include local daily and day of the week variation information for peak hour exceedence calculations, where available. Information on where to obtain traffic data from is provided in Section A2.08. Measured flows on Highway's Agency controlled roads can be obtained from Trads at trads.hatris.co.uk. Estimates of flow based on measurements for all A roads and motorways in the UK are available from www.dft.gov.uk/matrix. Data for Northern Ireland can be obtained from the Northern Ireland roads service. London specific data can be obtained as Traffic Notes from www.tfl.gov.uk/businessandpartners/publications/5353.aspx.
- Example 1: *Derivation of Traffic Flow Data* in Appendix A provides a worked example.
- **Vehicle split and emission factors:** For Detailed Assessments it is recommended that the EFT be used to estimate detailed vehicle split and EFs for each link. The EFT is preloaded with national average fleet compositions for different road types and can disaggregate a coarser set of vehicle categories into those required for emission estimation. However, where possible this split should be based on the link specific vehicle split for each road link being considered and should also be based on a more detailed local split than that used for the DMRB Screening Model Assessment. Some traffic count data will contain a basic vehicle split (cars, Light Goods Vehicles, Rigid HGVs, Articulated HGVs, Buses Coaches and Motorcycles). Where possible this level of detail should be used as the primary input data. For major roads, this level of detail can also be obtained for a large number of specific count points from www.naei.org.uk/data_warehouse.php and on the Department for Transport website: www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/traffic/
- **Speeds:** Estimating traffic speed is important for modelling of road traffic sources. Unfortunately, it is usually difficult to obtain data on speeds that would be ideal for air quality studies. Speed estimates for Detailed Assessment work must be link specific. At junctions, links will need to be broken down to their key elements as outlined in Figure A2.3. A worked example (Example 2: Vehicle splits and speeds) is included in Appendix A.
- An alternative approach is to estimate (or measure) the average time taken for vehicles to travel from one end to the other of the junction section and convert this to an average speed. You should allow for the different phases of the lights and different levels of congestion during the day.

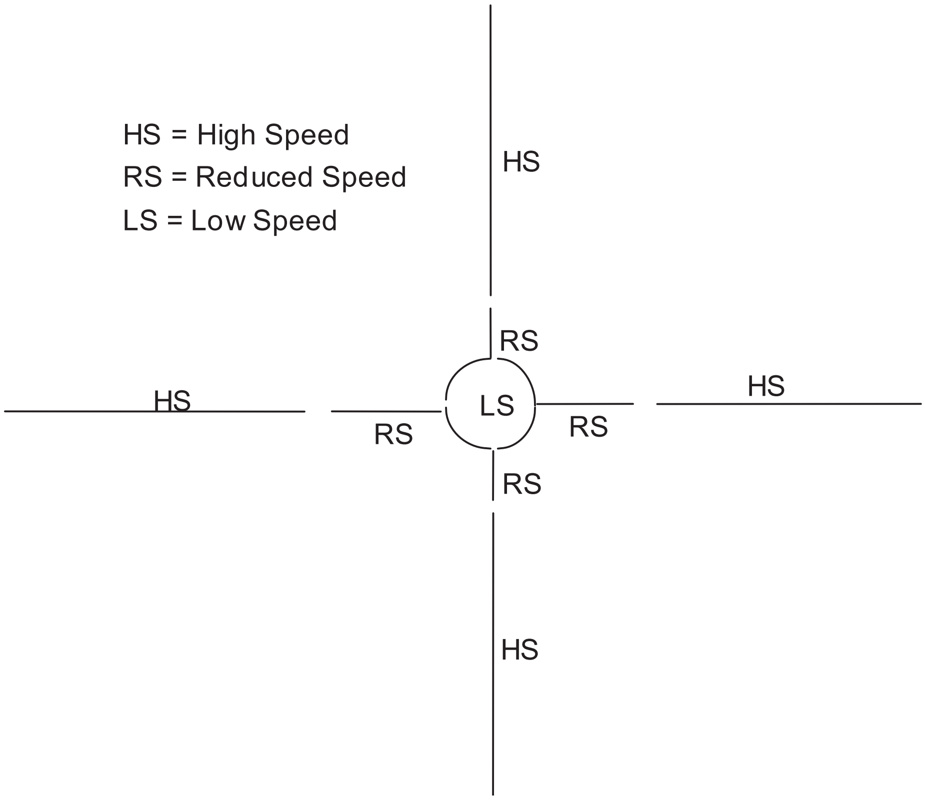
A2.13 Traffic models will usually include an estimate of average transit speed of vehicles along modelled links. However, this will be for the time period considered by the model network (for example, morning (am) peak), and will not be available for discrete sections of links. Generally, model-based speed estimates will be fairly crude approximations that will be heavily influenced by the nature and operation of the particular model software from which they are derived (for example, do they include "junction delays", how do they relate to pre-determined speed/flow curves?). Traffic counts do not provide data on speed directly. The following provides further guidance on an approach that can be used in the absence of better data.

- Speed data may be obtained directly from a traffic model (users should understand the basis on which the model speeds are calculated), from "floating-car" studies, from theoretical extrapolations based on speed limit/flow or limited data is available for Highways Agency roads from Trads at trads.hatris.co.uk.

- The use of hourly speeds throughout the day is also likely to be necessary. This can often be different for different roads and should be assessed locally if possible. In addition the more complex changing speeds on junctions should be considered.
- For junctions, there is no straightforward way to estimate speeds. Common sense and driving experience is therefore helpful. It is suggested that the aim should be to estimate average speeds over a 50 metre section of road – for example a 50 metre section leading up to traffic lights. The estimation of an average speed for two-way traffic on this 50 m section requires consideration to be given to three conditions:
  - Traffic on the carriageway pulling away from the lights – probably travelling at 40 -50 kph.
  - Traffic on the carriageway approaching the lights when green – probably travelling at 20-50 kph.
  - Traffic on the carriageway approaching the lights when red – probably having an average speed of 5-20 kph, depending on the time of day and how congested the junction is.

A2.14 It is considered that the combined effect of these three conditions is likely in most instances to be a two-way average speed for all vehicles of 20–40 kph. Speeds in similar ranges would also apply at roundabouts, although on sections of large roundabouts, speeds may well average between 40-50 kph.

Figure A2.2: Detailed Speed data at Junctions



Dealing with congestion

A2.15 Average vehicle speeds during traffic congestion will fall, and there is no simple factor that can be applied to the average speed to calculate a speed applicable to congested periods. The preferred approach is to calculate the emission rate for the affected roads for each hour of the day or week on the basis of the road speeds and traffic flows for each hour. The calculated emissions profile could then be used in the dispersion model. However, many dispersion models will only accept a single emission rate (normally expressed as grams of pollutant emitted from vehicles per second) for a road link, or section of a link. It may then be necessary to calculate a weighted average EF to take account of the varying traffic flows and vehicle speeds throughout the day. If there is only a small section of congestion, the weighted EF should be only be used to model the emissions along that section of road, and not for large distances either side.

A2.16 The following illustration summarises the calculations needed:

Table A2.1: Summaries of the congestion calculations

Hour	F (vehicles / hour)	E (g/km/vehicle)	F x E (g/km/hr)	(24 x F x E) / ∑ (F x E)
0				
1				
2				
3				
23				
	∑F		∑(F x E)	

Where:

F = vehicle flow

E = emission factor

$$\text{Weighted } E = \frac{\sum(F \times E)}{\sum F} \text{ (g/km/vehicle)}$$

A2.17 This weighted EF would be suitable to use in congested sections of road. Other models require the calculation of hourly factors to apply to the average emission rate. The last column of the above table illustrates the approach to employ in calculating the hourly factors. Remember, if there are more than several percent HDV travelling on a road link, emissions (and so indirectly, concentrations in air) may increase sharply as the speed falls below 20 kph – this means your choice of speed and hence EF will be especially important in this situation.

Dealing with idling vehicles

A2.18 The approach to treating emissions from idling vehicles is still under consideration at the time of writing this guidance.

Dealing with gradients

A2.19 Even hills with slight gradients may slow the traffic significantly, particularly if there is a large percentage of HDVs. As vehicles start to climb the hill, the power demanded from the vehicle engine will increase, although the speed of the vehicles may remain similar. As the power demanded increases, emissions will increase. However, for vehicles going down the hill the opposite occurs; drivers lighten the pressure on the accelerator, the power demanded from the vehicle engine declines, and consequently emissions decrease.

A2.20 When this guidance was written, new EFs had recently been published for use within the COPERT 4 model (EMEP CORINAIR Emissions Guidebook, Aug 2007). The guidance below is based on these data.

A2.21 To identify sections of hills, you could introduce a "hill section" in a similar way to the way the road links are broken into different components as shown in Figure A2.3. This "hill section" would contain the hill and some distance of road after the hill. Local knowledge is the best way to decide the length of road affected by the hill.

A2.22 For passenger cars and LDVs the normal speed related EFs should be used, taking into account that the average speed on the hill section may differ from that on the flatter sections either side of the hill.

A2.23 For HDVs there are larger and significant changes in emissions generated by HDVs. The general equation for the amended speed related EF for vehicles **going up** a hill is[60]:

$EF_2 = EF_1$ (1+ G x [C_1 x V + C_2])

where:
EF_1 = emission factor for vehicles travelling at the speed V on a level road (grams per vehicle km).
EF_2 = revised emission factor for vehicles travelling at the speed V on a level road (grams per vehicle km).
V = vehicle speed (km per hour)
G = the gradient of the hill, expressed as a decimal fraction (for example, a 6% gradient should be expressed as 0.06), and C_1, and C_2 are constants, which differ according to the HDV type, emission standard and the pollutant. These are given in Table A2.2 below.

A2.24 For vehicles **going down** a hill the amended EF is:

$EF_2 = EF_1$ (1- G x [C_1 x V + C_2]) for gradients <= 2.5%, and
$EF_2 = EF_1$ (1- 0.025 x [C_1 x V + C_2]) for gradients > 2.5%,

where the notation is as before.

A2.25 This equation indicates that emissions do not decrease further after the driver has taken his foot off the accelerator and is increasing the levels of braking, ie, for descents steeper than 2.5%.

A2.26 The overall effect of these two equations is that for roads with gradients up to 2.5% and with approximately equal numbers of vehicles ascending and descending the hill, there are no net changes in emissions, ie, the effect of gradients on all vehicles can be justifiably neglected.

[60] These relationships were developed from fitting speed related emission factors in the EMEP CORINAIR Emissions guidebook for =2%, +4% and +6% gradients.

A2.27 It is emphasised that the equation above describes EFs greater than those for the same vehicles travelling at the same speed on a level road. Coefficients for the above equations are provided for four groups of heavy vehicles:

- small rigid HGVs;
- medium sized rigid HGVs;
- articulated HGVs; and
- urban buses and coaches.

A2.28 It is found that the relative increase in EFs is generally greater for older technologies (which already have larger EFs).

Table A2.2: Gradient coefficients

	New vehicles (post 2001)				Old vehicles (2001 and earlier)			
	NO_X	NO_X	PM	PM	NO_X	NO_X	PM	PM
Vehicle weight category	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2
Small rigid HGV	0.29	10.74	0.12	-2.29	0.32	12.47	0.35	-1.35
Medium rigid HGV	0.48	10.81	0.36	-2.27	0.60	12.15	0.54	-3.25
Articulated trucks	0.62	12.44	0.46	-0.80	0.54	18.90	0.76	-2.86
Urban buses and coaches	0.48	7.41	0.17	5.01	0.53	10.20	0.46	1.14

A2.29 The relationship was developed for speeds between 10 and 48 kph (6 – 30 mph) becoming less accurate outside this range but typically still useable up to 64kph (40 mph). Evaluation of the expression at speeds of 24 and 40 kph (15 and 25 mph) for a 6% gradient gives the following EFs (Table A2.3)

Table A2.3: Example results for vehicles travelling at 24 and 40 kph

	24 kph				40 kph			
	New vehicles		Old vehicles		New vehicles		Old vehicles	
	NO_X	NO_X	PM	PM	NO_X	NO_X	PM	PM
Vehicle weight category	C_1	C_2	C_1	C_2	C_1	C_2	C_1	C_2
Small rigid HGV	2.06	1.31	2.34	1.43	2.21	1.42	2.52	1.76
Medium rigid HGV	2.34	1.38	2.80	1.73	2.59	1.58	3.17	2.10
Articulated trucks	2.64	1.61	3.23	2.06	2.91	1.92	3.43	2.65
Urban buses and coaches	2.14	1.55	2.60	1.71	2.38	1.73	2.88	2.17

A2.30 The table shows that the emissions multiplier increases with vehicle weight, increasing speed, and the increasing age of the vehicle. Also, for a 6% gradient, emissions of Nitrogen oxides (NO_X) are at least double those for a vehicle travelling at the same speed on a level road, and for older articulated trucks at 40 kph are a factor of 3.4 higher (an excess of 240%).

Dealing with cold start emissions

A2.31 Emission factors for cold starts are provided in the Data Warehouse section of the NAEI website. Crude emission estimates on a 1 x 1 kilometre basis are compiled for the UK maps. These datasets could be used in the absence of other data to provide a background map for these sources. See www.naei.org.uk/data_warehouse.php.

A2.32 Consideration should be given to temporal patterns - the morning (am) peak period will see a lot of "starts" in suburban areas, with a corresponding concentration of starts in the centre of towns in the afternoon (pm) peak (and vice-versa for trip ends). Emissions from cold starts can be calculated using the "Cold start" excess emissions model. This is an empirical model that calculates excess emissions from cars running with cold engines. These "cold start" emissions would be important if many of the car journeys in an area were short trips.

A2.33 This model is available in two variants:

- "Cold-start" which calculates the excess emissions from vehicles following being parked for a user defined period having arrived at the parking place at their normal operating temperature; and
- "Cold-start_Advanced" which has additional flexibility including modelling vehicles arriving at temperatures below their normal operating temperature, ie, after a short run, and the effect of varying fleet composition.

A2.34 Both models are an evolution of the previously available TRAMAQ[61] EXEMPT model[62], and are freely accessible as a spreadsheet, together with a user guide from www.airquality.co.uk/archive/laqm/tools.php.

A2.35 The model can be used as a simple tool for assessing the effects of certain types of developments, for example, a new out-of-town shopping complex, the effects of "the school run" or changing a city centre car park, where many cars may make their journey with cold engines. The models give results as excess emissions (units of mass per metre driven) for up to 10 km from the vehicles' starting point, not concentrations (mass in air). Further work is required independently of the model to calculate concentrations.

A2.36 Users are strongly advised to read the user guide and study the worked examples in this guide before they incorporate emissions from this model into a larger modelling study.

Dealing with evaporative emissions

A2.37 Evaporative emissions of petrol fuel vapour from vehicle tanks can constitute a significant fraction of benzene emissions from road transport. One mechanism by which gasoline fuel evaporates from vehicles is referred to as "hot soak". This represents evaporation from the fuel delivery system when a hot engine is turned off and the vehicle is stationary. It arises from the transfer of heat from the engine and hot exhaust to the fuel system where fuel is no longer flowing. Emissions from this source are usually estimated on the basis of the number of trips. The important spatial entity to estimate is the trip starts and the trip ends. Emission factors for hot soak can be found in the NAEI EF database www.naei.org.uk/data_warehouse.php.

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[61] TRAMAQ (the TRAffic Management and Air Quality Research Programme) is a six year programme originally commissioned by the Charging and Transport Division of the Department for Environment, Transport and the Regions. The programme now resides in the Department for Transport (DfT). The work is designed to assess effects of 1) traffic management schemes on air quality and 2) vehicle emissions. The work is designed to provide technical advice and guidance for Local Authorities so they can "better assess effects of traffic management on air quality in urban areas".

[62] EXcess Emissions Planning Tool (EXEMPT) is freely accessible (as a spreadsheet) from: www.aeat.co.uk/netcen/airqual/reports/tramaq/exempt.xls. The Summary report and User Guide can be opened at: www.aeat.co.uk/netcen/airqual/reports/tramaq/summary0638.pdf and www.aeat.co.uk/netcen/airqual/reports/tramaq/guide0639.pdf.

Dealing with brake and tyre wear

A2.38 Emission factors for fugitive particulate matter from brake and tyre wear and re-suspended road dusts are subject to a great degree of uncertainty. The factors are expressed per kilometre travelled by vehicle type. This component can be added to the major road link estimates using specific EFs from the NAEI data warehouse. Alternatively it can be calculated more generally by summing all vehicle kilometre data in each 1 x 1 kilometre grid squares for each basic vehicle type (cars, LGV, HGV, buses/coaches) and applying an EF from the "General UK emission factors" section of the data warehouse. Alternatively, The NAEI has a UK wide dataset of brake and tyre wear emissions based on 1 x 1 km grid of vehicle kilometres and NAEI factors – see www.naei.org.uk/data_warehouse.php.

A2.39 Further information on particle emissions from brake and tyre wear can be found in Chapter 4 of the Air Quality Expert Group's (AQEG) Particulate Matter in the United Kingdom Report[63].

Dealing with resuspension

A2.40 Particulate matter is deposited onto roads and adjoining pavements as the result of many processes. These include:

- material discarded from or falling from vehicles;
- corrosion of vehicles; brake and tyre wear (considered separately above);
- road wear, particularly where the surface has deteriorated;
- transfer on tyres from unmade side roads, construction yards, building sites;
- runoff from pavements, buildings, drainage channels into the gutter; and
- leaves falling from trees.

A2.41 There may also be areas of bare or sparsely vegetated soil close to the road as the result of construction activities or where vehicles run off the paved road. These areas may also provide a potential source of resuspended dust.

A2.42 Resuspension of these materials may be of particular concern where substantial quantities of Particulate Matter (PM) are present over long periods. The resuspension of particles by road vehicles occurs through two principal mechanisms. First, particles can be resuspended from the wear and shear of tyres acting on the road surface. Second, particles can be resuspended as a result of the turbulence caused by moving vehicles.

A2.43 There are no direct measurements available that quantify resuspension emissions in terms of grams per kilometre. Most estimations of the importance of resuspension have been based on receptor modelling techniques at specific locations. In some cases, however, these studies suggest that vehicular resuspension can be as important, if not more important, than exhaust emissions of particles from vehicles. The studies also indicate that HGVs are significantly more important in terms of resuspension compared with smaller vehicles such as passenger cars. Because the significance of resuspension is governed by many factors (for example, vehicle type, road surface condition and meteorological conditions), resuspended material is highly variable in terms of its source emission rate. It is therefore difficult to derive representative emission rates that can be expressed in terms of grams per kilometre. In cases where the road surface is clean and well-maintained, resuspension is of lesser importance.

[63] Available at www.defra.gov.uk/environment/airquality/panels/aqeg/publications/index.htm

Dealing with minor roads

A2.44 Roads that are not being assessed in detail will include minor roads as well as rural or more distant major roads. Minor roads will usually carry comparatively small amounts of traffic that are not likely to give rise to the possibility of an exceedence of Air Quality Objectives in their own right. Data describing traffic flows on minor roads is sparse, and this means that traffic will usually need to be estimated on the basis of fairly crude surrogate statistics.

A2.45 The objective is to compile an area source type grid (usually of 1 x 1 km resolution) of the roads that are not being assessed in detail. This grid will represent the emissions from hot exhausts from the network of roads not included in road link and junction assessments. This grid needs to be based on the best available data. There are two options:

- Using traffic count data: In many cases there will be a number of road counts for the major roads and some of the minor roads. For the minor roads, where the counts are likely to be sparse these data can be used to estimate an average flow per kilometre of minor road. This data can then be multiplied by the total minor road kilometres to get an estimate of total vehicle kilometres on the minor road network. Distributing the vehicle kilometres total across the area using road density from Ordnance Survey (OS) maps or the "minor road" distribution map from the NAEI will create a distribution of minor road vehicle kilometres that can be used to calculate emissions grids. It is recommended that a local traffic engineer be consulted when making these estimates. The other major roads can then be added to this or derived from the NAEI's major road maps and subtracting the roads being assessed in detail.
- Without using traffic count data: The NAEI holds national 1 x 1 km distribution data sets for emissions on minor roads. These datasets distribute the UK total minor road emissions and are based on average flow by road type and OS minor road density maps. These datasets can be accessed from the Helpdesk but should only be used in the absence of more detailed local data. Consider carefully whether the contribution from this source is likely to be material to the study being undertaken.

Dealing with background road data

A2.46 Background road emissions are those that are not the primary focus for concern. However, they may collectively contribute to local ambient levels. This means that the contribution from this may need to be taken into account in certain areas, particularly those considering wider than immediate major road corridors, or those where predicted compliance with objectives is in doubt. There are three categories of background road emissions:

- roads that are not being assessed in detail (minor and less significant major roads);
- cold start and evaporative; and
- brake and tyre wear.

A2.47 Background national emissions datasets can be found at: www.naei.org.uk/data_warehouse.php However, this dataset is based on national spatial statistics and therefore if the emissions from any of the above sources is likely to be significant in relation to air quality exceedences, it is recommended that more detailed local data are sought.

Frequently asked questions

Who do I contact for traffic flow information?

A2.48 The relevant department within your local authority should be the first point of contact for obtaining traffic flow information. It is discussed further in Para A2.08.

What type of traffic flow information exists?

A2.49 There are two possible types of traffic flow information:

- Traffic counts are made either by human observation ("manual counts") or machine ("automatic" or "continuous" counts). Essentially, traffic passing the observer is counted and (usually) "classified" (ie, organised into sub-categories for each of the main vehicle types) over a time period, or sequence of related time periods. These should be used in preference to traffic model data.
- Traffic/transportation models: a computerised representation of the road network. Local Authority traffic engineering departments commonly use these to investigate the likely impact of future road policies, such as infrastructure development.

A2.50 Data from traffic models has a greater amount of uncertainty associated with it than measured flows. Use of modelled data is therefore more suited to "screening" and DMRB Screening Model studies. Traffic count data will usually be more reliable at the level of the individual link and should be used wherever possible for Detailed Assessments. The primary disadvantage of "Traffic Count" data are that they are resource-intensive to collect for other than a small number of links; that care needs to be taken in extrapolating what are essentially point-based observations to whole "roads"; and that these data do not take account changes to traffic flow in subsequent years.

A2.51 In obtaining, understanding and manipulating traffic activity data from either traffic models or traffic counts, it is very important that users thoroughly understand the basis on which the data have been compiled. A large number of issues can arise here, and the following should be used as a checklist. Close working liaison between environmental and transport practitioners will be required. The latter should be able to assist on all of the points in this list.

What years do I need to assess my traffic for?

A2.52 You need to project traffic flows forward to the relevant year depending on the pollutant being assessed (see Main Document). Each traffic or transport department within a local authority should have estimates of the expected growth on roads under their jurisdiction.

A2.53 Specific future plans (either to reduce traffic congestion or to develop housing or commercial areas) will have an effect on the traffic flows and may even include the construction of new roads. Depending on the maturity of these plans there may already be flow estimates and even impact assessment data available from the planning department of the local authority or the County Council. This "Local" information should be used in any Detailed Assessment of traffic impacts.

A2.54 You should ask for year-by-year growth factors based on road types – the growth on motorways for example is likely to be different to the growth on urban roads.

A2.55 You may be provided with growth factors based on HIGH, MEDIUM or LOW estimates. Ask your transport, traffic or planning department to indicate which one is the most reasonable, and to provide you with a justification of which one you should use, particularly when low or no growth is advised.

A2.56 The English Regional Traffic Growth Forecasts from the National Traffic Model (NTM) should be used to undertake the necessary projections where local information is not available www.dft.gov.uk/pgr/economics/ntm/AF07_Annex_Baseline_summary.xls.

A2.57 These can be used to estimate the annual percentage increase in traffic by road type by English region and by whether the area is built up or not. These forecasts are updated annually. For areas outside England, the Scottish Government, the Welsh Assembly Government or the Department of Regional Development (Northern Ireland) should be contacted.

A2.58 Estimates specific to each local authority district in GB is provided by TEMPRO. The TEMPRO system provides forecast data on trips for transport planning purposes. However, it does not take into account changes to fuel cost and vehicle operating cost over time so is not suitable for direct use as a growth factor to be applied to traffic flows. It therefore needs to be used with the Department of Transport's published forecast from the NTM. Guidance on the use of TEMPRO data is contained in WebTAG unit 3.15.2 (www.webtag.org.uk) (not yet published). A copy of the model can be found at:www.tempro.org.uk.

A2.59 Further information on TEMPRO can be found at:
www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/traffic/rtstatisticsla/ and www.uwe.ac.uk/aqm/review/tempro.pdf.

A2.60 Consideration should be given to the appropriateness of NTM derived "regional" traffic growth forecasts for the roads under study, particularly where (as is the case in many cities) roads are effectively already operating at "maximum capacity". Please note the NTM forecast and TEMPRO do not apply in Northern Ireland. Information on traffic growth in this area can be obtained, in the first instance, from the Department for Regional Development , NorthernIreland, Roads Service Transportation Unit, Transport Planning Team.

A2.61 Traffic speeds variations should also be considered for future scenarios.

What kind of traffic count information can I use?

A2.62 There is a wide range of traffic count data available to local authorities. The following can be used as long as they allow the AADT to be estimated:

- 12-hour manual counts: counts – generally available for one day between 7am and 7pm. This may include vehicle classification, but generally not speed;
- Automatic traffic count (ATC) data – generally available for at least a week, covering 24-hour flows for each day. Can often provide a range of vehicle classifications and speed data (where traffic is moving above a certain speed threshold);
- Video data – CCTV used to film traffic flows on a road and manually counted at a later stage. Can provide information on vehicle classifications but estimates of speeds are more difficult; and
- Radar speed data – hand held or fixed instruments measure the speed across a section of road.

A2.63 In many cases, counting systems are placed on free flowing sections of roads away from junctions. However both manual counts and speed radar, and video footage can be used to obtain data at junctions.

What if no traffic data are available?

A2.64 You can try to use your local knowledge to assess whether the road could be significant in the first instance. If you are able to identify that flows could be significant, and that exposure is also relevant you will need to gather some idea of the likely traffic flows. To do this, you can:

- download major traffic count data from the NAEI at www.naei.org.uk/data_warehouse.php or from the DfT at www.dft.gov.uk/matrix;
- compare the results with similar roads in your area and use your local knowledge.

A2.65 In the absence of any data you may need to arrange for an initial traffic count to be undertaken, from which you can estimate traffic flows. This should be done in consultation with the Local Traffic department and aim at estimating the AADT and vehicle split (at least percentage HDV) for the links of interest. Additional vehicle split (Cars/Taxis, LGV, Rigid and Articulated HGVs, Buses and Coaches and motorcycles) as well as the daily and weekly variation should be recorded if the link is likely to require a Detailed Assessment.

My traffic data is not in AADT format, what should I do?

A2.66 The DMRB screening model requires AADT traffic flows. Your transport/traffic department should be able to give you factors based on your region, to allow you move between:

- AM or PM peak to 12-hour flows and/or 24-hour flows;
- 18-hour flows (commonly used for noise assessments) and 24-hour flows.

A2.67 It should be borne in mind that you will generally have to apply the same factors to total traffic flows and assume that vehicle split information is the same. You should check that this is a reasonable assumption, particularly where you are applying factors to peak hour traffic flows.

A2.68 In addition local factors from sets of traffic flow may be derived for a few roads in an area and applied to other roads of a similar nature. An example of how to do this is shown in A2.175.

A2.69 Local conversion factors should be used as first preference where available, particularly when estimating emissions for Detailed Assessments. "Default" national factors (see Table A2.4) can be used but will not reflect local conditions and are therefore only recommended for estimating AADT for Updating and Screening assessments.

Source: DfT, Transport Statistics Division, Unpublished.

Table A2.4: National default factors for expanding 12 hour traffic counts to AADT

For roads within inner London	12 hour count multiplied by 1.45
For roads within outer London	12 hour count multiplied by 1.35
For roads within and including the M25 (London)	12 hour count multiplied by 1.30
For roads elsewhere within the UK	12 hour count multiplied by 1.15

A2.70 An alternative source of information is the COst Benefit Analysis (COBA) manual www.dft.gov.uk/pgr/economics/software/coba11usermanual/part4trafinputtocobarevis315.pdf

A2.71 In addition to the collection of AADT24 traffic flows, additional temporal detail is recommended. This additional detail will provide modellers with an indication of the levels and duration of peak flows for assessing peak hourly exceedences. Where a count is taken over a number of hours, the variation in the flow volume over the course of a typical day can be obtained directly. An example (Example 1) of the derivation of traffic flow data in Appendix A provides a worked example.

How do I know that the traffic flows are representative for the year?

A2.72 If you have used 12-hour traffic counts, these are often carried out on a single day – therefore you should check if this day was typical or not. Some local authorities will need to consider seasonal patterns, particularly in tourist areas, when estimating annual traffic flows for the year. You can do this by comparing the flows on the day of the manual count with 24-hour flows from ATC or similar data over the same period. For instance, if your manual count was taken on a Friday you should:

- Obtain ATC data for the same period on a similar road;
- Compare the same Friday with the rest of the week to check if there were significant differences between the average on that day and the 7-day average;
- If the data from the ATC is available over a wider time period, you can also check to see if that week was typical of the wider period or season;
- Similarly you can use other long-term traffic data to check that you are basing your screening assessments on reasonable estimates of traffic flows.

Friday and Monday counts are likely to overestimate, while weekend counts are likely to underestimate when used as averages for AADT.

Where can I get vehicle split data from?

A2.73 Basic vehicle split information should be available with the traffic flow information. As a minimum you should expect to be provided with a percentage HDV split from traffic counts and traffic model data. Manual traffic counts should have some more detailed traffic type splits. However, these more detailed traffic splits are likely to be less common. The NAEI's data warehouse contains some current and forecasted national traffic split information that can be used in the absence of local data.

How do I determine my vehicle splits?

A2.74 The DMRB Screening model requires as a minimum the average percentage of HDVs on a road. Traffic departments or the Scottish Government can be contacted to obtain basic proportions of vehicle classifications for some or all roads in an area. It is unlikely these data will be available for all roads so some consideration to the types and nature of roads will be required in order to make reasonable assumptions. Example 2: Vehicle Splits and Speeds is included in Appendix A. Where basic vehicle split information (percentage HDV) is not available, the NAEI can be used to obtain an estimate by region and road type for the major road types. Alternatively Transport Statistics GB contains UK average vehicle splits by road type, see: www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/traffic/tsgbchapter7trafdatatables.xls

Where can I get traffic speed data?

A2.75 Traffic speed information is not usually available with traffic count data. The local transport department or the Scottish Government may have information on speeds for specific links. Alternatively use the speed limit as an indication of the average speed. When making Detailed Assessments the effect of congestion on speed should be considered. A worked example: Example 2: Vehicle Splits and Speeds is included in Appendix A. The COBA manual contains a methodology for estimating vehicle speeds.
www.dft.gov.uk/pgr/economics/software/coba11usermanual/part5speedsonlinks.pdf

A2.76 In addition, Transport Statistics GB contains some average UK speeds on different road types: www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/traffic/tsgbchapter7trafdatatables.xls

How do I estimate speeds at junctions?

A2.77 For a busy junction, assume that traffic approaching the junction slows to an average of 20 kph (approximately 12 mph). These should allow for a junction, which suffers from a lot of congestion and stopping traffic. In general, these speeds are relevant for approach distances of approximately 25 m.

- For other junctions (non-motorway) and roundabouts where some slowing of traffic occurs, you should assume that the speed is 10 kph slower than the average free flowing speed;
- For motorway or trunk slip roads you should assume average speeds of 40–45 kph (approximately 30 mph) close to the junction;
- You should use local knowledge of an area to help assess whether a junction suffers regularly from congestion. You may have speed data at only a few locations, but these may be representative of other roads in your area.

A2.78 See Section A2.08 for how to approach detailed speed assessments. A worked example: Example 2: *Vehicle Splits and Speeds* is included in Appendix A. The COBA manual contains a methodology for estimating vehicle speeds: www.dft.gov.uk/pgr/economics/software/coba11usermanual/part5speedsonlinks.pdf

Point sources

Introduction

A2.79 Point sources should be considered as any stationary source likely to give rise to significant emissions of air pollutants.

A2.80 The initial stage for assessing point sources is to compile a list of relevant point source information. Identifying the type of installation at this early stage is key to ensuring that effort can be focused at significant installations amongst a potential mass of other insignificant installations. A list of major point sources can be found at www.naei.org.uk/mapping/mapping_2005/Points2005_AllPolls.xls

A2.81 The list should cover all potential point sources and must include:

- Part A1 Integrated Pollution Prevention and Control (IPPC) installations controlled by the Environment Agency (EA) in England and Wales, Scottish Environment Protection Agency (SEPA) in Scotland and Northern Ireland Environment Agency (NIEA) in Northern Ireland;
- Part A2 IPPC installations controlled by the Local Authority in England and Wales, SEPA in Scotland and NIEA in Northern Ireland; and
- Part B (Part C in Northern Ireland) installations (Local Air Pollution Prevention and Control (LAPPC) installations controlled by the Local Authority in England and Wales, SEPA in Scotland and NIEA in Northern Ireland)[64].

It should also include small boilers and certain un-regulated installations such as some petrol filling stations, pottery kilns etc. In addition, any Part A1, A2 and B point sources in neighbouring local authorities, which are very close to the border (and therefore likely to impact upon air quality within the district in question) should be included in this list.

A2.82 Where point sources have already been assessed in earlier review and assessment work, changes or new installations should be identified. To assist authorities in reviewing the data, the EA, SEPA, and the Northern Ireland Industrial Pollution and Radiochemical Inspectorate (IPRI), have committed to provide information on any changes that may affect emissions from existing installations, and any new installations that have been, or will be, permitted. The information will be provided from the local office on request.

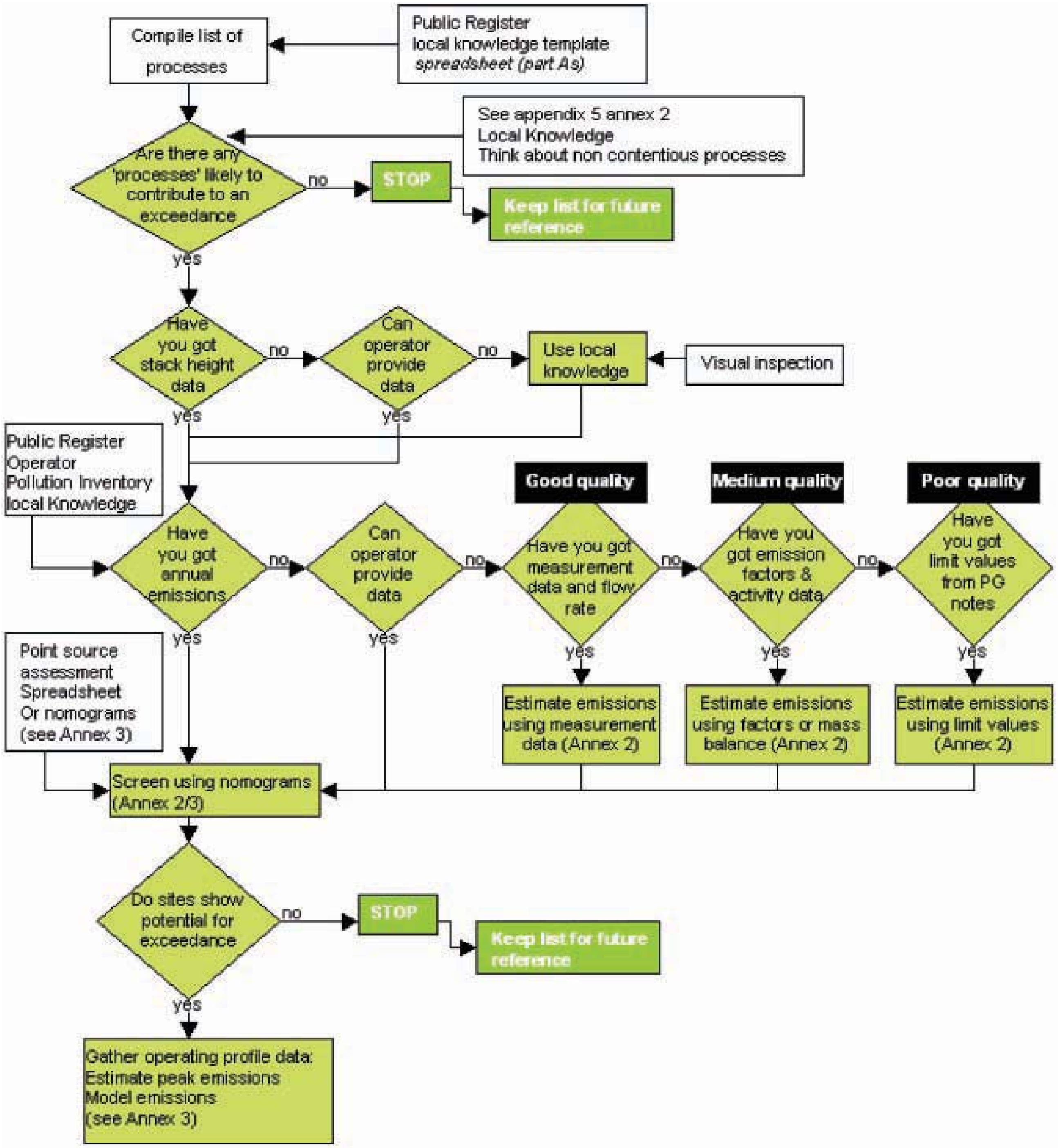
A2.83 All point sources should be listed with the minimum required pre-screening details of installation descriptions. For installations that are likely to have a significant impact on local air quality a basic nomogram assessment must be undertaken.

A2.84 Since 2001, the European Commission has collected data on emissions from all installations covered by the IPPC Directive. This information was published in the form of the European Pollutant Emissions Register (EPER). For reporting data from 2007 onwards, EPER is replaced by the European Pollutant Release and Transfer Register (E-PRTR). This requires emissions data to be reported by Local Authorities for those installations covered under IPPC plus for additional industrial sectors. The dataset is to be made publicly available, with a search facility. To achieve this, a website is to be set up, hosting the emission's database and a map interface. This will be a useful source of information and is expected to be made available in 2009[65].

[64] In Northern Ireland, processes are regulated under the Industrial Pollution Control (NI) Order 1997 and categorized as Part A, B and C. The Industrial Pollution and Radiochemical Inspectorate (IPRI) regulate Part A and B processes. Part C processes are regulated by Local District Councils. In Scotland, both Part A and Part B processes are regulated by SEPA.

[65] Website address not available at the time of publication.

Figure A2.4: Collecting emissions data for point sources



Identifying priority sectors and pollutants

A2.85 Significant emissions are likely from a number of different installations. This may include either Part A1, A2 (under IPPC), B and C regulated installations. It may also include smaller unregulated installations including small boilers. As well as defined (stack) releases, industrial installations may also give rise to fugitive emissions. This is particularly relevant to emissions of benzene, 1,3-butadiene, particles and lead. Fugitive emissions generally arise at ground level, for example from chemical storage and handling plant, quarries and some metal refining activities, and are more difficult to quantify using simple methods. As a result fugitive emissions from industrial source may need to be considered as area and/or volume sources. Appendix E provides a list of the major fuel storage depots.

Point source data gathering

A2.86 There are a number of different point source data sources.

A2.87 **Regulated Installations:** A large quantity of data for regulated Part A and B (including Part C in NI) installations will be contained in the public register. The public register should be regarded as the starting point for compilation of an initial list of names, addresses and descriptions of regulated installations. To reduce the burden on operators, Local Authorities should contact the appropriate regulator for the data before contacting operators directly. Part A installations public register is available on the EA website www2.environment-agency.gov.uk/epr.

A2.88 The exact details of any data held in the register depends on a site-specific permit, and this may not include all of the details required by local authorities because it was not specifically designed for the purposes of air quality management. Similarly, the register will document all substantial changes and variations as defined in regulations although this may not include changes such as an increase in throughput if this remains within the conditions of the permit, which specifies a range rather than an absolute value.

A2.89 **Unregulated Installations:** In addition to the large boilers that are a common feature of Part A and Part B industrial installations, a local authority may typically host several additional sites operating smaller boilers not regulated under Part A, B (or Part C in Northern Ireland), such as:

- large schools and colleges;
- hospitals;
- office headquarters;
- district heating schemes.

A2.90 There is evidence to suggest that localised exceedences of the 15-minute sulphur dioxide (SO_2) objective may occur in the vicinity of coal- or oil-fired combustion plant of less than 20MW rating.

A2.91 Information regarding boiler characteristics and operations is often difficult to acquire, and direct application to the boiler operators will usually be necessary. Oil is used in older small industrial boilers, or as a backup supply for non-guaranteed gas supply contracts. If the boiler is used as a backup boiler, while the boiler itself may be of a significant size, it may only be used for a few hours a year which could result in an exceedence.

Getting data from the public registers

A2.92 Public registers are an important source of information about emissions from, and operations at, permitted installations. These registers should be continually updated.

A2.93 The information contained in the registers differs between England and Wales, Scotland, and Northern Ireland. In England and Wales, there are two public registers – the EA IPPC public register (containing information about Part A1 installations – installations regulated by the EA) and the Local Authority registers (containing information about Part B (LAPPC) and/or Part A2 installations). In Scotland, the SEPA register holds information about IPPC Part A1, Part A2 installations and Part B installations. In Northern Ireland the public register holds information about IPPC Part A1, Part A2 and Part B installations and is maintained by the IPRI of the Northern Ireland Environment Agency. Local district councils hold Part C information.

A2.94 Commissioning data (that is, data collected when a plant first starts to operate) will not be as accurate as data from a recent monitoring exercise.

Public register for Part A industrial installations

A2.95 Information on Part A installations is collated and held on a public register by the relevant enforcing authority as detailed below:

A2.96 For each permitted installation the following information should be present:

Table A2.5: Public registers for Part A installations

Region of the UK	Relevant authority
England and Wales	The Environment Agency (EA)
Scotland	Scottish Environment Protection Agency (SEPA)
Northern Ireland	Northern Ireland Environment Agency (NIEA)

Table A2.6: Permitted Part A Installations	
Public register entity	**Information included**
Initial application for permit and details of subsequent variation to conditions of permit	• installation description • details of installation equipment – including any arrestment plant • activity data – throughput/production rates • release points • stack parameters • potential releases to atmosphere • commissioning data (including monitoring/modelling data) • modelling studies • operating hours • site plans – possibly detailing building dimensions
Permit conditions and details of subsequent variations to operating conditions.	• emission limits (annual/instantaneous) • reporting requirements • definition of release points
Compliance monitoring data	• emission limits (annual/instantaneous) • reporting requirements • definition of release points
Annual emissions data	• emissions estimates
Revocation, variation and enforcement notices	• emission exceedences and operating problems
Modelling studies*	• emissions estimates • stack parameters (for example, diameter, velocity, flow rate and temperature)
Emission reduction plans*	• emission reductions

*Possible additional information

A2.97 The availability of data on the Part A public register tends to vary for different installation types. Combustion processes are tested regularly and information down to stack configuration and location is often readily available. Organic installations, on the other hand, are often less well documented and information may be available about a large multitude of stacks and vents with no easily discernible differentiation. The public register does not contain information that is considered to be commercially confidential.

A2.98 An additional source of information with regard to Part A installations may be available through consultation with the appropriate local EA, SEPA on NIEA inspector. The EA maintains access, via a web site, to a database of releases from the industrial installations it regulates. See the section "Getting Data from the Regulator" below.

Public register for Part B industrial installations

A2.99 Information on Part B or Part A2 installations (and Part C in Northern Ireland) is collated and held on a public register by the relevant enforcing authority as detailed below:

Table A2.7: Public Registers for Part B Part A2

Region of the UK	Relevant authority
England and Wales	Local Authorities
Scotland	Scottish Environment Protection Agency (SEPA)
Northern Ireland	Northern Ireland Environment Agency (NIEA) & Local District Councils (Part Cs)

A2.100 The public register is continually updated and contains information on each permitted installation (usually in the form of an individual file for each installation). For each permitted installation the following information should be present:

Table A2.8: Permitted Part A Installations

Public register entity	Information included
Initial application for permit and details of subsequent variation to conditions of permit.	• brief installation description • details of installation equipment – including any arrestment plant • activity data – throughput/production rates • release points • stack parameters • potential releases to atmosphere • commissioning data (including monitoring/modelling data) • modelling studies • Operating hours • Site plans – possibly detailing building heights
Permit conditions	• emission limits (annual/instantaneous) • reporting requirements • definition of release points
Details of subsequent variations to operating conditions	• operating profiles
Modelling studies	Note: this is unusual for Part B installations
Emission reduction/upgrading plans	

A2.101 In general, the Part B public registers are less comprehensive than their Part A counterparts. In particular, information relating to release points and stack parameters is likely to be sparse. Part B installations are less polluting than Part A installations and therefore they will have less air quality impact and subsequently they require lower levels of monitoring.

A2.102 The Part B public registers will not contain information that is considered to be commercially confidential.

A2.103 A brief summary of the level of information that can be obtained from the Part B public register for the main installation types is given below:

- Combustion installation operators may provide emission monitoring data for SO_2, NO_X, carbon monoxide (CO), particles and organic compounds, although a complete set of data would be unusual. Waste oil burners rarely report emissions of fuel use data. When monitored data are not available emissions can be calculated, using the annual fuel use or boiler size with relevant EFs.
- Ferrous and non-ferrous metal installation operators may provide some monitored emissions data for SO_2, NO_X, CO, particles, organic compounds and lead/metals. Data are often incomplete and recourse will usually need to be made to EFs, based on a description of the installation characteristics.
- The cement and mineral industries are a potential source of particles but there is usually very little data relating to emissions. For some of these installations, use can be made of the UK Emissions Factor Database (EFD) provided that material throughput/production rates are known.
- Incineration installation operators may provide emission monitoring data for SO_2, CO, particles, metals and organic compounds. When monitored data are not available emissions can be calculated for clinical waste incinerators from EFs.
- Coating and timber installation operators do not often provide monitored emissions data. Where particles or hydrocarbon emissions from these installations are of interest, these may be estimated on the basis of materials throughput. Where incinerators or other hydrocarbon arrestment equipment is employed NO_X and CO emissions may be reported.
- The animal and vegetable processing industries vary greatly in the data supplied. Animal feed processors may have particle emissions data only, whereas the tobacco industry often has a reasonable set of monitored emissions data. A limited number of EFs are available for some of these installations. Details of throughput/output will be needed to calculate emissions.

A2.104 As yet Part B installations are not included in the Pollution Inventory (PI) in England and Wales. Currently there is no equivalent national database for Part B installation releases. However see Section A2.84 on E-PRTR.

A2.105 Activity data such as throughput of raw materials/production rates and operating hours given in the original application for permit may have changed significantly since the initial application. Although information concerning substantial changes and variations to the original permit should be kept on the public register, relatively minor changes may not be documented. This is particularly the case for Part B installations. As a result it is recommended that, for sites that are significant, data taken from the public register be checked with the operator.

Getting data from the regulator

A2.106 The Pollution Inventory for England and Wales: The specific requirements for reporting releases from Part A installations are set out in the conditions of each individual permit. From November 25th 1998 all Part A permits include a condition that requires installation operators to report annual releases of the substances listed in the PI where appropriate. Reported releases from Part A installations are submitted to the relevant local EA office. The PI is available on the internet at www.environment-agency.gov.uk [66]

- The PI identifies just over 200 substances that may be released to air, land or water. These substances include those identified in national/international legislation as well as those associated with health and/or environmental effects. The reporting requirements for the PI encompass emissions from an entire Integrated Pollution Control (IPC) installation and thus account for both point source emissions (stack emissions), and fugitive emissions (for example, material transfer/storage, cleaning and maintenance).
- Emissions data from IPC installations is submitted in a standard format against a common list of substances. Each substance listed in the PI has a "threshold reporting value". Operators are only required to report installation emissions where they exceed the threshold reporting values. Annual releases given on the PI for Part A installations are given for the entire plant. As a result the annual release figures could relate to many distinct stacks and could include fugitive emissions. The PI does not allow dissemination of these data, nor does it provide details of the release points that contribute to the total release of a substance. Releases are only reported on the PI if they exceed the EA's reporting threshold values. Some Part A installations may emit quantities of a substance that could be significant with regard to local air quality but fall below these thresholds. Such installations should not necessarily be discounted from review and assessment solely on the basis of their releases being below the reporting thresholds. This is especially the case for locations where there are several sources of a pollutant in close proximity.
- Although Part A installations are required to report emissions of PM_{10} over 1 tonne per year to the PI, data for PM_{10} can be difficult to obtain for industrial sources. Where required, particulate monitoring for Part A and Part B installations is nearly always undertaken for total particulate. For certain installations PM_{10} emissions can be estimated from total PM emissions using EFs for which particle size distribution studies have been undertaken.
- The situation is similar for lead emissions. Part A installations are required to report emissions of lead over 10 kg per year to the PI. Monitoring of lead emissions is usually undertaken for total metals. Releases of lead from industrial sources are frequently reported as total metals for a defined group of metals/metal compounds.

A2.107 Permits and inspectors information: Additional information can be found for Part "A" installations by contacting the EA directly. Environment Agency inspectors will have an in-depth knowledge of the Part "A" installations in their area and will be able to help with local knowledge.

A2.108 For SEPA regulated Part A and B installations: Information can be obtained by contacting the relevant unit in SEPA.

A2.109 Reported releases from Part A and B installations: Additional information in Northern Ireland can be obtained by contacting IPRI.

[66] Reported releases from Part A and B processes and additional information in Northern Ireland can be obtained by contacting NIEA.

Getting data from the operator

A2.110 A great deal of useful and up-to-date information can be obtained from the operator. It is recommended that the operator be consulted when estimating emissions and operating profiles. The extent of consultation will depend on both the detail and currency of the available data from the public register as well as the importance of the source. It is unnecessary to approach an operator of an installation unlikely to cause air quality exceedences as defined by the pre-screening assessment.

A2.111 Operators should have all the required information, however, the public register and the PI and regulatory bodies such as the EA for England and Wales, SEPA for Scotland and the Northern Ireland Environment Agency (and the E-PRTR data when it comes available) should be consulted first. In cases where the sources are likely to be significant, the operator should be asked to confirm the validity of the information used. They should also be asked to provide additional information where necessary which is not available from the centralised sources such as the public register or the regulatory bodies.

A2.112 Responses from operators are likely to take time and require pursuing. It is however worthwhile and should be started as early as possible.

Getting data from Process Guidance Notes

A2.113 The following guidance notes are available:

- process Guidance Notes (For Part B installations)
- sector Guidance Notes (For Part A2 installations)
- guidance for those operating Part A1 activities is available at www.defra.gov.uk/environment/ppc/regs/index.htm

Emissions estimation

A2.114 In many cases, the available data will be inadequate for estimating annual emissions. Many Part B installation registers only contain information on spot stack/vent measurements or emissions estimates for only part of the installation. Often there is no monitoring data or estimates of annual emission available. In these cases it is recommended that the emission estimates be derived in collaboration with the operator. A quick focused discussion with the operator could save many hours of uncertain calculation and guesswork. For the initial screening phase, annual emissions should be the main focus.

A2.115 Emission tests or continuous emission monitoring data, when available, are usually the preferred option for estimating the mass emissions from a installation. Generally, installation specific tests and/or continuous emissions monitoring programmes allow determination of the pollutant contribution from an existing source more accurately than the use of EFs. Even then, the results will be applicable only to the conditions existing at the time of the testing or monitoring. To provide the best estimate of longer term (ie, yearly or typical day) emissions, these conditions should be representative of the installation’s routine operations.

Using monitoring or emission limit data

Calculation of annual emission estimates using concentrations from monitoring or emissions limits data:

A2.116 Estimating annual emissions from stack/flue concentration data are done here in two steps. Step one calculates the mass emitted per second based on the measurement or limit values. Step two calculates the annual emission based on the operating profile of the plant. The following worked examples are included in Appendix A:

- Example 3: Calculating the Volumetric Flow Rate.
- Example 4: Estimating Emission Data from Monitoring Data.
- Example 5: Use of Emissions Factors for Calculating Emissions for Industrial Installations.

Step One: Calculating emissions in grams per second from concentration values

A2.117 ***Using monitoring data:*** There are two types of monitoring, continuous or periodic. Continuous monitoring will measure the concentration continuously and an average of this measurement is adequate for estimating an annual emission. Periodic monitoring exercises relate to a fixed instant in time. The release rate, exit velocity and exit temperature of efflux gases will relate specifically to the conditions under which the monitoring exercise was undertaken. For a continuous installation, which continually operates under the same conditions, variations from one monitoring exercise to another should be minimal. For batch installation, installations that frequently change their operating conditions and start up/shut down/emergency procedures a one-off annual monitoring exercise will not necessarily represent process emission accurately. Conditions of permit define the reporting conditions for monitoring data.

A2.118 In many cases not all releases from a installation will be monitored, generally only those specified in the conditions of permit will be reported on. The flow from similar ducts and stacks that have not been measures should also be considered assuming the same emission concentration as those measured.

A2.119 Where monitoring data are used to derive long term average concentrations, typical or average emission rates should be adequate. For pollutants with short term averaging periods a number of worst case scenarios should also be considered.

A2.120 Monitoring data for point sources are usually recorded as concentrations on a mass or volumetric basis (either mg/m^3 or ppm). Generally, releases are reported in units of milligrams per “normal” (N) cubic metre. A normal cubic metre of gas is a cubic metre of dry gas at 273 K, 101.3 kPa. Where monitoring results are given in units of ppm (parts per million) it may be necessary to convert to units of mg/m^3 or mg/Nm^3. Conversion from ppm to mg/m^3 or mg/Nm^3 is briefly described in Appendix B. GSS12 also contains information for this conversion.

A2.121 Monitoring data from point sources are usually corrected to standard reference conditions to take account of the effects of temperature, moisture content, oxygen content and pressure. The standard reference conditions are different for different installations. For example, pollutant concentrations in the discharge from a crematorium may be expressed at reference conditions of 273 K, 101.3 kPa and 11 % oxygen dry gas. Volumetric flow rates in the discharge are also usually corrected to the same reference conditions. If the volumetric flow rate and the pollutant concentration are both expressed at the same reference conditions then it is straightforward to calculate the rate of emission. However, significant errors may arise if the flow rate and concentration are expressed at different conditions. Seek expert advice if in doubt – for Part A1 installations, check with the local

EA, SEPA, or NIEA.

A2.122 ***Using Emission limits.*** Where emission monitoring has not been done or data are not available "emission limit" values may be used to estimate emissions in place of monitored concentrations. Certain installations may have emission limits for various releases. Emission limits, where applicable, are usually stated in the conditions of permit. These will normally reflect the limits contained in the relevant Process Guidance Note. For Part A installations some of the IPR Installation Guidance Notes contain emission concentration limits. Care must be taken when estimating emissions in this manner.

A2.123 Data relating to release limits will have obvious limitations in relation to accurate quantification of emissions for review and assessment and, in particular, downstream modelling applications where a temporal description of emissions may be required. Where limits apply over different time periods (for example, annual limits versus concentration limits) care should be taken to distinguish between the maximum permissible release over a short interval and the maximum permitted over a longer period. Many installations operate well within their specified emission limits. Thus, the use of release limits may lead to over estimation of emissions.

A2.124 For Part B installations the concentration release limits specified in the Process Guidance Notes generally relate to a specific unit within the installation – for example, to one spray booth, one print train or one incinerator. The installation in question may operate more than one of these units. Additionally, there is often more than one limit for a installation according to what (if any) form of control/abatement technology is in place. Thus, some detailed knowledge is required to use emission limits for the purpose of estimating releases.

A2.125 ***Calculation:*** To obtain the emission rate in units of grams per second, the following information will be required:

- release concentration (mg/Nm^3 or mg/m^3 at standard reference conditions) from monitoring data or emission limit
- volumetric flow rate (Nm^3/s or m^3/s at the same reference conditions) or estimated "volumetric flow rate" from stack diameter, temperature and velocity.

A2.126 The emission rate (g/s) can then be obtained from the following calculations:

Table A2.7: Estimating emissions from release concentration and flow rate

emission rate	=	release concentration at standard reference conditions	x	volumetric flow at the same reference conditions	x	0.001
		mg/Nm^3		Nm^3/s		g/mg

Step two: Calculating the annual emission

A2.127 Annual emissions can be calculated from the emissions rate (g/s) and the operating profile using the equation below. This profile will be based on the operation of the installation over the course of the hours of the day, days of the week and months of the year. The template spreadsheets provides a framework for recording this information as it is essential for estimating peak emission periods and generating suitable input for air quality assessment modelling. For more information on estimating operating profiles and using the default datasets see A2.142.

Table A2.7: Estimating emissions from release concentration and flow rate

Annual emissions	=	emission rate	x	seconds / hour	x	hours/day	x	days/wk	x	wks/year	x	0.000001
Tonnes/yr		g/s		g/h		h/d		d/wk		w/year		tonnes/g

A2.128 When making such assumptions local authorities should be aware of, and take into consideration, the inaccuracies that are being introduced. Emissions can be estimated from emission limit concentrations following the methodology described in this section. However, it is important to note that this calculation may only be used for screening purposes and is likely to lead to an overestimation of actual emissions.

Using emissions factors

A2.129 Example 5: Use of Emissions Factors for Calculating Emissions for Industrial Installations in Appendix A provides a worked example.

Calculating annual emissions using activity data and emission factors

A2.130 Emission factors can be used to calculate annual emissions from activity data such as fuel consumption, production, or consumption statistics. Emission factors can be based on one or several sets of measurement from similar installations and can be very generalised (such as an average for coal combustion in boilers) or highly specific (such as coal combustion in a tangential grate boiler).

A2.131 If you are using the point source estimating tool spreadsheet then this spreadsheet contains EFs for the significant installations. On entering the installation details and specific activity data a screening emission estimate will be calculated. Follow the instructions in the introductory pages of the spreadsheet.

A2.132 The use of EFs often requires a detailed knowledge of a installation and it is important to consider the "appropriateness" or "relevance" of an EF before applying it. Additionally, some EFs are more robust than others, depending on how they were derived and how much test data was available, and this should be taken into account when considering the accuracy of emissions estimated from EFs.

A2.133 Emission factors have been used as fundamental tools for air quality management for a considerable time. Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating emissions because the data provides the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over a prolonged period of time. Thus, EFs are frequently used for estimating emissions, in spite of their limitations.

A2.134 The application of EFs to estimate emission from an industrial installation is the same, in principle, for both Part A, Part B and unregulated installations. However, some installation types are better represented by EFs than others:

- Combustion installations (Part A and Part B) have been well studied and a wealth of EFs are available for a large range of pollutants.
- The metal industries have generated a reasonable number of EFs. Some of these are more applicable to the larger Part A installations than Part B installations. Emission factors for this industry sector tend to be dominated by particulate releases. Only a small number of factors are available for lead emissions. Some EFs exist for fugitive releases from these installations. A relatively detailed knowledge of the installation itself and the installation equipment (ie, furnace type, abatement technology) is required to use these factors effectively.
- Mineral installations are reasonably represented by EFs. For some installations, such as cement batching, factors are available for fugitive particulate emissions. However, particulate size distribution data are limited, hence estimations of PM_{10} are generally difficult.
- There are relatively few EFs for the chemical industries as these installations tend to be unique. Engineering judgement or mass balance techniques coupled with local knowledge are recommended for estimating emissions from the chemical industries sector.
- The waste disposal industries are well documented. Emission factors are available for a large range of substances.
- For the "other industries" installations EFs are relatively sparse or rely on activity data that may be difficult to obtain.

A2.135 Emission factors for industrial installation generally relate the release of a substance to an activity associated with that process. The actual activity data required to carry out emissions estimation varies depending on the installation in question.

A2.136 For most installations raw material usage (throughput) data or production rate data are necessary. For example, EFs for combustion installations require fuel use data and factors for steel manufacturing process require steel production rates. It can be difficult to obtain the appropriate activity data from the public registers – especially for Part B installations. It may be best to approach the operator directly for the most up to date and reliable activity data.

A2.137 Many EFs are very specific to particular equipment types, firing configurations, abatement/arrestment technologies etc. In order to ensure the most appropriate factor is selected for use it is necessary to have a reasonably detailed knowledge of a process. A table listing the main sources of EF data can be found in Appendix B.

Material balance (mass balance) and engineering judgment

Calculating annual emissions using "expert" engineering judgment or mass balance

A2.138 A mass balance approach may provide reliable average emissions for specific sources. A pragmatic definition of mass balance is "what goes in comes out, unless it stays there!". For some sources, a material balance may provide a better estimate of fugitive emissions than emission tests alone. In general, material balances are appropriate for use in situations where a higher percentage of material is lost to atmosphere via fugitive means (for example, storage tanks). In contrast, material balance may be inappropriate where a material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput.

A2.139 Engineering judgment: If no other reasonable option exists, releases can be estimated using best engineering judgment. This can be based on release data from other similar installations (where releases are already known) combined with knowledge of the physical and chemical properties of the materials involved. For example, for certain installations, vapour pressure and/or equipment design information can be used to make appropriate assumptions in order to estimate the amount of a substance released.

Estimating future emissions

A2.140 There will be very little information on future emissions in the public register and getting this information from the operators is likely to be difficult. Where possible, get the regulatory body to provide details of likely future emissions from plant which they regulate. Alternatively the operator should be able to provide details of likely future emissions. If this data is not available then forecast profiles for specific industrial sectors can be obtained from www.berr.gov.uk/energy/index.html.

Estimating fugitive emissions

A2.141 Fugitive emissions may also give rise to significant emissions for some large installations or storage facilities. This is particularly relevant to emissions of benzene, 1,3-butadiene, particles and lead. Emissions can be calculated from mass balances or loss inventories for products or feedstock compiled by the operators. Where the fugitive emissions are from an installation and the release is not product or feedstock loss then it can only be estimated using EFs and activity data. Emission factors can be found on the NAEI data warehouse website or in the point source estimating tool spreadsheet.

Operating profiles

A2.142 For detailed modelling it is important to understand the operating profile of the process. This is especially important for processes that do not operate at a constant level all day, week or year. In these cases the annual emission may be concentrated into only a few hours of the day, days of the week or months of the year and will be far more likely to contribute to significant exceedences.

A2.143 Hours of the day: The number of operating minutes for each hour of the day should be added here. For a continual process then each hour should be assigned 60 minutes.

- Days of the week: These profiles should be entered as percentage of a standard day (ie, normal working day = 100%).

- Months of the year: These profiles should be entered as percentage of a standard month (ie, normal working month = 100%).

A2.144 It is highly recommended that these data be compiled in consultation with the operator especially for complex batch installations. If no data are available or the processes follow general patterns then default profiles can be used.

Other stationary sources

A2.145 In evaluating the possible contribution from this source, it is particularly important that local authorities are clear about the definition of this group of emissions, so that the potential for double-counting is avoided. The definition of the scope of these emissions that is usually applied is "emissions arising from the combustion of the remaining fuel in an area-wide consumption statistic once fuel giving rise to emissions already identified as point- or line-based sources (particularly Part A/B installations and boilers treated explicitly as point sources) have been subtracted".

A2.146 Emission estimations for this source suffer particularly from difficulties associated with obtaining good activity data, and the relatively poor quality of the available EFs. A general method for estimating area-based emissions sources is given in Example 6 in Appendix A. Users should note that spatial re-apportionment across several different geographical bases may be required. The following sections confine themselves to a discussion of some of the more important issues relating to activity data and EFs.

Biomass burning

A2.147 Procedures are set out in Chapter 5 of the Main Document to enable local authorities to undertake screening assessments to determine whether a biomass combustion installation in the range 50 kW to 20 MW thermal will lead to pollutant concentrations exceeding the air quality objectives or will compromise the effectiveness of measures set out in their Action Plans. Nomograms are also provided in Chapter 5 of the Main Document to assess the impact of boilers larger than 20MW. The provision of chimneys for biomass burners less than 50 kW thermal is covered by the Building Regulations.

A2.148 The local authority may obtain details of the maximum thermal capacity of the appliance instead of the maximum rates of emission. Local authorities may then estimate rates of emission based on the Clean Air Act exemption limits or on the basis of EFs provided by the EMEP/CORINAIR Emission Inventory Guidebook – 2006. In smoke-controlled areas, biomass burners require exemption under the Clean Air Act. Exempted appliances are required to emit less than 5 g/h PM plus 0.1 g/h per 0.3 kW of heat output. The EMEP/CORINAIR Emission Inventory Guidebook – 2006 gives typical EFs solid fuel appliances. These are summarised in Appendix A.

Low level domestic and commercial combustion

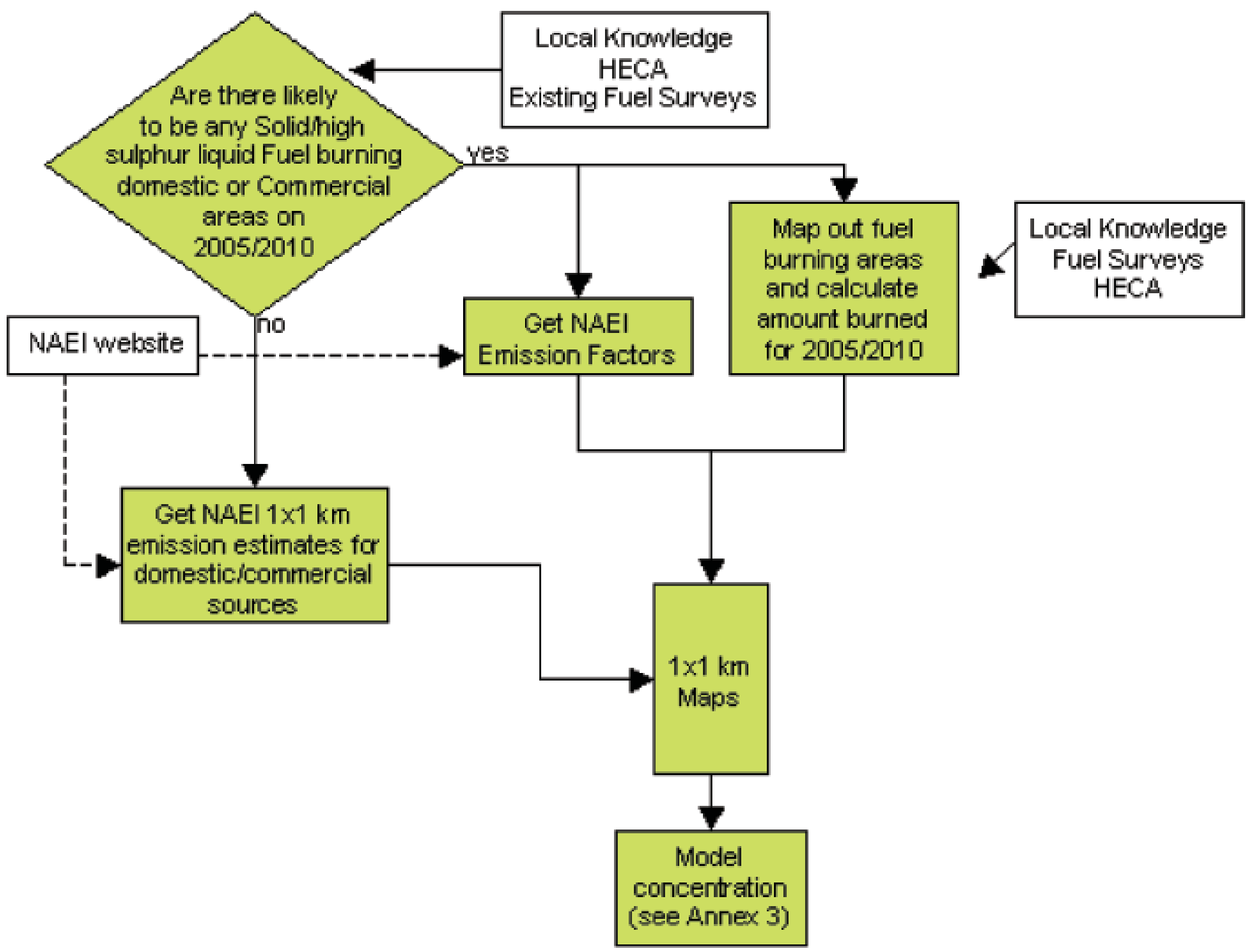
A2.149 For SO_2 and PM_{10}, in areas that are particularly associated with the domestic combustion of high solid or high sulphur liquid fuel, it is important to fully assess the impact of these sources. For other pollutants it is unlikely that emissions from low-level domestic and commercial combustion will contribute a significant quantity of emissions and will not warrant detailed treatment.

A2.150 Figure A2.5 shows a flow diagram for assessing non-point domestic/commercial combustion. In cases where local knowledge can show that there is no significant domestic or non-point source commercial combustion of coal or oil then NAEI background grids for domestic and commercial emissions can be used and no further investigation is needed. The NAEI background grids can be obtained from www.naei.org.uk/data_warehouse.php.

A2.151 Many domestic fuel use surveys have been undertaken in Northern Ireland, so it is worth checking to see what information is already available in these areas before conducting further assessments.

A2.152 Where it is likely that there will be significant emissions from domestic or commercial sources then a Detailed Assessment of the spatial emissions must be done. This should be at least at a 1 x 1 km emission map of domestic and commercial solid/liquid burning for the current year and 2010.

Figure A2.5: Estimating residential and commercial emissions



A2.153 Identifying solid/liquid fuel burning areas: Using local knowledge and maps highlight the areas where solid or high sulphur liquid is burned (estates, commercial areas etc). These areas will be used to constrain the distribution of solid and high sulphur fuel burning in the emission maps. If there are significant commercial sites then these should be treated as point sources and dealt with according to the point source guidance.

A2.154 Getting activity data – in some cases coal/smokeless solid fuel (SSF) or other solid fuel sales data may be available from coal merchants, possibly on the basis of postcode or other sales areas. It is important to attribute these sales to the point of use, which is potentially different from point of sales. Population or household numbers are a useful surrogate for distributing this sales data within the areas defined as "solid/liquid fuel burning areas".

A2.155 Local surveys under The Home Energy Conservation Act (HECA) can provide detailed postcode level survey data on domestic fuel consumption by fuel type. This data if available can be obtained from the local authority Energy Conservation officer. This data can give quantitative as well as spatial activity data for solid, liquid and gaseous fuel consumption.

A2.156 If no local data is available, estimates of emissions from domestic fuel burning on a 1 X 1 kilometre grid square basis can be obtained from the mapping section of the NAEI data warehouse. Improvements were made to this data set in the 2005 maps.

A2.157 Basic EFs for the combustion of coal and other solid and liquid fuels are provided in the EF section of the NAEI data warehouse. Emission factors for peat and some other solid fuels are not currently included. If EFs for these sources are required then please contact the LA Air Quality Support Helpdesk for more information.

A2.158 It is not expected that emissions from the combustion of gaseous fuels will need to be evaluated in detail. National Atmospheric Emissions Inventory emission grids are available for emissions from commercial and domestic gas consumption at www.naei.org.uk/data_warehouse.php.

Other sources

A2.159 There are a wide variety of other area-based sources that give rise to emissions of pollutants for which objectives have been prescribed. An example of an area source is quarrying. Total emissions from these sources, and the data that is available to estimate them, are such as to not warrant detailed studies by local authorities. Background emission maps can be obtained from the NAEI on www.naei.org.uk/data_warehouse.

A2.160 In some cases it may be necessary to estimate specific sources in more detail depending on their significance. In the case of PM_{10}, wind-blown dust, sea salt, fugitive emissions from activities such as quarrying and bulk materials handling etc may form a significant component of ambient PM_{10} levels. These sources are not amenable to conventional emissions calculations, and local authorities interested in PM_{10} levels from this perspective are advised to contact the Local Authority Air Quality Support Helpdesk.

A2.161 One further source of PM_{10} emissions is from activities arising from poultry farms. There is currently limited information available and to date no Detailed Assessments have been completed. The large poultry farms (more than 40,000 birds) are controlled under Environmental Permitting Regulations.

Other mobile sources

Emissions from aircraft movements in the vicinity of airports

A2.162 Airports are complex and highly-visible activities which may be considered as part of a review and assessment. In general, however, the contribution of aircraft movements at the busier UK airports is unlikely to give rise in itself to an exceedence of Air Quality Objectives in areas with residential or other non-occupational population. Nevertheless, the contribution from this source may combine with other activities associated with the airport (particularly associated road traffic) to form the focus of a Detailed Assessment. The emissions from airports may also need to be scrutinised for wider purposes, such as the consideration of airport expansion plans.

A2.163 For the narrow purpose of review and assessment, detailed work should only be justified at the larger airports in the UK (in excess of 10 million passengers per year). In all of these cases, comprehensive and recent inventories have been provided from a number of sources. To find out about existing work on emissions from significant airports contact the Local Authority Air Quality Support Helpdesk. Appendix C contains a list of airports and their activity in 2006.

A2.164 For smaller airports, aggregate datasets from the NAEI on www.naei.org.uk/data_warehouse.php can be used as background emission maps.

Emissions from inshore and estuarine shipping

A2.165 Shipping is unlikely to be the primary cause of a possible exceedence of Air Quality Objectives anywhere in the UK, and therefore it is unlikely that local authorities will need to undertake detailed work on this source. A detailed assessment is only recommended for large ports (defined as more than 5,000 movements per year) and where there is relevant public exposure within 1 km of berthing and manoevering.

A2.166 Defra is currently sponsoring work to quantify emissions from all recognised ports (including both large ships as well as smaller passenger craft and fishing vessels) within the UK. Once available, the data will be used in the NAEI emission maps and the final report from the study will be made available on the NAEI website.

A2.167 Until this study comes available, or if users prefer to compile their own emission estimates, then annual shipping movements are available from the Department for Transport Maritime Statistics www.dft.gov.uk/pgr/statistics/datatablespublications/maritime/

A2.168 More specific data may be available from the Harbour Master at the port of interest. The average time taken for vessels to berth at the dock is required, as is the time to travel either to the end of the study area or a known point out to sea. These times should be available from the Harbour Master.

A2.169 For more detailed work, the engine power rating of each vessel is required instead of the tonnage. This data can be purchased from the Lloyds Maritime Information Services for vessels other than ferries, and ferry data can be obtained from published timetables and the ferry operators.

A2.170 Average EFs for shipping activities are available from the NAEI data warehouse. More detailed EFs and an accompanying methodology can be found in the latest EMEP/CORINAIR Guidebook available at: reports.eea.europa.eu/EMEPCORINAIR5/en/page002.html

A2.171 If modelling shipping emissions, they are best represented as a line source (ie, along lines of rivers or shipping lanes). The approach taken should take into account the plume rise.

A2.172 Ships arrive and depart from ports at irregular intervals. Shipping berths in port may not be occupied at all times. For much of the time, there may be no ship present on the shipping lane. It is important to take account of the time varying nature of emissions when assessing the impacts of the shipping against short-term air quality objectives (for example, for SO_2). Ideally, the model would include shipping schedule data. However, in the absence of detailed schedules, useful simulations can be obtained by assuming that ships arrive at random intervals.

A2.173 European Council Directive 2005/33/EC imposed new limits on the sulphur content of fuels used by ships.

A2.174 Cargo handling operations at large ports, for example rubber-tyred gantry cranes for container handling, may provide a significant source of pollutant emissions.

Appendix A: Worked examples

Example 1: Derivation of traffic flow data

A2.175 The following is an example of the traffic data available:

- 24-hour count data providing total volumetric flows for each hour has been provided by the local transport department for two roads. One road (ROAD A) is a main street with many shops, the other is an urban road (ROAD B) through the city. Detailed counts are available and a summary over ten weeks has been prepared.
- 12-hour manual counts at a number of locations throughout the town are available for one day.
- Peak hour counts covering the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00 for a number of locations.
- Vehicle classifications based on 12-hour counts for Road A and Road B.
- 24-hour speed profile of traffic on Road A and Road B.

Step 1:

A2.176 For initial screening and DMRB assessment the 24-hour AADT flow needs to be determined for each road, along with an estimate of average speed and HDV percentage.

A2.177 The 24-hour AADT for Road A and B can be determined directly from the 24-hour count data provided by the traffic department. The average 24-hour flow for the period of ten weeks for each road should be an appropriate estimate for the annual average. This can be confirmed by asking the local traffic department if there is a significant seasonal factor for traffic in the area.

Step 2:

A2.178 Consider the roads for which only 12-hour and/or peak hour information is available. Divide the roads up into those, which are of a similar nature to Road A, and Road B using local knowledge.

A2.179 Using the detailed 24-hour counter data for Road A or B, calculate a factor between the 12-hour and 24-hour flow for each day of the week. At the same time, sum the traffic flows for each day for the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00 for each day. This enables a ratio between the total peak hour flow and the 24-hour total to be calculated. An example of this is shown below for Road B. It is possible to derive other factors from the peak hour flow data. However, the approach taken in the example makes good use of the available data.

A2.180 Example detailed count data for 1 week for Road B are shown in Table A2.11:

Table A2.11: Detailed count data example

Hour end	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	7 day wk
1	197	204	229	263	250	418	413	282
2	126	127	127	152	165	322	275	185
3	151	96	114	113	112	238	238	152
4	105	102	87	115	111	222	212	136
5	151	137	159	155	164	150	137	150
6	336	347	372	399	414	261	113	320
7	1113	1067	1124	1099	1131	523	271	904
8	2512	2673	2622	2736	2623	983	446	2085
9	2743	2798	2647	2678	2713	1278	469	2189
10	2013	2050	2191	2108	2223	1532	753	1839
11	1971	2051	2000	2110	2035	1841	1168	1839
12	2025	2058	20175	2118	2283	2076	1557	1882
13	2153	2300	2247	2303	2422	2250	1700	2042
14	2267	2316	2284	2404	2463	2388	1793	2196
15	2232	2311	2244	2372	2558	2231	1793	2274
16	2357	2369	2310	2444	2559	1907	1805	2250
17	2735	2683	2852	2791	2861	1851	1697	2496
18	2838	2833	2827	2812	2606	2009	1503	2490
19	2162	2088	2473	2254	1968	1488	1225	1951
20	1551	1545	1881	1719	1644	1304	1111	1536
21	1136	1213	961	1369	1140	962	918	1100
22	866	907	995	974	959	725	828	893
23	574	660	1727	710	734	672	608	812
24	379	427	517	446	559	511	467	472
Total for peak hours ending 8-10 and 16-18	15,198	15,406	15,449	15,569	15,585	9,560	6,673	13,349
12-hour	28,008	28,530	28,872	29,130	29,314	21,834	16,970	25,951
16-hour	32,674	33,262	33,383	34,291	34,188	25,348	19,098	30,385
18-hour	33,627	34,349	36,077	35,447	35,481	26,531	20,173	31,669
24-hour	34,693	35,362	37,165	36,644	36,697	28,142	21,561	**32,895**
Ratio 24-hour/12-hour	1.24	1.24	1.29	1.26	1.25	1.29	1.35	**1.27**
Ratio 24-hour/total peak	2.28	2.30	2.41	2.35	2.35	2.94	3.23	**2.46**

A2.181 From the data above, a factor of 1.27 has been derived to estimate the 24-hour count from a 12-hour count on road similar to Road B. In addition, a factor of 2.46 has been derived to enable an estimate of the 24-hour flow from the peak count data for Road B.

Step 3:

A2.182 Check that the 24-hour flow calculated from the detailed data for one week is representative of the longer period of measurement. The 24-hour average flow over a ten week period on Road B was 32,178 vehicles. Therefore the one of week detailed flow of 32895 would need to be multiplied by a factor of 0.98 (approx) to be corrected to 32178. This indicates that the week used for detailed flows is representative of the longer term monitoring and that it is not necessary to further adjust the 24-hour flows.

A2.183 12-hour counts for roads similar to Type B should be multiplied by 1.27 to adjust to a 24-hour AADT estimate. The total peak hour counts (ie, the sum of the flows for the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00) for Road B should be multiplied by 2.46 to estimate the 24-hour AADT on these roads.

Step 4:

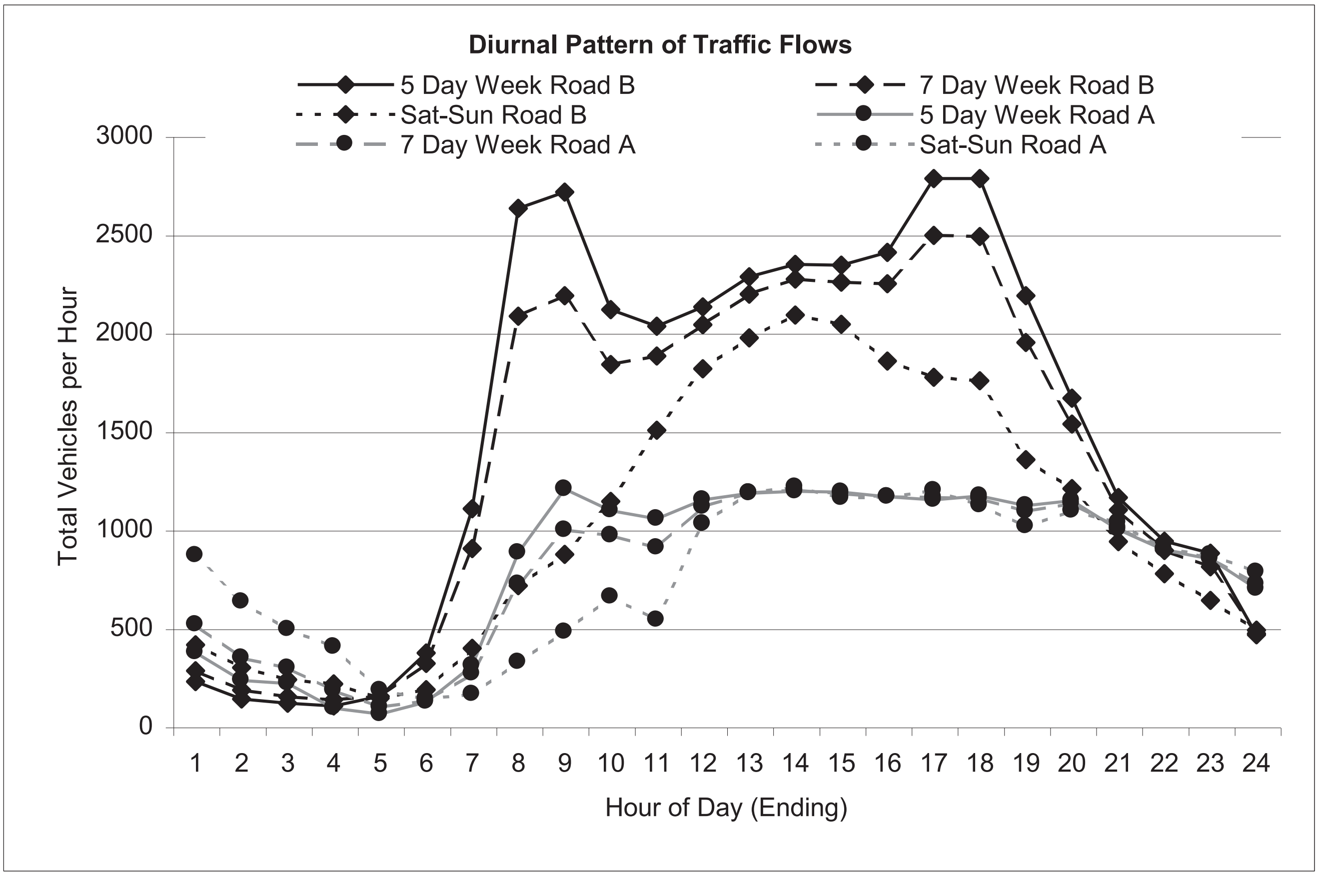
The same exercise was carried out for Road A.

A2.184 A factor for 12-hour to 24-hour flows of 1.5 was derived, and a factor of 3.13 for total peak hours to 24-hour flows. In addition, when the 24-hour flow for the week of 18245 was compared to the longer term set of data, an average 24-hour flow of 19350 was calculated, giving a ratio of 1.06. This additional factor should be applied to the 24-hour flows to give an estimate of the 24-hour AADT for roads of similar nature to Road A.

A2.185 The derived factors indicate that the patterns of flows on Road A and Road B are significantly different and highlight the importance of considering the nature of roads when trying to determine a reasonable estimate of the 24-hour AADT flow.

A2.186 It can also be seen in the graphs below that there are differences to the patterns of flows on the week days and weekends. Therefore, careful consideration to traffic patterns for the roads should be given when carrying out a Detailed Assessment.

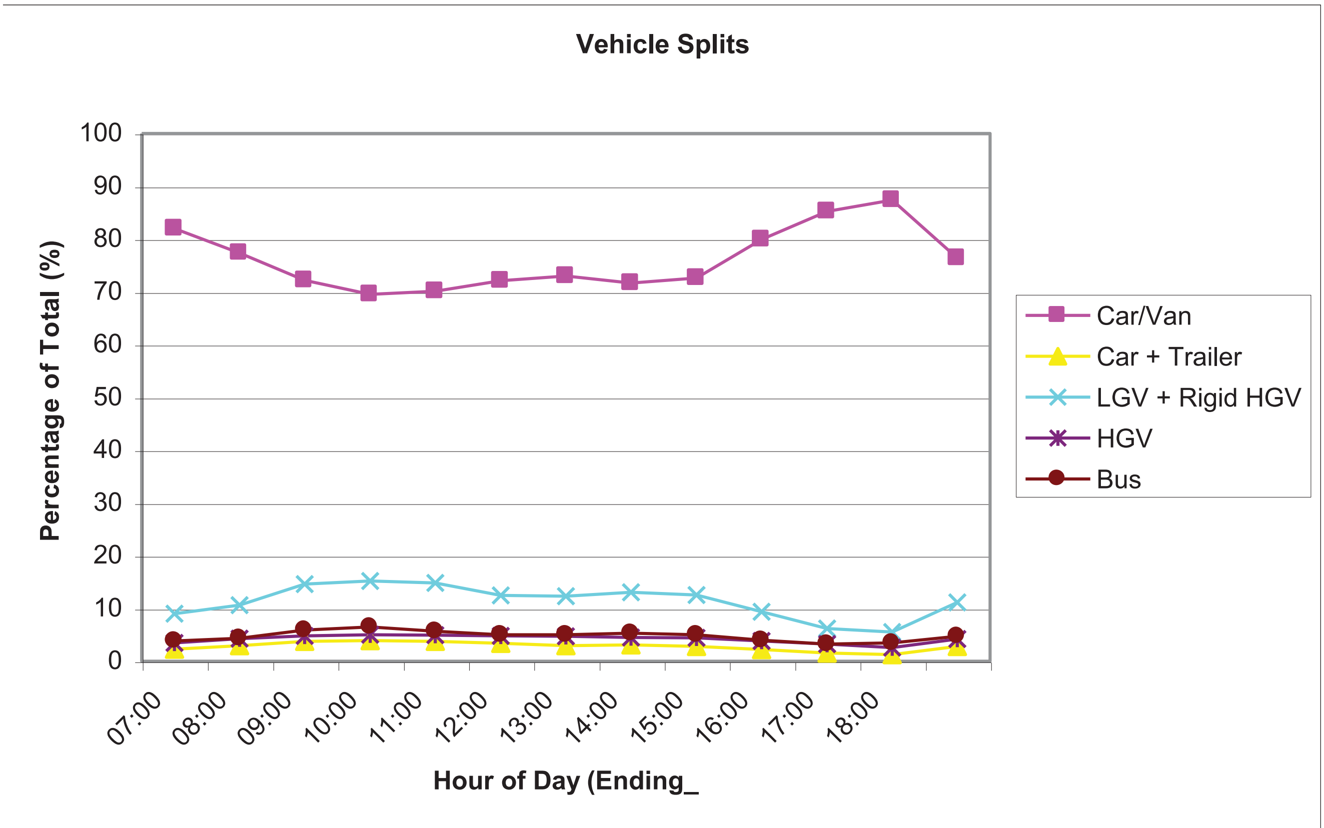
Figure A2.6: Diurnal patterns of traffic flow



Example 2: Vehicle splits and speeds

A2.187 For the same roads in Example 1, the local authority has obtained vehicle split data based on 12-hour manual counts. The data for road B is shown in the graph below.

Figure A2.7: Vehicle split %



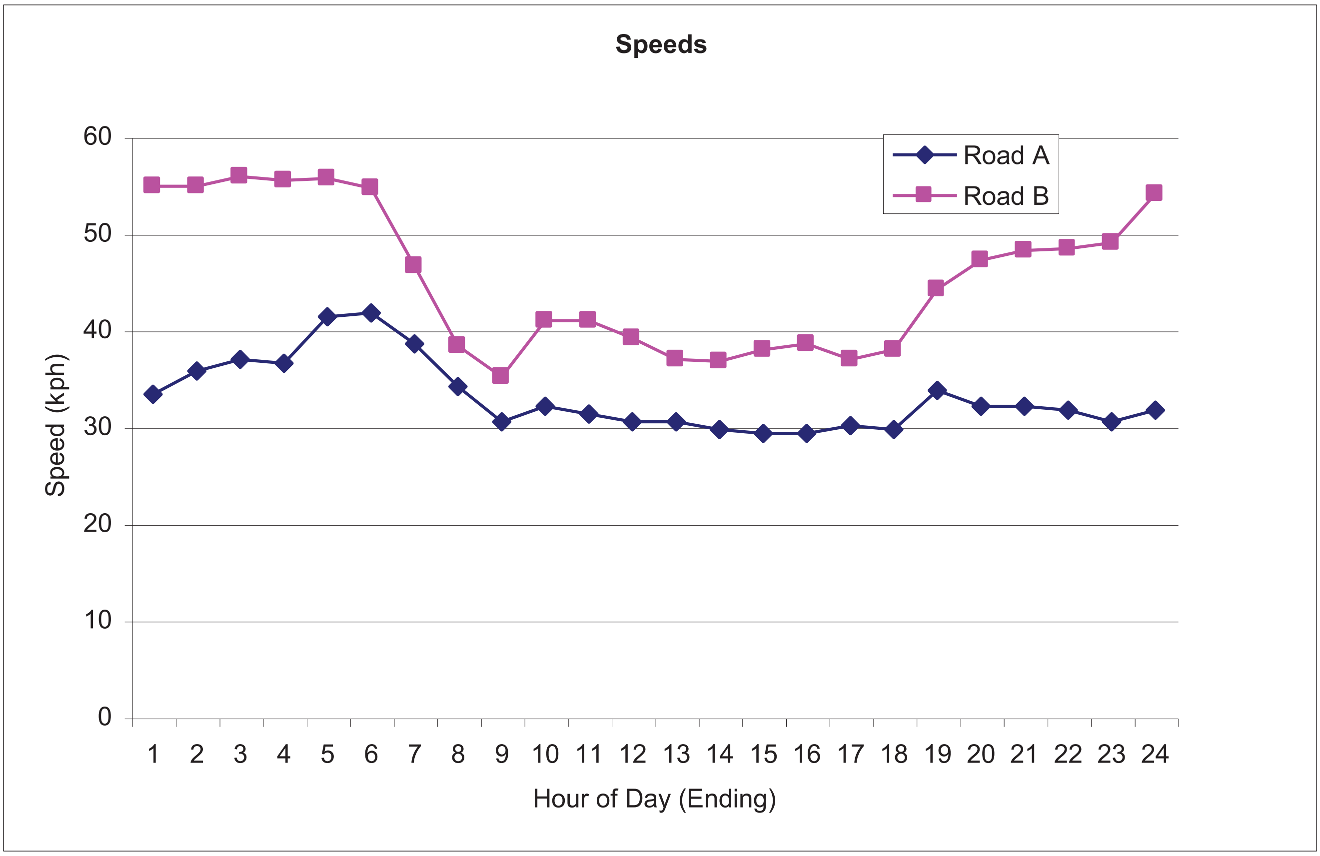
A2.188 The data indicates that while there is some variation of traffic flows throughout the daytime, it does not appear to vary significantly, and therefore an average split for the day can be derived from the data. The count data are not suitably classified to separate into LDV and HDV, as required by the DMRB Screening Model, or for calculating emission rates for different vehicles types as the count data combines splits. The traffic department and suppliers of count data were contacted and provided information to enable the count data to be further defined as appropriate for emissions calculations, as shown below.

Table A2.12: Vehicle split data

Original split	Car / Van	Car + trailer	LGV + rigid	HGV	Bus
	76.8%	2.8%	11.3%	4.3%	4.8%
Revised split	Car / Van	Car + trailer	LGV + rigid	HGV	Bus
	74.0%	13.0%	6.8%	4.2%	2.0%

A2.189 In addition, the local authority has been able to obtain speed data on an hourly basis for Road A and Road B. A graph of the data is shown below.

Figure A2.6: Diurnal patterns of traffic flow



A2.190 The speed graph shows that the two roads have different speed profiles, and the average speed of Road A is much lower than Road B, particularly at night. The average speed for the relevant road should be applied to roads of a similar nature. For detailed modelling in areas of exceedences, a variation in speed throughout the day should be considered. Using the shape of the profiles, a separate speed for the daytime and one for night-time would sufficiently reflect the variation throughout the day.

Example 3: Calculating the volumetric flow rate

A2.191 The calculation of rates of emission from monitoring results requires a measurement of the flow rate of the discharge at specified conditions of temperature, pressure, moisture content and oxygen content. When the flow rate is not reported with the monitoring results, an approximate estimate can be calculated from the stack diameter (m) and stack gas velocity (m/s) as follows:

Flow rate	=	area of stack	x	stack velocity
m^3/s	=	m^2	x	m/s

A2.192 However, this calculation may contain substantial errors if the actual temperature, oxygen content and moisture content of the discharge are markedly different from the specified conditions. Seek expert advice if in doubt – for Part A1 installations, check with the EA, SEPA, or the NIEA.

Worked example of how to obtain an approximate estimate of flow rate

A 13 m high stack has a diameter of 0.4 m.

Stack gas velocity is 1 2 m/s

Stack cross sectional area	$= \pi r^2$
	$= 3.14 \times (0.4/2)^2$
	$= 0.126\ m^2$
Flow Rate	= 0.126 x 12
	$= 1.24\ m^3/s$

Example 4: Estimating emission data from monitoring data

A2.193 The following data has been obtained from the Public Register:

Installation	Crematoria, Part B installation, 5.1
No of installation units	One
No of flues	One
Stack height	15 m
Volumetric flow at reference conditions of temperature, pressure, moisture content and oxygen content	2.1 Nm^3/s
CO emissions at reference conditions of temperature, pressure, moisture content and oxygen content	173 mg/Nm^3
The following data has been assumed:	
Operating hours	2,000 hr/yr

Annual carbon monoxide emissions										
CO	=	173	x	2.1	x	3600	x	2000	x	0.000001
kg/yr	=	mg/Nm^3	x	Nm^3/s	x	s/hr	x	hr/yr	x	kg/mg
	=	**2616 kg/yr**								
Note: When using monitoring data from a batch installation it is important to use the actual operating hours (ie, those for which the installation is operating and not the opening hours of the facility) to calculate annual emissions.										

A2.194 This method can also be used to calculated release rates (g/s) from monitoring data. In this case the annual operating hours are not required and the following calculation would be carried out:

Carbon monoxide emission rate (g/s)						
CO	=	173	x	2.1	x	0.001
g/s	=	mg/Nm^3	x	Nm^3/s	x	g/mg
	=	**0.36 g/s**				
Note: When using monitoring data to estimate release rates (g per s), for pollutants with Air Quality Objectives with short term averaging periods, it is important to understand what operating conditions the monitoring data represents. If the monitoring data are an average of many monitoring runs, or typical of average conditions of operation it may not be representative of worst case scenarios (for example, start up/shut down).						

Example 5: Use of emissions factors for calculating emissions for industrial installations

A2.195 The following case study illustrates the general procedures used to calculate emissions from point-source installations using EFs. Some of the features illustrated in this case study are:

- The scope of ideal activity data requirements from process operators.
- The limitations of activity data that is commonly available.
- The use of key engineering assumptions in completing the set of activity data required for the application of EFs.
- The selection and use of EFs.

Case Study 1

A2.196 This case study illustrates the use of EFs where the operator has provided sufficient information such that no assumptions, regarding the installation itself, need to be made.

A2.197 The following information has been obtained from the process operator:

Installation	Part B 1.3, waste oil combustion
No of flues	One
Fuel Use	Waste Oil
Sulphur content	1.8%
Ash content	0.1%
CO emissions at reference conditions of temperature, pressure, moisture content and oxygen content	173 mg/Nm^3
Oil consumption	76 m^3/yr
Operating hours	1,978 hours/year

A2.198 The basic details supplied by the operator are sufficient for a simple emissions calculation, using the EFs from the NAEI data warehouse. The EFs for: SO_2, NO_X, CO and PM and PM_{10} from the data warehouse are as follows:

Table A2.13: Emission factors for waste oil combustion (kg per cubic metre)

Pollutant	SO_2	NO_X	CO	PM	PM_{10}
Factor	17.6 x S	2.28	0.6	7.7 x A	79% of PM

S = % sulphur in fuel (by weight)
A = % ash in fuel (by weight)

Using this information, the following calculation can be made to estimate annual emissions for these pollutants:

Etot = F x T

Where:
Etot is the total annual emission for one of the case study pollutants (kg/yr).
F is the emission factor for a Part B waste oil combustion process (kg/m^3).
T is the annual throughput of waste oil (m^3/yr).

Application of the above equation results in the following annual emissions estimates:

Table A2.14: Annual emissions from waste oil burner (kg/yr)

Pollutant	SO_2	NO_X	CO	PM	PM_{10}
Emission	2408	173	47	59	46

Case Study 2

A2.199 This case study illustrates the use of EFs where the operator has provided insufficient information to enable a straight forward calculation of annual emissions from EFs. This study highlights the limitations of activity data and the nature of the assumptions that may be required in order to complete emission calculations. The following information has been obtained from the process operator:

Process	Part b 1.3, waste oil combustion
No of flues	One
Fuel Use	Waste Oil
Thermal Rating	0.5MW

The throughput can be estimated from the thermal rating of a boiler. To calculate the throughput the following information is required:

- annual operating hours, and
- calorific value of the fuel.

A2.200 In cases where the operating hours are not available, but are necessary to calculate annual emissions, it is reasonable to make an educated guess. The composition of waste oil varies according to its former use and, as such, it is difficult to provide fuel parameters that will be representative for all types of waste oil. In the absence of a detailed fuel specification it is possible to use fuel parameters for Heavy Fuel Oil (HFO)/residual oils. Average fuel parameters are provided in Appendix D. Thus, to estimate fuel consumption the following assumptions have been made:

Annual operating hours	8 hr/day, 5 day/week, 48 week/yr (1920 hr/yr)
Calorific value of oil	41,808 MJ/m^3

Using these assumed values the annual throughput can be calculated as follows:

$T = (R \times 3600 \times H)/C_{val}$

Where:

T	Is the annual throughput of waste oil (m^3/yr)
R	is the thermal rating of the boiler (MW)
H	is the annual operating hours (hr/yr)
C_{val}	is the calorific value (of the waste oil) (MJ/m^3)
in this instance:	
R	0.5 MW
H	1920 hr/yr
C_{val}	41808 MJ/m^3
Thus,	
T = (0.5 x 3600 x 1920)/41808	
T = 83 m^3/yr	

It should be noted that in calculating the throughput from the thermal rating of the boiler the following, additional, assumptions have been made:

The engine is continually operating at full load, and that fuel is consumed with 100% efficiency.

A2.201 Having calculated the annual throughput of waste oil the annual emissions can be calculated as described above. For this case study the operator did not supply a fuel specification thus, it will be necessary to make assumptions about the ash and sulphur content of the waste oil. In the absence of a detailed fuel specification it is possible to use fuel parameters for HFO/residual oils. Average fuel parameters are provided in Appendix D. It should be noted that waste oil generally has a lower sulphur content and a higher ash content than HFO/residual oil.

Assume:

% sulphur in waste oil	=	2.0%
% ash in waste oil	=	0.1%

This gives the following annual emissions:

Table A2.13: Annual emissions from waste oil burner (kg/yr)

Pollutant	**SO_2**	**NO_X**	**CO**	**PM**	**PM_{10}**
Emission	2922	189	50	64	50

Example 6: Area sources – preparing an emissions inventory from coal combustion over a residential area

A2.202 The following worked example illustrates the general procedures used to calculate emissions from area-based sources. An example of emissions from general coal combustion over a small (hypothetical) residential area where there is high solid fuel or coal use is given. Particular features illustrated by this worked example are:

- The form of the base activity data commonly received from data suppliers.
- Spatial re-apportionment using the capabilities of a mapping package/GIS.
- The importance of recognising and eliminating double counting of emissions in area – source estimates.

A2.203 Activity data for area sources is often available only on a spatially-aggregated basis to protect commercial confidentiality, or simply due to the impracticality of obtaining more detailed data. Where this is the case data needs to be re-apportioned from the original geography (which may typically be a postcode sector, electoral ward, county or even national level statistics) to the kilometre grid squares common to the other sources in the inventory. Data may also be estimated per household and apportioned per household. Coal sales data for an area were obtained from the several coal suppliers and merchants in the area for the last full year on a postcode-sector basis. Table A2.16 illustrates the typical form of the raw activity data. If the area in question is a smoke control area, the solid fuel used will in fact be SSF.

Table A2.16: Coal sales data in tonnes per year, as received from fuel suppliers

Postcode sector	Domestic coal (tonnes per year)	Coke (tonnes per year)
BX8 3	102	19
BX9 1	38	12
BX9 2	45	0
BX9 3	57	5
BX10 7	62	0
BX11 0	110	10
BX11 8	54	3
BX11 9	81	2
BX20 0	70	0

A2.204 Industrial and commercial coal (for example, hospitals, council buildings) should be counted under point sources, where possible. If coal is accounted for as an area source, care should be taken not to double-count.

A2.205 To be used in an emissions inventory, the original data (on a postcode sector basis) needs to be re-apportioned to the 1 by 1 km grid square geography. This can be done using the capabilities of a mapping package. In this case, a simple reapportionment based on area proportion is used (ie, the individual grid squares are assigned values depending upon the extent to which they overlie postcode sectors with different total values). More complex re-apportionments (for example, weighted by relative population density or road length) can be devised if appropriate.

A2.206 The spatially re-apportioned fuel usage per kilometre grid square is then multiplied by the EF to produce the emissions per grid square for each pollutant. The EFs for domestic coal (as an example) are given in Table A2.18, and the final calculated emissions from domestic coal in Table A2.19, by multiplying the coal used per square by the relevant EF.

Table A2.17: Coal sales data re-apportioned by kilometre grid square

Grid square (reference ID)	Domestic coal (tonnes per year)	Coke (tonnes per year)
354500,178500	17.97	1.60
355500,178500	12.38	0.68
356500,178500	6.14	0.05
354500,177500	16.89	1.20
355500, 177500	14.72	0.07
356500,177500	18.99	1.58
354500,176500	12.35	0.06
355500,176500	14.96	0.09
356500,176500	17.68	1.20

Source: 2006 NAEI data warehouse

Table A2.18: Emissions factors for domestic coal, in kg of pollutant per tonne of fuel

Pollutant	SO_2	NO_X	CO	PM
Factor	24.32	3.47	180.69	9.7

Table A2.19: Calculated emissions from domestic coal, in kg per year

Grid square (referenceID)	Domestic coal burnt (tonnes/year)	SO_2 kg/yr	NO_X kg/yr	CO kg/yr	Benzene kg/yr	PM_{10} kg/yr
354500,178500	17.97	377	536	24,114	6,945	72,226
355500,178500	12.38	260	369	16,613	4,784	49,758
356500,178500	6.14	129	183	8,239	2,373	24,678
354500,177500	16.89	355	504	22,665	6,527	67,885
354500,177500	14.72	309	439	19,753	5,689	59,163
355500, 177500	18.99	399	566	25,483	7,339	76,326
354500,176500	12.35	259	368	16,572	4,773	49,638
355500,176500	14.96	314	446	20,075	5,782	60,128
356500,176500	17.68	371	527	23,725	6,833	71,060

Example 7: Area sources – emissions from small boiler combustion over a mixed use area

A2.207 Solid fuel burning tends to be concentrated into small areas or estates, which generally cover less than 1 km^2. The procedure requires authorities to:

- Identify the areas with the highest densities of houses and service sector appliances burning solid fuels.
- Identify the types of solid fuel appliance used in each area from the list in Table A2.20.
- Count the numbers of each domestic heating appliance type in the identified 500 x 500 m squares. Estimate the floorspace occupied in the service sector in each of the identified 500 m x 500 m squares for each of the identified types of solid fuel burning plant.
- Multiply the number of houses for each appliance type by the annual household emission shown in Table A2.20. Sum the emissions from each of the domestic appliance types to give the total annual domestic emission from the 500 m x 500 m square.
- Multiply the service sector floorspace (in hectares) for each appliance type by the annual service sector emission per hectare. Sum the emissions from each of the service sector appliance types to give the total annual service sector emission from the 500 m x 500m square. Add the service sector emissions to the domestic emissions to give the total emissions from the square.

A2.208 Estimate the fraction of space in the 500 m x 500 m square occupied by solid fuel burning premises or domestic properties. Divide the annual emission by the fraction occupied by solid fuel burning to give the emissions density for the square (kg emissions per 500 m x 500 m area). This emissions density can then be compared to the relevant nomograms to determine if a Detailed Assessment is required or not.

A2.209 Consider a 500 m x 500 m square containing a new six hectare development of 400 houses on the outskirts of a large town. The houses are fitted with advanced automatic wood pellet boilers. The new development adjoins an eight hectare older estate. The older estate has largely converted to gas heating but there remain 50 houses that use conventional boilers burning coal. The 500 m x 500 m square also contains a school with floor area of 0.2 hectares in a plot of one hectare: the school is heated by means of a wood-burning advanced automatic boiler. There is also a public house with floor area of 0.1 hectare in a plot of 0.5 hectare; the public house is heated by open wood fires. The remaining part of the 500 m x 500 m square does not contain premises burning solid fuels.

A2.210 The total emissions of PM_{10} from the residential area is 400 x 3.54 + 50 x 23.03 = 1416 + 1152 = 2568 kg. The total emissions of PM_{10} from the school and the public house are 0.2 x 295 + 0.1 x 2291 = 59 +229 =288 kg. The total emissions from all solid fuel sources are then 2568 + 288 = 2856 kg.

A2.211 The area of the 500 x 500 m square occupied by solid fuel heated premises is 6 + 8 + 1 + 0.5 = 15.5 hectares. Thus the fraction occupied is 9.5/25 = 0.62. The emissions density is then 2856/0.62 = 4606 kg/year.

A2.212 The background PM_{10} in the area is estimated from the national maps to be 21 $\mu g/m^{-3}$. From Figure 5.22 in the Main Chapters, the threshold emission density is 5013 kg/ year. In this case, the calculated emissions for the 500 m x 500 m square are less than the threshold and there is no requirement to carry out a Detailed Assessment.

Table A2.20: emission factors for small combustion sources					
Description	**Corinair category**	**Fuel**	**Emission factor, g/GJ net**		
			PM_{10}	**$PM_{2.5}$**	**NO_X**
Open fireplaces: this type of fireplaces is of very simple design – basic combustion chamber, which is directly connected to the chimney. Fireplaces have large openings to the fire bed. Some of them have dampers above the combustion area to limit the room air intake and resulting heat looses when fireplace is not being used. The heat energy is transferred to dwelling mainly by radiation. Open fireplaces are usually of masonry type and have very low efficiency while having significant emissions of Total Suspended Particulate (TSP), CO, non-methane volatile organic compounds (NMVOC) and polycyclic aromatic hydrocarbons (PAH) resulting from the incomplete combustion of the fuels. **Partly closed fireplaces** are equipped with louvres and glass doors to reduce the intake of combustion air. Some masonry fireplaces are designed or retrofitted in that way in order to improve their overall efficiency.	Fireplace	Coal	330	330	60
		Wood	860	850	50
Closed fireplaces are equipped with front doors and may have distribution of combustion air to primary and secondary as well as a system to discharge the exhaust gases. They are prefabricated and installed as stand-alone units or as a fireplace inserts installed in existing masonry fireplaces. Because of the design and the combustion principle, closed fireplaces resemble stoves and their efficiency usually exceeds 50%. They have similar emissions like stoves, ie, lower than open, as well as, partly closed fireplaces. For this reason they can be rated among stoves. **Conventional stoves** have poorly organised combustion process resulting in low efficiency (40% to 50%) and significant emissions of pollutants mainly originating from incomplete combustion (TSP, CO, NMVOC and PAH). Their autonomy is low, lasting from three to eight hours. Those, which are equipped with hot plate zones, are used also for cooking – kitchen stoves. Some of them could also be used for hot water preparation. **Classic energy efficient stoves;** due to the utilisation of secondary air in the combustion chamber their efficiency is between 55% to 75% and emission of pollutants are lower, their autonomy ranges from six to 12 hours.	Stove	Coal	450	450	100
		Solid smokeless fuel	100	100	100
		Wood	810	810	50

Table A2.20: emission factors for small combustion sources *(cont'd...)*					
Description	**Corinair category**	**Fuel**	**Emission factor, g/GJ net** PM_{10}	$PM_{2.5}$	NO_X
Advanced combustion stoves: These stoves are characterised by multiple air inlets and pre-heating of secondary combustion air by heat exchange with hot flue gases. This design results in increased efficiency (near 70% at full load) and reduced CO, NMVOC and TSP emissions in comparison with the conventional stoves.	Advanced stove	Coal	240	220	150
		Wood	240	240	90
Pellet stoves: They can be fed only with pelletised fuels such as wood pellets, which are distributed to the combustion chamber by a fuel feeder from a small fuel storage. Pellets stoves are equipped with a fan and electronic control system for supply of the combustion air. For this reason they are characterised by high efficiency (above 80% up to 90%) and low emissions of CO, NMVOC, TSP and PAH.	Pellet stove	Wood	76	76	90
Conventional natural draught boilers < 50 kWth	Boiler<50 kWth	Coal	380	360	130
		Solid smokeless fuels	100	100	200
		Wood	475	475	120
Conventional natural draught boilers > 50 kWth and <1 MW th	Boiler > 50 kW th and < 1MW th	Coal	190	170	160
		Solid smokeless fuels	80	80	150
		Wood	240	240	150
Conventional natural draught boilers > 1 MW th	Boiler>1MW th	Coal	76	72	180
		Wood	67	65	150
Advance, under-fire coal boilers: In general the design and the combustion technique are similar to the conventional under-fire boiler. The main difference is that a fan controls the flue gases flow. Control system for the primary and secondary air might lead to increase in efficiency above 80% (usually between 70% and 80%).	Advanced manual boiler	Coal	140	130	200
Downdraught wood boilers: This type of boiler is considered state of the art in the lump wood combustion. It has two chambers, first one where the fuel is fed for partial devolatilisation and combustion of the fuel layer, and a secondary chamber, where burning of the released combustible gases occurs. The advantage of this boiler is that the flue gases are forced to flow down through holes in a ceramic grate and thus are burned at high temperature within the secondary combustion chamber and ceramic tunnel. Owing to the optimised combustion process, emissions due to incomplete combustion are low.		Wood	76	76	150

Table A2.20: emission factors for small combustion sources *(cont'd...)*					
Description	**Corinair category**	**Fuel**	**Emission factor, g/GJ net** PM_{10}	$PM_{2.5}$	NO_X
Stoker coal burners: The fuel with low ash contents and the grain size of between 4 mm up to 25 mm is automatically fed into a retort by a screw conveyor. Stoker boiler is characterized by higher efficiency, usually above 80%. The advantage of stoker boiler is that it can operate with high efficiency within load range from 30% to nominal capacity. In a properly operated stoker, emissions of pollutants resulting from incomplete combustion are significantly lower, however NO_X increases due to the higher combustion temperature.	Advanced automatic boiler	Coal	76	72	200
Wood pellet boiler has a fully automatic system for feeding of pellet fuels and for supply of combustion air, which is distributed into primary and secondary. The boilers are equipped with a smaller pellet storage, which is fuelled manually or by an automatic system from larger chamber storage. The pellets are introduced by screw into burner. These boilers are characterised by a high efficiency (usually above 80%) and their emissions are comparable to those of liquid fuel boilers.		Wood	66	66	150
Best Available Technology Domestic Boilers		Wood	20*	20	
ABATED Emissions					
Boiler, with fabric filter <20 mg/Nm³ TSP		Coal	6	5	180
		Wood	7	6	150
Older boiler with fabric filter or electrostatic precipitator <100 mg/Nm³ TSP		Coal	25	12	180
		Wood	25	12	150
Boiler with uncontrolled multicyclone		Coal	60	35	180
		Wood	70	55	150

* Based on an assessment of achievable performance from measurement data reported to AEA Technology for approval as exempt appliances under the Clean Air Act

Example 8: Biomass plant 50kW to 20 MW

A2.213 A 500 kW net thermal input capacity pellet stove is installed in a building 15 metres high. The stack height is 21 m and the stack diameter is 0.5 m.

A2.214 The pollutant emission rates are estimated from the factors for pellet stoves given in Appendix A. These are 76 g/GJ for PM_{10}, 76 g/GJ for $PM_{2.5}$ and 90 g/GJ for NO_X. The emission rates are then 76 x 500 x 10^{-6} =0.038 g/s for PM_{10} and 90 x 500 x 10^{-6}=0.045 g/s for NO_X.

A2.215 The background annual average nitrogen dioxide (NO_2) concentration is 35 µg/m^3. The background annual average PM_{10} concentration is 25 µg/m^3. Table A2.19 shows the calculated background adjusted emission rates.

A2.216 The effective stack height is 1.66 x (21-15)= 10 m.

A2.217 Table A2.21 also shows the threshold emission rates determined for each pollutant metric from Figures 5.19 to 5.21 in the main chapters. In each case the background adjusted emission rate is less than the threshold emission rate and so more detailed assessment is not required.

Table A2.21: Background adjusted emission rates and threshold emissions rates

	PM_{10}	**Annual mean NO_2**	**Hourly mean, NO_2**
Emission rate, g/s	0.038	0.045	0.045
Background concentration, g/m^3	25	35	35
Background adjusted emission rate, g/s	0.0054	0.009	0.014
Threshold emission rate, for 10 m effective stack height, g/s	0.0063	0.020	0.10

Appendix B: Sources of emissions factors

A2.218 Although several sources of EFs exist, the UK NAEI data warehouse was developed to aid in the Review and Assessment procedure; www.naei.org.uk/emissions. The UK EFD is based on emissions data used to derive the UK's NAEI. The EFs in this database are UK average factors for a large number of different source sectors including industrial processes, combustion, transport and residential and commercial combustion. The database also includes a number of screening factors based on employment, number of processes and population.

Other information sources

A2.219 An atmospheric emission inventory guidebook has been prepared by the expert panels of the UNECE/EMEP Task Force on Emissions Inventories and is published and distributed by the European Environment Agency. The Guidebook is designed to provide a comprehensive guide to atmospheric emission inventory methodology for each of the emission-generating activities listed in the Selected Nomenclature for Air Pollution (SNAP) and Nomenclature For Reporting (NFR) formats reports.eea.europa.eu/EMEPCORINAIR5/en/page002.htm.

A2.220 The United States Environmental Protection Agency (USEPA) has developed a large compendium of EFs, which is known as AP-42. AP-42 includes EFs for most of the review and assessment pollutants. The USEPA reviews and revises its air pollutant EFs every three years www.epa.gov/ttn/chief/ap42/

A2.221 Each AP-42 EF is given a rating from "A" through "E", with "A" being considered as being the most reliable. A factors rating is a general indication of the reliability, or robustness, of that factor. This rating is assigned based on the estimated accuracy of the tests used to develop the factor and on both the amount of data available from tests and the representative characteristics of that data. In general, factors based on many observations, or on more widely accepted test procedures, are assigned higher rankings. Since ratings are subjective and only indirectly consider the inherent scatter amongst the data used to calculate factors, the ratings should be used as approximations. An A rating should be considered an indicator of the accuracy and precision of a given factor being used to estimate emissions from a large number of sources.

Appendix C: Airport activity in 2006

Airport	Region	Air transport movements	Terminal passengers	Freight lifted (thousand tonnes)
ABERDEEN	Scotland	97,863	3,162,624	4,022
BARRA	Scotland	1,118	9,808	36
BELFAST CITY	Ireland	36,862	2,105,597	827
BELFAST INTERNATIONAL	Ireland	48,212	5,015,264	38,417
BENBECULA	Scotland	2,771	33,433	245
BIGGIN HILL	South East	6	220	–
BIRMINGHAM	West Midlands	108,658	9,056,004	14,681
BLACKPOOL	North West	12,622	552,641	55
BOURNEMOUTH	South West	11,889	960,773	5,068
BRISTOL	South West	65,825	5,710,222	32
CAMBRIDGE	Eastern	121	1,391	45
CAMPBELTOWN	Scotland	962	8,928	2
CARDIFF WALES	Wales	21,872	1,993,097	2,212
COVENTRY	West Midlands	8,177	609,859	7,785
DERRY (EGLINTON)	N. Ireland	4,748	341,719	–
DONCASTER SHEFFIELD	Yorkshire and the Humber	7,310	899,307	161
DUNDEE	Scotland	2,339	51,496	–
DURHAM TEES VALLEY	North East	12,372	900,107	457
EAST MIDLANDS	East Midlands	56,305	4,720,819	272,303
EDINBURGH	Scotland	115,846	8,606,651	36,389
EXETER	South West	15,252	970,614	63
GATWICK	South East	254,414	34,080,345	211,857
GLASGOW	Scotland	96,754	8,820,462	6,289
GLOUCESTERSHIRE	South West	4	166	–
HAWARDEN	North West	–	–	–
HEATHROW	London	470,891	67,339,227	1,263,129
HUMBERSIDE	Yorkshire and the Humber	13,157	515,889	144
INVERNESS	Scotland	16,575	670,894	652
ISLAY	Scotland	1,307	26,218	245
ISLE OF MAN	North West	32,048	782,734	897
ISLES OF SCILLY (ST MARYS)	South West	11,104	128,093	164
ISLES OF SCILLY (TRESCO)	South West	2,588	41,906	351

Airport	Region	Air transport movements	Terminal passengers	Freight lifted (thousand tonnes)
KENT INTERNATIONAL	South East	461	9,845	20,841
KIRKWALL	Scotland	9,935	116,837	102
LANDS END (ST JUST)	South West	4,430	23,380	85
LEEDS BRADFORD	Yorkshire and the Humber	37,251	2,787,217	101
LERWICK (TINGWALL)	Scotland	1,462	4,438	–
LIVERPOOL	North West	47,792	4,962,460	5,724
LONDON CITY	London	66,129	2,358,159	–
LUTON	South East	78,840	9,414,829	17,993
LYDD	South East	329	2,754	–
MANCHESTER	North West	213,026	22,123,762	148,957
NEWCASTLE	North East	58,053	5,407,362	306
NEWQUAY	South West	9,983	343,143	–
NORWICH	Eastern	21,350	745,192	126
PENZANCE HELIPORT	South West	6,300	93,958	196
PLYMOUTH	South West	4,661	76,568	–
PRESTWICK	Scotland	19,405	2,394,928	28,537
SCATSTA	Scotland	11,409	255,147	730
SHOREHAM	South East	1,405	4,508	–
SOUTHAMPTON	South East	46,314	1,912,702	195
SOUTHEND	South East	562	30,222	70
STANSTED	South East	189,995	23,680,352	224,312
STORNOWAY	Scotland	7,168	120,288	520
SUMBURGH	Scotland	6,604	128,233	86
TIREE	Scotland	601	7,016	25
WICK	Scotland	2,661	19,538	5

Appendix D: NAEI Data Warehouse

A2.222 The NAEI's data warehouse contains up-to-date emissions data for different sources and pollutants. Data are available for download and email delivery.

Emissions data warehouse

A2.223 This is an online archive of emissions and supporting mapping data available for use by local authorities, the wider scientific community and the public. The datasets provide Local Authorities with the specific component emissions data that they need to supplement their more detailed review and assessment studies.

Local authority data warehouse

A2.224 Data are stored on the warehouse for each local authority. The user can search by keyword or can navigate through web pages listing the datasets available and select those required for download (the list below illustrates the data that are available).

Table A2.20: Local Authority boundary CSV files

Data type	Sector	Detail	Notes
NAEI calculated emissions data (1 x 1 km^2) for LAQM pollutants *	Road transport	• Major roads • Cold starts • Evaporative • Minor roads • Brake and tyre wear	Emissions broken down into the road transport sectors necessary for review and assessment. Many Local Authorities will be making Detailed Assessments for the major roads and therefore will only require other road transport emissions from the system to complete their picture.
	Domestic	• Coal • Natural gas • Oil	Emissions grouped by the key fuel types
	Other transport	• Rail • Shipping • Mobile Machinery • Airports	Emissions grouped by the key fuel types
	Non-point source (industry)	• Combustion Processes	All industrial emissions excluding point sources
	Point sources	• Large points sources (by point location)	
Mapping datasets (1 x 1 km^2) *	Population (1 x 1 km (total number of people)	• 1995 total number of people	
	Domestic fuel use (GJ fuel consumed)	• Coal • Natural gas • Oil	
	Road transport	• AADF for major roads by count point location • Minor roads AADF	
	Other transport	• Ports activity • Airports activity	

* Unless otherwise specified

The section also includes brief descriptions of the datasets including the year of the dataset, description and assumptions.

Appendix E: Petrol terminals (major fuel storage depots)

Regulator	Process operator	Site	Postcode	OS_GRE	OS_GRN	Size
Environment Agency	Lindsey Oil Refinery Ltd	Killingholme	DN403LW	515800	417700	L
Environment Agency	Shell UK Ltd	Shellhaven	SS1 79LD	573200	182600	L
Environment Agency	Phillips-Imperial Petroleum Ltd	North Tees	TS21 TT	451400	524000	L
Environment Agency	Shell UK Ltd	Stan low	L654HB	343000	375000	L
Environment Agency	Elf Oil Ltd	Milford Haven	SA733JD	190300	205800	L
Environment Agency	Texaco Ltd	Pembroke	SA71 5SJ	190900	202500	L
Aberdeen	BP Oil (UK) Ltd	Aberdeen	AB1 1 5QW	395325	805569	L
Cardiff	Texaco Ltd	Roath	CF15US	320439	174945	L
Dingwall	BP Oil (UK) Ltd	Inverness	IV11SX	266489	846341	L
Dingwall	Esso Petroleum Co Ltd	Inverness	IV11SX	266489	846341	L
Eastleigh	BP Oil (UK) Ltd	Hamble	SO314NR	447701	106417	L
Hounslow	Esso Petroleum Co Ltd	West London	TW1 97LZ	507183	174099	L
Ipswich	Vopak	Ipswich	IP3 0BG	617620	243320	L
Leeds	Total Oil Ltd	Leeds	LS90RT	431531	432365	L
NE Lincolnshire	Conoco Ltd	Immingham	DN402PB	518913	416849	L
North Lincolnshire	Total Oil Ltd	Killingholme	DN403LJ	515373	417795	L
Northampton	BP Oil (UK) Ltd	Northampton	N N55J N	474349	260279	L
Plymouth	Esso Petroleum Co Ltd	Plymouth	PL40RJ	249151	53881	L
Plymouth	Shell UK Ltd	Plymouth	PL40RY	249745	53979	L
South Tyneside	Shell UK Ltd	Jarrow	NE323HH	434105	564809	L
Stirling	Ross Chemicals & Storage	Grangemouth	FW38UD	293000	683000	L
Stirling	BP Oil (UK) Ltd	Grangemouth	FK39UW	293991	681625	L
Sunderland	Sunderland Oil Storage	Sunderland	SR12EN	441115	556661	L
Thurrock	Esso Petroleum Co Ltd	Purf leet	RM191RS	556167	177665	L
Thurrock	BP Oil (UK) Ltd	Coryton	SS1 79LQ	574233	182965	L
Thurrock	Van Ommeren Tank Terminal London B.V. Ltd	West Thurrock	RM203EY	558593	177497	L
North Warwickshire	BP Oil (UK) Ltd	Kingsbury	B782EA	422279	296689	L
North Warwickshire	Texaco Ltd	Kingsbury	B782EJ	422431	297461	L
North Warwickshire	Warwicks Oil Storage	Kingsbury	B782EF	422407	297461	L
West Berkshire	Murco Petroleum Ltd	Theale	RG75BJ	463425	170525	L
Ged ling	Total Oil Ltd	Colwick	NG42JN	462471	340449	L
Dacorum	BP Oil (UK) Ltd	Buncefield	HP27JA	508523	208437	L

Regulator	Process operator	Site	Postcode	OS_GRE	OS_GRN	Size
New Forest	Esso Petroleum Co Ltd	Hythe	SO456NL	443600	105700	L
Trafford	Esso Petroleum Co Ltd	Trafford	M1 71 FU	379365	397779	L
Poole	Texaco Ltd	Poole	BH1 54AJ	400561	90131	L
Unknown	Shell UK Ltd	Londonderry	BT487SH	60814	581770	L
Unknown	Esso Petroleum Co Ltd	Belfast	BT39EA	149039	531001	L
Unknown	BP Oil (UK) Ltd	Wymondham	NR1 89QY	613475	300773	L
Unknown	Esso Petroleum Co Ltd	Erdington	B248DN	411383	290193	L
Unknown	Esso Petroleum Co Ltd	Avonmouth	BS119BN	352095	180611	L
Carlisle	BP Oil (UK) Ltd	Dalston	CA57LX	336443	550441	M
NE Lincolnshire	Simon Storage Co Ltd	West Riverside	DN402QU	519215	416829	M
South Gloucestershire	Murco Petroleum Ltd	Westerleigh	BS378QE	370599	180461	M
Stockton-On-Tees	Seal Sands Storage	North Tees	TS21UB	451495	524057	M
Thurrock	ST Services Ltd	Grays	RM1 75YU	560381	178279	M
Kings Lynn	Kings Lynn Storage Ltd	Kings Lynn	PE302HH	561861	321357	S
Slough	Total Oil Ltd	Slough	SL36ED	500839	179959	S
Nuneaton and Bedworth	Murco Petroleum Ltd	Bedworth	CV79EJ	435865	285461	S
Adur	Texaco Ltd	Brighton	BN411EL	526235	104871	S
Isle of Wight	Dominion Oils Ltd	East Cowes	PO326HF	450353	94595	S
Unknown	BP Oil (UK) Ltd	Fort William	PH336LR	211311	774411	S
Unknown	BP Oil (UK) Ltd	Benbecula	HS85 N U	81245	843447	S
Unknown	BP Oil (UK) Ltd	Orkney	KW1 51 LG	345079	1011249	S
Unknown	BP Oil (UK) Ltd	Skye	IV51 9XP	139745	864749	S
Unknown	BP Oil (UK) Ltd	Lerwick	ZE1 0LZ	447537	1141803	S
Unknown	BP Oil (UK) Ltd	Stornoway	HS12BS	142535	932659	S

Notes: L = large, M = medium & S = small

Annex 3: Modelling

Introduction

A3.01 This Annex of the Technical Guidance provides advice to local authorities on the use of air quality dispersion models for the purposes of Review and Assessment. Dispersion models are a valuable tool in the Review and Assessment process for a variety of reasons:

- pollutant emissions arising from different sources types can be taken into account in terms of their impact upon ground-level concentrations;
- concentrations across a wider geographical area can be predicted than is possible through monitoring alone;
- geographic boundaries of any exceedences of objectives can be determined;
- concentrations can be predicted for future years taking into account changes in emissions sources and emissions data; and
- scenario testing can be undertaken in order to determine the source contributions and effects of measures on predicted concentrations.

A3.02 The purpose of this section of the Technical Guidance is to:

- promote best practice and the efficient use of resources for dispersion modelling;
- provide local authorities with useful information and methods to consider when undertaking detailed dispersion modelling;
- provide methods for local authorities when "fine tuning" existing models and inputs;
- help obtain as reasonable results as practicably possible from dispersion models and to increase the confidence in model predictions; and
- assist in the sensible interpretation of results.

A3.03 The main changes to this Annex include more information on:

- options when modelling complex road layouts such as street canyons, car parks and bus stops/stations;
- a summary of methods to assess the impacts from point sources, and how to account for background concentrations; and
- how to verify dispersion modelling results, and methods for adjustment of modelled contributions.

Review and Assessment tools

A3.04 Throughout the Review and Assessment process Defra and the Devolved Administrations have provided a number of easy to use tools to assist local authorities in the assessment of air quality.

A3.05 A variety of Local Air Quality Management (LAQM) tools are available for download from the Local Authority Air Quality Support website www.laqmsupport.org.uk and at the Review and Assessment helpdesk website www.uwe.ac.uk/aqm/review/. New tools referenced in this guidance are also provided at www.airquality.co.uk/archive/laqm/tools.php. Local authorities are strongly encouraged to register with the Helpdesks (see Box 1.1) in order to receive notification of changes to these tools, and updates to information. Authorities can register by visiting one of the Helpdesks or by emailing directly to lasupport@aeat.co.uk or aqm-review@uwe.ac.uk.

A3.06 Chapter 2 of the Main Document provides further information on updates to the LAQM tools that are available at www.airquality.co.uk/archive/laqm/tools.php and which include:

- Design Manual for Roads and Bridges (DMRB) Screening Model;
- background maps;
- Nitrogen oxides (NO_X) – Nitrogen dioxide (NO_2) Conversion tools;
- diffusion tube bias and precision calculators;
- emissions tools;
- industrial nomograms;
- biomass nomograms;
- supplementary assistance for stack height calculations for small boilers;
- vehicle emission factors (EFs);
- National Atmospheric Emissions Inventory (NAEI) data warehouse; and
- Environment Agency Data Analysis Software – a spreadsheet based toolbox that can be easily used to produce wind roses, pollution roses, time-averaged data and diurnal, weekly and monthly profiles available by email at: steven.oliver@environment-agency.gov.uk.

Sources

A3.07 The Updating and Screening Assessment checklists provided in Chapter 5 of the Main Document should be used to identify any potentially significant sources that may require a Detailed Assessment. Such sources are expected to include mainly road transport and some industrial processes. However, a number of other potentially significant sources have been identified which include other transport sources such as aircraft, railways and shipping, commercial and domestic sources related to biomass and other solid fuel burning, and fugitive sources such as quarries, waste transfer sites and major construction sites.

A3.08 In some cases, road traffic sources, and in particular movements of heavy duty vehicles (HDV), will play a significant role in contributing to the overall pollutant concentrations from sources such as ports, airports and sites with fugitive sources such as aggregate storage, quarries, and waste transfer stations. Therefore modelling of these types of sources may often require inclusion of road traffic emissions to take into account the combined impacts.

Emission Factors

A3.09 Annex 2 (Estimating Emissions) provides a detailed overview of the recent updates on EFs available to local authorities through the NAEI (www.naei.gov.uk) and other relevant sources. These updates include:

- road traffic speed-related EFs within the Emissions Factors Toolkit (EFT);
- information on estimating idling EFs;
- information on accounting for the effect of gradients on EFs;
- updated information on cold start emissions and excess emission (EXEMPT);
- non-exhaust EFs;
- non-road traffic vehicle EFs;
- biomass emissions;
- primary NO_2 EFs.

A3.10 Reports providing the description and source of information upon which the NAEI EFs are derived are available at www.naei.org.uk.

A3.11 Road traffic EFs are provided up to and including the year 2030. Where an assessment is required beyond 2020, it may be assumed that, background concentrations remain constant after this time.

Road traffic sources

A3.12 The Updating and Screening Assessment checklists in Chapter 5 of the Main Document should first be used to determine which roads may be significant. The DMRB model can be used to assess roads in more detail and allow identification of road traffic sources that may require detailed dispersion modelling.

A3.13 In many cases, previous rounds of Review and Assessment will already have allowed local authorities to identify significant road traffic sources. The information provided in the sections below provides further information on methods to assess common road traffic sources in more detail which include the DMRB, AEOLIUS and more complex dispersion models.

A3.14 As required for any detailed dispersion modelling, the predicted concentrations from the DMRB should also be compared against local monitoring data, provided the measurements are of good quality, have been measured over a reasonable time period, and are representative of the receptor location assessed, in order to provide confidence in the results and any decisions made based on the outcome of the modelling.

A3.15 Whilst many local authorities are expected to focus on predictions of annual mean and 24-hour mean concentrations, the potential for exceedences of the hourly mean NO_2 objective should also be considered, and the Updating and Screening Assessment checklists should be referred to in order to assist identifying these locations.

Design Manual for Roads and Bridges

A3.16 The DMRB Screening Model is provided by the Highways Agency. The latest version to use and procedures for using it are described on the Local Authority Air Quality Support Helpdesk website[67].

Detailed Assessment of road traffic sources

A3.17 Where, following an Updating and Screening Assessment or Progress Report, potential exceedences of an Air Quality Strategy objective have been indicated by a DMRB assessment, or by monitoring data, or where a particularly complex site such as a junction or a street canyon which could not be adequately assessed using screening tools has been identified, a Detailed Assessment should be carried out.

[67] Available at: www.airquality.co.uk/archive/laqm/tools.php.

A3.18 A Detailed Assessment may include modelling, but monitoring also has a very important role to play. Data from continuous analysers, diffusion tubes or other long-term monitoring, can be used in a number of ways including:

- providing further information on pollution levels in complex areas such as large and/or congested junctions, and street canyons or similar situations that may not be assessed well by dispersion models; and
- providing information that can be used to help verify (and where necessary to adjust) any dispersion modelling that is undertaken.

A3.19 It is expected that most local authorities proceeding to detailed modelling of road traffic sources will be concerned with potential exceedences of the annual mean (for NO_2 and/or PM_{10}) and the 24-hour mean PM_{10} objectives. However, the potential for exceedences of the hourly mean NO_2 objective must also be considered at relevant receptor locations.

How detailed should my traffic flows be?

A3.20 The level of detail of traffic input data will depend on how much information is available for roads within an authority's area, but may also be determined by the ease of input into dispersion models.

A3.21 The following level of detail is required as a minimum:

- the annual average daily traffic flows (AADT);
- the annual average speeds on roads and near junctions; and
- the average vehicle splits (percentage Light Duty Vehicles (LDV) / HDV).

A3.22 Local authorities may consider focusing detailed modelling on specific areas and specific receptors to scales of 10's of metres, as opposed to wider scale modelling that may miss out the details at roadside locations where exceedences are more likely, ie, it is important that hotspots are assessed. However, it is recognised that some authorities have already set up models covering wider urban areas which may include many different types of sources. It may however be useful for some sources to be refined in more detail where there are specific local concerns or where local knowledge indicates that an area requires greater attention.

A3.23 In general, the use of more complex dispersion models will require geographical information such as:

- the grid reference of the start and end points of a section of road;
- the grid references of vertices representing the path of the road (roads are not generally straight and they should not be modelled as such);
- the width and elevation of the road or street canyon being assessed; and
- the grid reference of the specific receptors at which pollution levels need to be assessed.

A3.24 It is important that the correct source-to-receptor distance has been modelled and a visual check (through model interface or Geographical Information Systems (GIS)) should be carried out to ensure that the roads modelled follow the actual alignment appropriately, and that the start/end nodes and vertices of links are in the correct place.

A3.25 The use of GIS can be a quick and easy way to retrieve the correct co-ordinates for sources that can be input directly into dispersion models. In addition, web-based aerial mapping sites can be extremely useful when building dispersion models as they can provide information on layout and alignment of roads, and in many cases are suitable to determine if there are junctions, pedestrian crossings, bus stops, and road signage (for example, stop lines and speed limits) in the location of interest. However, these systems are generally not suitable for deriving grid coordinates of sources as the locations may not be exact when compared to Ordnance Survey base maps, but they can be a useful reference tool.

Traffic Patterns

A3.26 Most dispersion models allow more complex traffic patterns than a single AADT to be assessed including:

- AADT patterns varied by day of the week, month or season; and
- Diurnal patterns varying for each hour of the day, and also on the day of the week.

A3.27 A diurnal pattern of average hourly speeds may also be available to use in modelling predictions, but where it is not, average speeds can be used. Local authorities may consider further splitting a road link, for example a junction, in order to reduce the average speed in these locations.

A3.28 Local authorities may consider an estimate of speeds over the following periods in order to account for congestion during peak hours and more free flowing traffic at night (times are inclusive and are for example only and may vary at different locations):

- Morning Peak (for example, 7am – 9am)
- Inter-peak (for example, 10am – 4pm)
- Evening Peak (for example, 5pm – 7pm)
- Night-time (for example, 8pm – 6am).

A3.29 It should be noted that diurnal patterns (both in terms of traffic flow and speed) may be related to two-way flows, and therefore the road links within a model should reflect this. Where a road, for example a motorway or A-road, has been modelled as separate sources depending on direction of flow, then the diurnal patterns for each of these sources should also reflect the direction of flow. This may be important for example where a road experiences a larger volume of traffic in one direction in the morning, whist the flow on the other direction has a different pattern, with large flows in the afternoon.

How can I model variable speeds?

A3.30 The pattern of speed and to a lesser extent the proportion of HDVs, can also vary throughout the day. Speed, in particular, can vary considerably throughout the day with much lower speeds during AM and PM peak hours, but often only the average daily speed throughout the day is considered within detailed dispersion modelling.

A3.31 Where significant variations in hourly speeds are known to occur it may be useful for local authorities to account for speed variations. Some models may allow detailed variations to be input relatively easily, but other models may require the user to split or duplicate links a number of times in order to emulate variable inputs; a few options are discussed below when direct inputs are not an option.

A3.32 The simplest way to consider variable speeds is to split road links into three sections – one at each end of the link representing the road where a junction is approached and assume a lower average speed over these sections, whilst the middle section represents the average free flowing speed. This is not strictly a variable pattern as the same speed for each hour is still considered, but provides an easy method to account for lower average speeds, for example where queuing is known to occur.

A3.33 Where a model does not allow the user to input hourly speed information, a more complex method may be used which involves overlapping links a number of times and the use of emissions profiles to apply the emissions at the appropriate hours in the day. (An example is provided below but the relevant local times and speeds may be different.)

- Enter the same link a number of times within the model and provide emissions for the relevant speed as representative of the hour required for each copied link.
- Then use variable EFs to effectively "turn-on" or "turn-off" the relevant link in the dispersion at the appropriate time. For example, a link may be copied four times thus:
  - Link1_AM: AM peak speed (hours beginning 7 + 8am)
  - Link1_PM: PM peak hour speed (hour beginning 5 + 6pm)
  - Link1_Inter: Inter-peak speed for other daytime hours between beginning 7am – 6pm
  - Link1_Eve: Night-time speed for hours between 7pm – 6am
- When setting up the road links, the speed for the relevant hour is entered:
  - Link1_AM: 10 mph
  - Link1_PM: 15 mph
  - Link1_Inter: 30 mph
  - Link1_Eve: 40 mph
- The emission profile for Link1_AM will then be provided so that only the hours 7+8am have emissions accounted for. This is normally done by providing a factor of one for these two hours, whilst all other hours have a 0 (zero emission). Similarly the emissions profile is entered for the other links by applying one or zero to the relevant hours.

A3.34 The use of this overlapping system allows greater variability of inputs, and may also be used to vary other data such as proportions and speeds of HDVs. In this way, detailed traffic flows and speeds can be considered within dispersion models, however the user must be careful not to exceed any limitations on the number of links.

A3.35 At the outset, modellers should determine what level of detail is required as a significant amount of model setup time may be required. In some cases, specific road links may warrant this type of detailed approach but this may not be required for all roads.

A3.36 An example of when this type of detailed approach may be useful is when assessing the impact of traffic management measures which are expected to reduce queue lengths of traffic, improve speeds on roads, or vary the diurnal pattern or speed of traffic flows on specific roads.

How can I vary my speeds and traffic flows for different hours?

A3.37 In many models, the user can vary the number of vehicles per hour per link assuming a particular speed. For example, the vehicles per hour entered for Link1_AM is 1200 vehicles per hour at 10mph, which represents the 7am traffic flow and speed. The emissions profile for that link can also be used to alter the traffic flow for the hour 8am but allowing the speed to remain the same. For example, the traffic flow at 8am is twice that of the 7am flow (with an average speed of 10mph). Using the emissions profile, the factor for the hour 7am remains at one, but for 8am is factored up by two (thus doubling the hourly traffic flow whilst maintaining the same speed).

A3.38 Note, it may be much more difficult to use the emissions profiles in the same way to vary the proportion of HDV and speed at the same time as the factors are more difficult to determine (unless emissions tools and inventories are used to perform the calculations). If this were required, and a model does not allow hourly input to this level, a duplicate set of links may be entered, one for example for LDVs only, and one set for HDVs only. Each can then be varied for speed and/or flow throughout the day using link copies.

A3.39 In this way, detailed traffic flows and speeds can be considered within dispersion models, however the user must be careful not to exceed any limitations on the number of links. At the outset, modellers should determine what level of detail is required as a significant amount of model setup time may be required. In some cases, specific road links may warrant this type of detailed approach but this may not be required for all roads.

A3.40 An example of when this type of detailed approach may be useful is when assessing the impact of traffic management measures which are expected to reduce queuing traffic, improve speeds on roads, or vary the diurnal pattern or speed of traffic flows on specific roads.

How can I model congestion?

A3.41 In many cases, the area undergoing a Detailed Assessment is likely to include busy junctions where traffic congestion is a main concern. Modelling congestion can be carried out in many ways depending on the constraints of the model, in particular the number of links that can be entered.

A3.42 A simple way to model congestion is to split the road link into three sections, similar to that representing a junction or crossing, and reduce the speeds in those sections where queuing traffic is known to occur. Additional complex methods also involve accounting for the variable speeds during different hours as described above.

A3.43 However, other complex model setups can be considered which include varying certain links representing queues and estimates of the following would be required:

- queue length;
- traffic speed; and
- variability of congestion throughout the day.

A3.44 To represent the variability of congestion during the day, the method described above for overlapping links can also be used. Local authorities should be careful not to double count emissions of traffic when modelling queues and diurnal patterns. Local authorities may consider using both variable speeds and idling emissions in some specific locations, for example complex junctions.

A3.45 Research into the development of idling emissions factors, which may be useful for modelling congestion, is ongoing but is not yet available. When these become available, modellers may use these emissions factors instead of reducing speeds on queue links.

My model only allows me to input Light Duty Vehicles and Heavy Duty Vehicles

A3.46 Whilst many models provide user friendly interfaces for entering traffic flows based on LDV and HDV, it is often possible to provide user-defined pollutant emissions rates in most models, allowing account to be taken of other vehicles types if required.

A3.47 These may include (but are not limited to) the following vehicle type classifications:

- cars (petrol and diesel);
- LGV (petrol and diesel);
- HGV (rigid and articulated);
- buses and coaches; and
- taxis (sometimes defined as a separate category when derived from traffic models).

A3.48 A combined emission rate can be entered into a road link based on the relevant proportions of each type of vehicle on the road. If this is the case, the speed for all vehicles will be assumed to be the same. In some cases the speed may be different (for example, HDVs on motorways), or a local authority may be interested in calculating the contribution a certain type of vehicle makes to the annual mean concentrations. This may be done using the "layering" system described above by setting up one source on top of each other for each vehicle type and entering in emissions for that type only. So a road source termed A123 which incorporates all vehicle types, would be entered into the model as A123Cars, A123LGV, A123HGV and A123Bus as separate sources.

A3.49 This type of setup can be useful as the contribution of each road link to concentrations predicted at a receptor can easily be determined, and the model input can also easily be changed: for example, to determine what happens if the speed of vehicles changes, as well as changes in the numbers of these vehicles.

A3.50 Local authorities may have more detailed estimates of vehicle classifications such as proportions of diesel and petrol cars and LGVs, rigid and articulated HGVs, along with separate estimates of buses. Local estimates should be included in dispersion modelling where available. However, in the absence of local estimates, default splits of petrol/diesel and EURO categories are built into the EFs from the NAEI and EFT.

A3.51 If you have good estimates of average splits of vehicles you can use a more detailed split than just HDV and LDV. This is particularly useful where you are required to look at the relative contribution of vehicle types to pollution levels (source apportionment) in locations where exceedences are predicted and Air Quality Management Areas (AQMAs) declared. In many assessments, this greater level of detail on vehicle splits would not be required unless specific local circumstances (for example, bus lanes, higher proportion of diesel vehicles) are known to occur, or until the further assessment and source apportionment is undertaken.

How do I determine the source apportionment from different vehicle types?

A3.52 You are required to undertake some source apportionment studies as part of further assessments in order to determine the relative contribution of vehicle types at specific worst-case receptor locations. These source apportionment studies can also be useful when considering the impacts of different traffic management options, for example as part of scenario testing within action plans.

A3.53 Source apportionment can be relatively easy and based simply on the proportion of emissions rates for HDV and LDV (or more detailed vehicle splits), as applied to the predicted road contribution at a receptor. Where there are a large number of sources contributing to pollutant concentrations at a receptor (for example at a junction), it may be easier to use dispersion models to calculate the source apportionment to concentrations at receptors by turning on and off emissions sources. Box A3.1 provides a method for determining source apportionment of vehicles.

A3.54 Further information on the requirements for source apportionment, and reporting of required pollutant reductions, and a worked example of determining the proportion of each source, including background, as derived from modelled or monitoring contributions is provided in Chapter 7 of the Main Document.

Box A3.1: A method for determining the source apportionment of vehicles

A dispersion model has been used to predict an annual average NO_2 of 46 µg/m^3 at a relevant receptor close to a junction. Background contributes 28 µg/m^3 and three road sources contribute to the total concentration at the receptor and contribution of these sources is 18 µg/m^3.

Determining the contribution of each road source to annual average NO_X.

Some models have a "contribution" option included which reports the relative contribution of each source based on the traffic data or total emission rate input to the model. If the emission rate for each source includes both the HDV and LDV contributions, your model will provide you the relative contribution of each source to total emissions, but may not provide a breakdown for each vehicle type. If your model does not have a "contribution" option or similar, you can run your model with only one source at a time (either by deleting sources or setting their emissions to zero). The predicted concentrations of NO_X is therefore only for that source and by repeating the process for all sources you will build up the relative contributions of each source at your receptor.

Using this method the following is determined for road sources (links) at the receptor:

	Link_A	Link_B	Link_C	All Links
NO_x contribution (µg/m^3)	45.2	7.8	9.6	62.6
Percentage Contribution	72.2%	12.5%	15.3%	100%
Relative NO_2 Contribution (µg/m^3)	13.0	2.2	2.8	18

This information is useful as it allows the dominant road source to be identified and may be particularly important where there are differing highways authorities responsible for the roads involved. For example, in this case, Link_A is responsible for a significant proportion to the overall contributions at the receptor.

Determining the contribution of each vehicle category to annual average NO_X and NO_2:

Some models may provide the emission rate per vehicle type and this can be used directly to determine the contribution of each vehicle type to the source. Information on emissions rates may be accessed directly from model interfaces, input screens, input files and emissions inventories. Where emissions rates are calculated by the user they are often derived from the EFT and held within spreadsheets.

Alternatively, where a model automatically generates the total emission rate, by setting the number of HDVs for the link to zero, the resulting emission rate is recalculated and represents the remaining vehicle categories (for example the LDV emission rate). The difference between the total emission rate and the LDV emission rate represents the HDV emission rate. Similarly, for all links the following was determined:

		Link_A	Link_B	Link_C
LDV	Emission Rate (g/km/sec)	0.103	0.0512	0.0555
HDV	Emission Rate (g/km/sec)	0.375	0.1018	0.0779
Total	Emission Rate (g/km/sec)	0.478	0.153	0.133
LDV	Percentage	22%	33%	42%
HDV	Percentage	78%	67%	58%

The above relative contributions may be derived for more detailed vehicle splits such as Cars, LGV, HGV, Buses, and for additional splits such as diesel and petrol fuel vehicles. The level of detail is dependent on knowing the percentage of each within the vehicle flow, the total emission rate, and the emission rate for each vehicle class required.

These proportions of emissions can then be applied to the relative proportions of the predicted NO_X concentrations at the receptor in order to allow the total contribution of vehicles types to be determined. However, the information broken down as above is useful as it may allow targeting of different traffic management measures on each road according to the source contribution.

Relative Contributions of road source NO_X are determined by multiplying the percentage vehicle type on each link by total link contribution:

	Link_A	Link_B	Link_C	Sum All	Source Apportionment
Total NO_X Contribution (µg/m^3)	45.2	7.8	9.6	62.6	
LDV NO_X Contribution (µg/m^3)	9.7	2.6	4.0	16.3	26%
HDV NO_X Contribution (µg/m^3)	35.5	5.2	5.6	46.3	74%

As the total contribution to NO_2 concentrations at the receptor for road sources was determined to be 18 µg/m^3 the following source apportionment information can be derived for the road traffic sources:

	Link_A	Link_B	Link_C	All
NO_2 contribution (µg/m^3)	13.0	2.2	2.8	18.0
LDV NO_2 Contribution (µg/m^3)	2.8	0.8	1.2	4.7
HDV NO_2 Contribution (µg/m^3)	10.2	1.5	1.6	13.3

The method available for source apportionment varies depending on model and user input information. The supplier of your model or the Local Authority Air Quality Support Helpdesk may be contacted for further assistance.

Street canyons

A3.55 Dispersion modelling in urban areas can be difficult due to the presence of obstacles (buildings, trees, walls, etc) that modify the wind flow locally and alter dispersion. This is especially the case in so called "street canyons", where buildings on both sides of the road can lead to the formation of vortices and recirculation of air flow that can trap pollutants and restrict dispersion (often termed as the "canyon effect"). Street canyons can generally be defined as narrow streets where the height of buildings on both sides of the road is greater than the road width. However, broader streets may also be considered as street canyons where buildings result in reduced dispersion and elevated concentrations (which may be demonstrated by monitoring data). Therefore canyon effects can occur both in small towns or large cities.

A3.56 Locations on the windward side of a canyon can experience greater dispersion and ventilation leading to lower pollutant levels, while pollutants can become trapped on the leeward side, particularly when wind directions are perpendicular to the orientation of the street. However, over short time periods wind flows can reverse, highlighting the level of complexity of dispersion in these circumstances.

A3.57 Studies involving monitoring campaigns on both sides of street canyons have shown that background concentrations influence pollutant levels within street canyons as the air mass at rooftop level moves into the canyon, leading to increased ventilation and "flushing out" of polluted air. Similarly, gaps between buildings may allow increased wind flows to enter the canyon thus re-circulating pollutants away from the junctions, but causing increased concentrations further away. The opposite effect however may occur if the gap is at junction, where road traffic emissions are carried into the canyon, resulting in higher concentrations.

A3.58 Even when using commonly available, but very complex three dimensional models, it is unlikely that such degrees of complexity are adequately accounted for, but the uncertainties of such predictions are difficult to quantify.

A3.59 Many local authorities have carried out monitoring within street canyons (often based on diffusion tubes) and it is common to measure significantly different concentrations at different locations and heights within the canyon, and on each side of the canyon. The variability of monitoring data within these areas is also reflected in the difficulty of modelling concentrations in these locations.

What do street canyon models do?

A3.60 Models designed for the prediction of air pollution concentrations within street canyons aim to calculate the zone of recirculation of wind flow in order determine the resulting concentrations within these locations. Wind direction and velocity is used to determine where (for example on which side), and how large the recirculation zone may be. The size of the recirculation zone varies and may occupy the whole width of the street, or the leeward side only (the upwind side). Concentrations within the recirculation zone are considered to be uniform (or homogenous) by many models such as OSPM (which is incorporated within the ADMS models).

A3.61 Models used for street canyons may be based on many different formulations which include standard Gaussian plume dispersion, box models, and computational fluid dynamics (CFD). Models make different assumptions regarding the variability of pollutant concentrations within street canyons, and the way in which they vary at distance along the canyon, close to façades at the bottom of the canyon, and with varying height within the canyon. Computational fluid dynamic models simulate very complex wind flow patterns within street canyons and show complicated dispersion patterns near facades and gaps in canyons, such as close to junctions.

A3.62 The use of complex models and CFD models (or wind tunnel simulations) may be considered in very contentious cases, however these tools are often complex to use and have limited use for the purposes of review and assessment. They require considerable resources, model run times are often lengthy, and they may not provide long-term concentrations such as annual means, for direct comparison with the objectives. The limitations and uncertainties of modelling concentrations within street canyons must be considered and monitoring should be carried out in these locations.

What are the main parameters to consider when modelling a street canyon?

A3.63 The dispersion pattern in a street canyon depends on a number of factors including:

- the orientation of the street with respect to wind direction;
- wind speed;
- the height of buildings on either side of the street;
- the variation in the height of the buildings;
- the volume and speed of traffic on the roads;
- the distance from the roadside to the buildings;
- whether there are any gaps in buildings or roads junctions along sections of the street; and
- other atmospheric conditions such as temperature.

A3.64 All of these physical parameters affect the pattern of dispersion within a street canyon such that very complicated wind flows and vortexes may form under certain conditions making it very difficult to fully understand and to predict accurately the concentrations at specific locations.

A3.65 In practice, weather conditions such as wind speed, direction and temperature are often included in a meteorological file (generally hourly sequential data for a whole year) as model input data. Therefore, the main parameters that need to be considered (for each modelled road link assumed to be a street canyon) are:

- the road width (distance measured as façade to façade of buildings on either side of the street, therefore including the kerb width, as opposed to the kerb-to-kerb width generally required for standard road modelling); and
- the average height of buildings on both sides of the road (some models may allow specifying different heights for each side).

A3.66 Where a street can be partially classified as a street canyon, for example where there are gaps in between blocks of buildings, monitoring in such locations may indicate elevated concentrations. It is therefore recommended that local authorities consider these links as street canyons otherwise predicted concentrations are likely to be underestimated.

A3.67 It is sometimes appropriate to model a street canyon even if one side of the road is an open area, as dispersion is reduced and concentrations on the street canyon side would otherwise be under-predicted. When this is the case, the distance from the façade (street canyon side) to kerb (open side) may be considered along with the relevant receptor locations to ensure they are within the canyon width on the appropriate side of the road. Receptor locations modelled outside the specified canyon width can have significantly lower predicted concentrations than within.

A3.68 Local authorities may model wide areas and use GIS to determine the road links layouts and receptor locations. Often, it may be a very large task to check if all receptors fall within the canyon width, but GIS can be used for this purpose by buffering links based on the canyon width and checking for receptors which fall outside the canyon.

What are the main issues associated with street canyon modelling?

A3.69 The treatment of street canyons and receptors should be confirmed by consulting model suppliers and manuals. It is a common mistake to wrongly locate specific receptors at the façade of properties so that they actually fall outside of a street canyon. Models accounting for street canyons generally split the modelled area in two parts: the actual street canyon (delimited by the canyon width) and areas outside the canyon on both sides of the road. While predicted concentrations within the canyon are higher, the concentrations outside decrease rapidly to predicted levels assuming no street canyon. Therefore, it is recommended to check the distance of receptors to the centre of the road and compare to the canyon width, to ensure they are correctly located within the street canyon. This can be important where a street canyon is asymmetric; where the distance from kerb to façade is significantly different on each side of the road. In these cases, the centre of the canyon is not aligned with the centre of the road surface.

What if I need to estimate concentrations at different heights within a street canyon?

A3.70 Local wind effects within street canyons are complex and concentrations at different heights within a street canyon may vary. However, most studies seem to have shown that concentrations are highest at ground level. Where a dispersion model is used to predict concentrations at ground floor, and predictions compare well with local monitoring data, if exceedences are not predicted then concentrations at greater height are likely to be lower than those at ground level. Where a local authority is concerned about concentrations within a street canyon at different heights, for example where ground floor concentrations are predicted to exceed or are close to the objectives, it is recommended that monitoring at more locations at different heights is undertaken to better determine the likelihood of exceeding the objectives.

Where should I install monitoring sites in a street canyon?

A3.71 Local authorities are advised in most circumstances to monitor concentrations at the roadside and building façade at a number of locations within a street canyon (see Annex 1). In the absence of widespread monitoring in a number of street canyons, the results from a single detailed study could be used to help assess similar areas on the bases of comparisons of traffic flows and to compare against the predictions from models.

Are there other models that can be used to model street canyons?

A3.72 Where street canyons or enclosed streets with buildings close to the road on both sides are highlighted, and where conventional modelling is not providing reasonable estimates of pollutant concentrations, other models are available at no cost such as AEOLIUS (Assessing the Environment Of Locations In Urban Streets).

A3.73 The AEOLIUS model was produced by the Met Office[68]. The model has been developed to assess the air quality in street canyons. An updated version of AEOLIUS is available which allows:

- use of an hourly sequential meteorological data file
- use of user defined EFs (to allow for updates to EFs)
- hourly traffic flows (diurnal patterns)
- hourly vehicle speeds (diurnal patterns)
- output of NO_X and PM_{10} concentrations.

A3.74 Local authorities are reminded of the importance of monitoring within street canyons in order to support the findings of results of dispersion modelling in these locations.

Complex road layouts (Junctions)

Junctions

A3.75 Junctions are relatively easy to describe in dispersion models and consideration of speeds, road widths, queue lengths and congestion as described in the sections above may be considered. The requirement to increase the level of detail at a junction will depend on the level of relevant exposure at the location and the risk of exceeding the objectives. Local knowledge and data gathered through local monitoring studies will assist in this regard. Local authorities may wish to consider these additional levels of detail where exceedences of the hourly objective is likely, where local concerns have been raised, or where traffic management plans are expected to significantly alter the travel patterns in an area.

A3.76 The level of detail may also depend on the availability of information, and in particular, the flow of traffic at a roundabout. There may be measured flows on very large roundabouts, or an estimate may be made from turning counts based on the movement of traffic on the various arms of the junction.

A3.77 In many cases it may be suitable to model a junction by simply accounting for reduced speeds on road links within 25 to 50 m of the junction. This, in combination with the use of diurnal patterns of traffic flows, is often sufficient.

Car parks

A3.78 Car parks are unlikely to require detailed modelling as part of review and assessment; however local authorities should still consider the local roads which are used to access the car parks, which are of more concern locally, particularly where queuing and congestion is created on these roads. In some cases, local authorities may wish to consider the impact of a car park on local air quality, perhaps where there are receptors close by or where a new car park is proposed. Information on the potential ways to model car parks is provided below; however, in many cases, the focus should be on the local access roads which can experience queuing traffic during busy peak hours.

[68] www.metoffice.gov.uk/environment/aeolius1.html

A3.79 There are a number of different types of car parks including surface, multi-storey, underground and mezzanine. Emissions due to car parking may be released directly to air, through open-to-air façades, and/or through the use of mechanical or passive ventilation systems. Each of these may be modelled differently, for example some mechanical ventilation systems may be modelled more as point sources, with estimate of the volume of gases released being required (as they are usually not monitored). The latter may be case for underground car parks, or emissions may be released through surface vents.

A3.80 Surface and multi-storey car parks are typically modelled as area or volume sources. Model developers and manuals should be referred to for the specific requirements of each of these sources. Modellers should be aware that some models do not allow the temperature and/or velocity of volume sources to be varied which may result in higher concentrations as the dispersion of plume due to thermal buoyancy and/or momentum is significantly reduced. In some cases, the sensitivity to the use of area and volume sources may be determined.

A3.81 It is recommended that for multi-storey car parks, a series of area sources be used as opposed to one single volume source. This allows the emissions to be spatially located and may better represent the relative distance to receptors.

A3.82 Where detailed modelling of car parks is deemed necessary the following information is often required:

- the hourly profile of number of vehicles entering the car park;
- the hourly profile of number of vehicles entering the car park;
- assumptions related to idling time for vehicles. This may vary for short-term and long-term car parks. Estimate the emissions for the idling time assuming a speed of 5kph (in the absence of idling emissions factors (described in Annex 2) and apply to the area (or volume) source;
- assumption of the proportion of vehicles assumed to enter and/or leave the car park under cold start conditions. The EXEMPT model can be used to estimate the excess emissions due to cold starts and further information is provided in Annex 2;
- an estimated average distance travelled by each car within the car park and the average speed (often a speed limit of 5 – 10 mph is in place). Where this is not known, it may be assumed that each vehicle travels a distance equivalent to the perimeter of the car park and, for example, into the centre of car park. It must be noted that this is only a rough guide and can vary considerably. Where a multi-storey car park is being modelled, the assumptions may be determined for each level of car park, particularly where the area/number of spaces varies; and
- Location and hourly pattern of traffic on local roads used to access the car park.

A combined emission rate for the area, volume, or point source can be determined which includes an estimate for travel within the car park (entering and leaving), idling, and cold starts. Additional road sources can be used for the access routes for the car park.

Bus stations and bus stops

A3.83 It is sometimes necessary to include the contribution of emissions from a bus station or a bus stop when carrying out detailed modelling, as these are often responsible for hot spots of pollution concentrations in urban areas. NB: Authorities are advised to read the guidance in Paras 5.16 to 5.18 of the Main Document regarding the treatment of potential exceedences of the 1-hour mean objective for NO_2.

A3.84 The key issue in bus station/stop modelling is the uncertainty in bus EFs, especially from idling engines. Emission factors for buses are available from the NAEI website are described in Annex 2 in more detail.

How to model a bus station?

A3.85 Modelling a bus station should not be undertaken without robust monitoring data, as the predicted results are likely to subject to significant uncertainties; therefore modelled results should be thoroughly verified against monitoring data.

A3.86 In some cases, local authorities may consider that monitoring alone is a better way to determine the impact of bus stations on pollutant concentrations. For example, if a bus station is located in an urban area with adjacent properties that encircle the bus station, sources such as areas and volumes will have be used in the model setup, leading to increased model uncertainty. Commonly used dispersion models do not account for the effects of buildings when modelling these types of sources. Monitoring data must therefore be available in order to verify the modelling results, particularly where decisions regarding requirements for an AQMA are being made.

A3.87 The most common way of modelling a bus station is to include an area or volume source in the model set-up with a specific EF, as well as modelling the road sources. Emission factors should be combined with local parameters such as:

- the number of buses per hour stopping at the station, and
- the average time of idling.

A3.88 This should allow the calculation of an overall emission rate that reflects the local conditions. For bus stations, access roads (into and out of the station) should also be modelled as road links where there are receptors close to these routes.

A3.89 The diurnal pattern should also be included to reflect the variations of bus flows throughout the day. This could involve undertaking detailed traffic counts on relevant roads close to bus stations in order to determine patterns appropriately, or, in some cases, bus station timetables could be used to determine the frequency of buses throughout the day.

A3.90 In the absence of idling emissions factors for buses, it is possible to estimate emissions assuming buses travelling at a low speed (the lowest speed allowed by the model should be used, typically 5kph). If using speed related EFs for idling buses, the method described above (for car parks) should be used, with the relevant EFs for buses, and the estimated idling time for each bus to determine the emission rate. It is recommended that idling times are based on the observed operation of buses as these may vary.

A3.91 If a bus station is modelled as part of a wider area (part of a town or city centre), a separate model verification may be necessary for the bus station area alone (based on monitoring data from sites located near the station), while the rest of the model is verified with results from typical roadside monitoring sites. This is important to avoid over-adjusting the whole model, as predicted results near the bus station may be subject to greater uncertainty.

How to model a bus stop?

A3.92 In practice, it can be difficult to model all bus stops within a large area (for example if the model domain includes a town or city centre). Therefore, the decision to include bus stops in the model set-up should, wherever possible, be based on evidence from monitoring data that the Air Quality Strategy objectives are at risk of being exceeded at sensitive receptors nearby.

A3.93 However, local authorities should take care when selecting bus stops as monitoring locations, as these sites are only likely to be representative in terms of exposure to the 1-hour mean objective for NO_2.

A3.94 Bus stops can be modelled as area or volume sources, similarly to bus stations. The overall emission rate should ideally be based on:

- an idling EF;
- the number of buses per hour (or per day);
- a diurnal pattern to take into account variability in bus traffic throughout the day.

A3.95 Further information on the calculation of emission rates at bus stops is provided in Annex 2.

A3.96 If a bus stop affects the speed of traffic locally, it may be useful to split road links close to the bus stop to assign appropriate lower speed to vehicles.

A3.97 As mentioned above, care must be taken when verifying dispersion modelling at bus stops, and at bus stations. If monitoring at these locations is used to verify and possibly adjust modelling results the factors used should only be used for similar locations and not the whole model area as there may be a widespread over or under adjustment of the model due to the higher uncertainties of the predicted results.

Pedestrian crossings

A3.98 Local knowledge may highlight specific pedestrian crossings in an area where considerable queuing of traffic occurs. A local authority should only consider modelling pedestrian crossings in specific areas rather than across whole areas. Locations where they might be considered important are in sensitive locations where there is queuing traffic on busy roads during peak hours, for example in the vicinity of schools.

A3.99 The simplest way to model pedestrian crossings is to split the road link into three sections, similar to that representing a junction and reduce the speeds near the crossing.

Multiple lanes of traffic

A3.100 In certain circumstances, it can be useful to model separate traffic lanes (for different directions) instead of modelling one road. This may improve the accuracy of predicted results along the road of concern. Locations where separate lanes may be useful to consider include:

- wide roads, like dual carriageway A-Roads and motorways with physically separate lanes;
- queuing on one side of the road near a junction while the other side is free-flowing.

Care should be taken with regard to how the model deals with road widths, particularly in areas that are being modelled as street canyons.

Should I model a motorway or A-road based on multiples lanes?

A3.101 If traffic data are available, detailed dispersion modelling of motorways and A-roads may include separate road sources for each direction. This may be beneficial as there is better representation of different speeds for traffic travelling in different directions (for example approaching a major junction or exit), and different proportions of vehicles and patterns of traffic may be incorporated.

A3.102 Splitting wide roads into different directions may have effect on the vehicle induce turbulence calculations. However, in many cases the better representation of traffic flows in the model may have a greater effect on emissions than that due to turbulence calculations. The DMRB model does not allow roads to be modelled as separate sources for different directions.

A3.103 It is important to check whether the diurnal flow pattern is directional before modelling a two-way traffic flow separately. Daily traffic variations can be significantly different in one direction compared to the other one, and may have an influence on final modelled results. Annex 2 provides further information on deriving traffic patterns.

A3.104 Where possible, local authorities should test the difference in predicted concentrations at a few receptors; this may be considered as a sensitivity test especially where a local authority has monitoring against which modelled results can be compared.

Road gradients

A3.105 Emissions factors for HDVs only that may be used where a road has a significant gradient are described in Annex 2. In the absence of suitable gradient factors for cars and LDVs, the local authority may consider the effect of the gradient on reducing the average speed of vehicles, and use speed-related emission rates accordingly.

Terrain

A3.106 Most of the dispersion models have been developed to predict pollutant concentrations on flat terrain, ie without taking into account topography. However, in reality a modelled area may include complex terrain such as hills or valleys which can have a significant effect on the dispersion of pollutants, especially for large scale modelling (over 1km). Many dispersion models now include an option to include the effect of terrain in their calculations, based on a digital terrain model (DTM) which can be entered in the model set-up.

A3.107 The effect of terrain is mostly considered in the case of point source modelling, where emissions from stacks can have an impact far from the source. This case is discussed in further detail in the section A3.135.

When should I consider including terrain when modelling road traffic sources?

A3.108 Model providers should be contacted for advice on including terrain when modelling sources such as roads. Terrain modelling has important limitations, and the following points should be considered prior to including terrain within the model:

- Does the modelling area include significant variations in elevations? In most of the UK, the elevation gradient in the area of concern will not be significant enough to have an impact on dispersion modelling. The standard criterion in considering terrain is a 10% gradient in slopes. Under this value, it is generally unnecessary to include terrain in the model set-up.
- Is the modelling area wide enough to consider the effect of terrain? In many cases of urban traffic dispersion modelling, the area of concern will be a busy junction, a set of streets within a small area, or a town centre, where the overall topography can be considered as flat terrain at this scale (even in hilly regions). Locally, emissions factors for road with steep gradients may be applied as discussed above.

- What is the precision of available terrain files? Even if the modelled area is wide enough and contains significant variations in terrain, the model output is unlikely to reflect the impact of topography if input data are not precise enough. Most dispersion models base their calculation on a DTM. Precision should always be checked by the supplier of data. Local authorities are generally concerned with the predicted concentrations within a few metres of roads that are generally 10 – 30 m wide. The spacing of information within a terrain file is often considerably larger and it is unlikely to account for any variation in terrain between the road and most receptors. Further advice on how to consider local variation in height between road sources and receptors is provided in Section A3.110.
- What level of detail can my model include in terrain modelling? Some models may read elevations from the DTM and interpolate the results on a coarser grid, to simplify the calculations and make the models run quicker. This can result in a loss of detail in the terrain data, and the model will not reflect the actual complex topography. Information about how the model takes into account terrain data should be read carefully. It is also important to notice that although many models include a terrain option, most of them cannot deal with very complex topography which can require more complex algorithms and specific model software.
- Are there more important parameters than terrain that will impact the dispersion of pollutant? Most of the time in urban areas, other issues such as the traffic data, emissions factors, street canyon effects etc, will have a more important impact on local dispersion than topography.

A3.109 Local authorities are advised to consider the information below where sections of roads and receptors have variable heights.

Road layouts which vary with height

A3.110 A typical approach to modelling a road network is to consider the road elevation and the modelled receptor heights to be input into the model, for example, a road elevation at 0 m (or at grade) and ground level receptors at 1.5 m (or at a particular building storey height). Some dispersion models allow the type of road to be defined including bridges, depressions and cuttings, embankments, elevated roundabouts and slip roads. These types of road layouts are common on sections of major roads such as motorways and trunk roads.

A3.111 In more complex locations the height of the road relative to the rest of the road network may change (positively or negatively) depending on, for example, where there is a cutting or bridge. However, some models do not allow for road heights to be reduced below zero (negative height) and therefore the user may need to consider how to account for varying road source heights, especially where there are sensitive receptors. By way of an example, defining a uniform road height of 10 m across a modelled network would not be an acceptable approach if you are attempting to model a road cutting in a small part of the network. Whilst this would allow link heights to be reduced to account for the cutting (since negative elevations are not allowed), a 10 m road height (with receptors at 11.5 m) across the whole of the network would not perform acceptably. This is because the model also accounts for the release height of the source and the vertical profile of the wind field.

A3.112 Setting the whole road network at an elevated base level may result in the model under predicting. For example, the predicted concentration at a receptor set at 1.5 m elevation close to a road set at 0 m is 68 μg/m^3 NO_X. Whereas, the same road set at 10m height with a receptor height at 11.5 m (still 1.5 above the road height) is 41 μg/m^3 NO_X. Therefore, there is a risk of underestimating concentrations in those locations where the road source is not elevated if the whole of model is set at a base of 10 m.

A3.113 Conversely, not accounting for elevated road sections appropriately may result in the model over predicting. For example, the predicted concentration at a receptor set at 1.5 m close to a road set at 0 m is 113 μg/m³ NO_X. Whereas, the same road set at 5 m height with a receptor height at 6.5 m (still 1.5 above the road height) is 80 μg/m³ NO_X.

A3.114 Consequently, assigning road and receptor heights is an important step in determining predicted concentrations at receptor locations, especially where these locations are used for model verification (and possibly adjustment).

A3.115 Where a model does not incorporate different road types such as bridges and/or cuttings, or easily account for height differences between sources, users should consider the relative position of roads (and their adjacent receptors) on a local basis only, ie, ignore other links greater than 200 m from the link. A simple example may be an elevated road section placed at 3 - 5 m height, with receptors at 1.5 m. However, more complex examples may include a large modelled network with very small discrete areas where there are bridges and/or road cuttings that need additional consideration of source and receptor height relationship. As such, it would be acceptable to model the majority of the road network as 0 m, with receptors at 1.5 m. However, in the immediate vicinity of the bridge and cutting, the appropriate road sources may be elevated at 3 to 5 metres, thus allowing bridges to be modelled at 6 - 9 m (for example), but more importantly allowing the road in the cutting to be modelled at 0m (since negative road heights may not be allowed). Employing such a method would also require sensitive receptor heights to be adjusted accordingly when in proximity to a bridge or cutting in order to reflect the actual difference in heights between the receptor and bridge or cutting. Where properties are not adjacent to the road, Ordnance Survey maps should be used to determine their elevation in respect to the nearest road (or road with largest impact). In both cases, a difference of a few metres may have a significant impact on predicted concentrations, and care should be taken where these locations are being used to verify and possibly adjust dispersion modelling results.

A3.116 Model suppliers should be contacted for further advice on representing variably source heights within models, particularly where heights greater than 10 m are thought to be required as vertical wind profiles determined within models may become important. As for many detailed dispersion modelling options, some testing of the sensitivity of results to these options is recommended, particularly where model verification is being performed locally.

How detailed should my model predictions be for road sources?

A3.117 The aim of the Review and Assessment process is to gradually focus on more specific sites/sources such as single roads or junctions at which potential exceedences of the Air Quality Strategy objectives are identified through the means of different levels of screening exercises.

A3.118 If you are assessing roads that are 10 - 20 m wide, you should be predicting concentrations at either:

- Specific receptors representative of exposure as identified using maps; and/or
- A receptor grid spaced at 5 - 10 m near to the roadside to provide detailed predictions in the areas where exceedences are more likely to occur.

A3.119 Where models generate receptor locations automatically (for example based on a function determined by road width) local authorities must check that receptor locations are representative of relevant exposure and do not miss out the areas closest to the road source and therefore do not represent the worst-case receptors.

A3.120 Concentration contours are generally drawn for the areas where exceedences have been identified based on (verified) dispersion modelling of road traffic sources. This does not mean that whole urban areas necessarily need to be contoured, particularly background locations in smaller towns where pollutant concentrations are unlikely to approach the objectives. Specific receptors should first be used for any detailed modelling at the roadside and then contours produced for the relevant areas with, or close to exceedences. This approach can save considerable time and resources.

A3.121 Where contour maps for a whole urban area are required, these should include greater detail within 30 to 50 metres of roads (maybe further for some motorway sites where the drop off distance to background is greater), and generally be based on a grid spacing of 5 to 10 metres. General background concentrations for most urban areas are well known and do not require detailed contouring. However, verified modelled background concentrations based on local emission inventories may be useful for wider decision making purposes.

A3.122 Contours produced at the end of road sections are not appropriate as the concentrations may be lower simply due to the interpolation of a reduced number of points. Therefore, modellers should ensure that roads sources and the gridded area are extended by at least 30 m beyond the area for which the contour is required.

A3.123 Modelling of large regions at low levels of spatial detail, for example with a 50 m grid spacing, can result in localised exceedences at junctions and roadside sites being omitted. For the purpose of review and assessment, predictions should also be undertaken at specific receptor locations representing relevant exposure in addition to gridding for the production of contour maps.

Point Sources

Dispersion modelling of point sources

A3.124 See Annex 2 for information on what data to collect and how to collate the information on point source emissions.

A3.125 When predicting the impacts of a stack for review and assessment purposes, the use of emissions limits for authorised processes is often pessimistic and many plants operate well below these. The modelling assumptions should be realistic but conservative. The onus has to be on information from the operators. Useful data may also be obtained from the annual returns from process operators to the regulatory agencies[69].

A3.126 It is important to identify the emissions profiles for point sources as these have an impact on the contributions to short-term concentrations. It is advisable for local authorities to contact the regulatory agencies for information on any previous modelling assessments and/or emissions data in order to avoid duplication of effort and ensure consistency.

A3.127 Local authorities are advised to pay additional attention to sections A3.191 to A3.215 of this Annex when modelling point sources.

[69] Environment Agency in England and Wales, Scottish Environment Protection Agency in Scotland, and the Northern Ireland Environment Agency in Northern Ireland.

When should I model variable emissions from a stack?

A3.128 In the first instance, variable emissions data should be used if modelling using a constant annual emission rate has indicated exceedences of the relevant objective (after allowing for background). Local authorities should first find out about the variation in emissions (ie significant excursions/ divergences from the mean value). Where there is significant variation (as identified in Box A3.2) in hourly emissions, modelling results may be under-predicted for both long-term and short-term concentrations, depending on variation of the emissions in relation to the mean value used.

A3.129 Local authorities should check general operation times for processes, particularly if initial screening indicates potentially significant ground level concentrations. In many cases, operations may only occur during day time hours, or in relation to shift patterns, and dispersion models should take account of these when refining modelling. If there is any doubt regarding the process operation times then continuous emissions should be modelled.

A3.130 For a process identified as having batch cycles that cannot be described temporally, liaison with the operator and/or regulatory agency will be required. These processes can vary randomly, in terms of emissions, temperature and even velocity profiles and are very difficult to model. Some continuous monitoring of the source emissions is required in order to determine the extent and nature of any variations. A basic profile may be determined and modelled by staggering over different periods to try to cover predictions when the batch profile is high at night, and during daytime. The Local Authority Air Quality Support Helpdesk may be able to help for specific situations, perhaps with regard to interpretation of fuel use statistics or production logs to help estimate the cycles.

A3.131 Random infrequent events such as cleaning start up/shut down and failure should not be modelled for review and assessment purposes. In general monitoring is not available during these times. If these events are part of the normal operations, perhaps occurring every morning/ evening/ weekend or occur regularly, then they should be included.

A3.132 Changes in fuel use should also be considered. Most operators have evidence that shows how often they may have had to use alternative fuel sources such as heavy fuel oil (perhaps during disruption to gas supplies) – this may not occur every year, and while regulatory agencies require these to be looked at for authorisations, these are not required for review and assessment. However, where an operator commonly switches fuel during certain times of years (some food/agricultural processes after harvests) these can be considered normal operations and should be modelled.

A3.133 If information regarding future abatement, changes to feed quality or future production are known, these should be considered for modelling of future years. It is suggested that any such information should be agreed with the regulatory agency prior to modelling.

A3.134 Monitoring is nearly always undertaken for total particulate matter (PM), not PM_{10}. For certain processes, the PM_{10} emissions can be estimated from particle size distributions reported in the literature[70] or the Local Authority Air Quality Support Helpdesk can be contacted. The available particle size distribution data are primarily from the USA. The worst-case assumption that all the PM emissions will be in the PM_{10} fraction may be too pessimistic for detailed stack modelling where the contribution of the stack is significant (in relation to the background concentration and/or the air quality objectives). Similarly, total metals are often monitored rather than specific species of concern for LAQM, for example lead. Total volatile organic compounds (VOCs) are frequently measured in a stack, rather than specifically benzene. For PM_{10}, where size fraction information is not available or reliable, all PM will be required to be modelled as PM_{10}.

Box A3.2: Data required for stack modelling

	Sulphur dioxide	NO_2	PM_{10}	Benzene and 1,3-butadiene	Carbon monoxide
Physical data	Stack height and diameter				
Stack emission conditions	Temperature, velocity, Volumetric flow-rate				
Temporal data –when required	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than nine hours per year	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than 18 hours in the year	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than 35 days in the year (seven days in Scotland)	Annual emissions data adequate	If the excursions about the annual mean emission rate are greater than 100%,

Complex effects

A3.135 Buildings close to stacks and complex terrain can be modelled far more readily now, due to improvements in model codes and faster run times. Terrain data files are readily available at reasonable cost.

A3.136 However, validation of models for these situations are ongoing and the results form modelling such complex effects are generally considered to have greater uncertainty. The results from different new-generation models, when building wake effects and/or terrain effects are included, can be very different[71, 72], and caution must be exercised in the interpretation of these predictions.

A3.137 The difficulties with modelling terrain and building downwash effects should be borne in mind. The results obtained when using building and terrain algorithms should be treated with caution, and a greater margin of uncertainty allowed for, when deciding on a declaration of an AQMA. It is noteworthy that terrain modelling is usually unnecessary if the slope is less than 10%.

A3.138 When incorporating complex effects such as terrain or buildings in dispersion models, the model manuals and/or providers should be contacted for advice.

[70] US EPA AP 42 Compilation of Air Pollution Emission Factors (www.epa.gov/ttn/chief/ap42etc.html)

[71] R&D Technical Report P353: A review of dispersion model Intercomparison studies using ISC, R91, AERMOD and ADMS.

[72] R&D Technical Report P362: An Intercomparison of the AERMOD, ADMS and ISC dispersion models for regulatory applications

Buildings

A3.139 In the case of building wake effects particular care should be paid to results predicted at receptors within the main plume recirculation zone where a proportion of a plume is calculated to be trapped (or entrained) by models (in the lee of the building), and in the turbulent wake zone, which is at a greater distance on the leeside of the building. In many cases, these areas are within or close to the site boundary of facilities, but where concentrations are predicted to approach the objectives it is recommended that further model sensitivity tests are undertaken. In some cases where there are relevant receptors, monitoring may be required to support the findings of the dispersion modelling.

A3.140 Modellers should take care when considering the number of buildings to be input to dispersion models and the model suppliers should be contacted for further advice as the treatment of large numbers of buildings vary. It is essential that the buildings upon which stacks sit (on top or adjacent to) are considered and in many cases these will be the most significant buildings affecting the plume dispersion. However, there may be other tall buildings on industrials sites which may also have an impact on plume dispersion and these should be included. Where there are very complex layouts with many buildings, some sensitivity testing should be carried out as a means of determining the most significant buildings.

A3.141 Where there are a large number of buildings in the vicinity of stack source, those closest (and often tallest) should be included and the surface roughness assumed in the model may be increased.

A3.142 Models allow buildings at great distances from stacks to be input. It is important to ensure that buildings at these distances from stacks are not considered to be the main building affecting the initial plume dispersion and building downwash effects. It is recommended that users consider carefully the need to include these buildings within the model setup and where they are included, the model should be run with and without these buildings as the effect for different model setup and parameters will vary.

A3.143 In some cases, an authority may be interested in understanding the potential impact of large plumes on high rise buildings. It is recommended that receptors are placed at varying heights in the location of interest and the results can be examined to determine the difference in plume dispersion at these heights. As mentioned above, the effect of the building may be tested (by running the model with and without the building) but this will not include any estimate of increased concentrations at the virtual façade of the building due to, for example, impaction of the plume.

Rain shields, vents, areas and volume sources

A3.144 The use of rain shields on stacks inhibit the vertical plume rise. It has been "custom and practice" for some time to set the exit velocity at 1 m/s for such releases. This effectively allows only the thermal buoyancy of the efflux gases to affect plume rise and stack tip downwash (or stack induced downwash) calculations are often performed by models in these circumstances.

A3.145 Release points are sometimes non-vertical, ie, a vent protruding from the side of a wall. Whilst model allow these types or sources to be input (for example as jets), complex entrainment between buildings is likely, which currently cannot be modelled reliably by practical, short-range dispersion models.

A3.146 Most models allow users to input area and volume sources. The user manuals should be consulted when modelling these type of sources, and the predicted contributions from these sources are more uncertain. In some cases, volume and areas sources are used interchangeable by many modellers, however it is important to note that for area sources, the temperature and efflux velocity can usually be varied, but often cannot for volume sources. Where a source has an ambient temperature or higher (albeit difficult to quantify in some cases) it will have some initial plume rise due to thermal buoyancy (rather than none) and areas sources may be more appropriate in these circumstances. For volume sources, the source height and vertical dimensions are important parameters and will affect the predicted concentrations.

A3.147 There are other circumstances where proprietary dispersion models are unsuitable for use, such as for prediction of pollutant concentrations between buildings on an industrial site. Under these circumstances, physical modelling (ie, in a wind tunnel) or CFD modelling may be useful tools with which to investigate the air quality impacts for certain meteorological scenarios. However, these require very specialist use and interpretation, as they are difficult to set up and have limited use for review and assessment.

Coastal Effects

A3.148 Some advanced dispersion models allow for the simulation of coastal effects. Generally these effects are understood to be important only for stack sources within a maximum of 5 km of the coastline. In addition, modelling of coastal effects requires some additional meteorology data such as sea surface temperature and temperature over land near the sea.

A3.149 The coastal effects mainly result from differences in meteorological conditions near the coast. The main regional differences in meteorology are stronger winds near the coast (particularly towards the west). At inland locations, the wind speed is lower on average, and the more extreme dispersion conditions occur more often.

A3.150 For the purpose of Review and Assessment, coastal modelling is not required to be undertaken. However, in particular circumstances local authorities may choose to investigate the impacts using coastal modules and it is recommended that local meteorological data from a site representative of the coastal location are used for these purposes. It is also recommended that modelling is carried out with and without the coastal effects module in order to determine the difference between the predicted concentrations.

How detailed should my model area be for point sources?

A3.151 Where local authorities are assessing point sources, model resolution should be in the order of 25 - 50 m, particularly where relevant exposure exists within 500 m of a stack. Greater spacing can result in areas of impact being missed (Box A3.3).

Meteorological data

Sources of data

A3.152 There are a number of suppliers of meteorological data in the UK including the Met Office[73], MeteoArchive[74], ADM[75], and World GeoData[76]. When purchasing meteorological data it is important to check that the proper Quality Assurance and Quality Control (QA/QC)[77] has been undertaken. The Met Office website (www.metoffice.gov.uk) contains a list of observation sites for which observed data for modelling are available. Links to sources of relevant information on equipment and site locations, and changes to the site, are also provided. References are also available for the quality control processes used for the datasets provided by the Met Office.

[73] www.metoffice.gov.uk

[74] www.meteoarchive.com

[75] www.aboutair.com

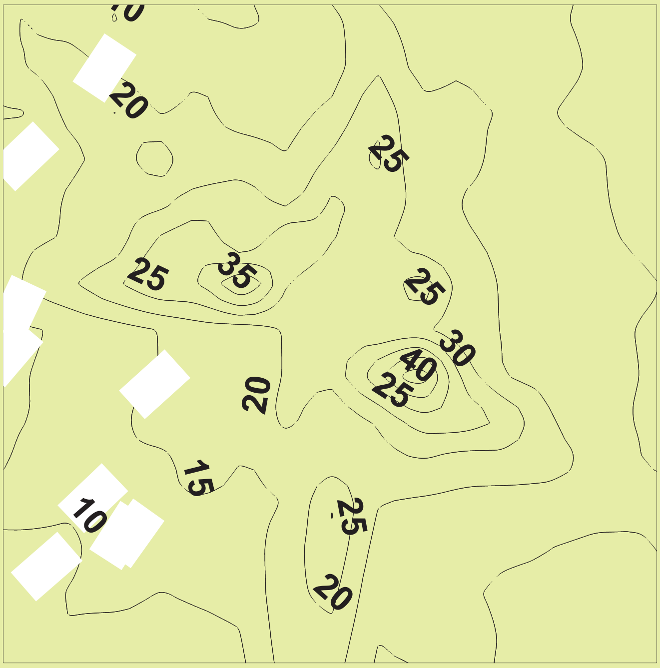
[76] www.worldgeodata.com/home.aspx

[77] www.metoffice.com/bookshelf/observations/making_obs/01_0369_MakingALL.pdf

Box A3.3: Difference in Contours based on modelling at 200 m (upper) and 50 m (lower) grid spacing. The lower plot clearly indicates that the impact area to the north of the stack is not represented at larger grid spacing.

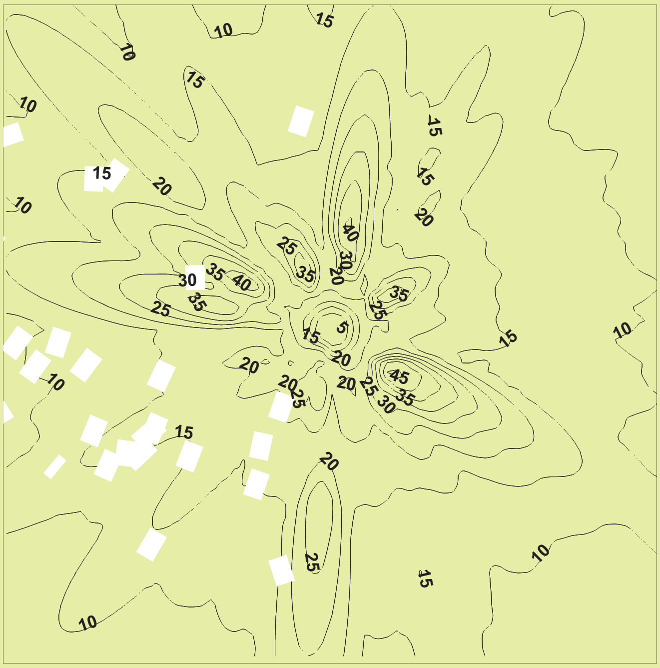
200 metre grid spacing

(stack at centre)



50 metre grid spacing

(stack at centre)



A3.153 Common checks that should be made when purchasing meteorological data include:

- the units of the data (for example wind speed as m/s or as knots) are correct for the model being used;
- cloud cover octas are within appropriate range;
- wind directions are all within 0 – 360 degrees;
- confirmation of percentage data capture.

A3.154 Information on the source of data and where possible the type of instrumentation employed should be obtained. Users should confirm whether the data provided are hourly sequential, as measured, or whether missing hours have been filled. For example, some automatic stations provide data every three or five hours, and algorithms are used to calculate the missing data. However, it is difficult to quantify the impact upon model predictions, but where possible hourly measured data would be preferred.

A3.155 The number of sites providing manual cloud cover is reduced across the UK, but there are a large number of sites with automatic cloud cover measurements. The use of these sites will help to reduce the distance of the nearest available meteorological to the modelled domain. There have been previous concerns that automatic cloud cover measurements may have some effect on the calculated number of hours with very low and very high cloud cover. However, comparison of the general shape (or profile) of cloud cover between a site based on manual versus automatic cloud cover suggests the differences are no more significant than the variability between data from different meteorological stations or different years of data.

A3.156 In some cases a local authority may have local wind speed and direction measurements, as well are more detailed information such as temperature and rainfall. Local meteorological data can assist in many studies, particularly where it is undertaken as part of monitoring campaigns and can provide useful information for source apportionment studies. However, if dispersion modelling is carried out for local wind speed and direction measurements it should be compared against that from a data source which has undergone suitable QA/QC checks.

A3.157 The Met Office can be contacted for advice on the placement and operation of meteorological stations. In addition, locally operated meteorological stations may not provide all of the required parameters required for dispersion modelling, for example cloud cover. The Met Office can advise on the combination of information from different stations, commonly cloud cover from one site combined with other parameters from a different site. Local authorities should not undertake this without further advice as suitable checks on the data are required to ensure inappropriate parameters are not derived.

Treatment of calm and missing meteorological data

A3.158 In calm conditions (ie, wind speeds close to 0 m/s), a number of models have a mathematical discontinuity. This means that the concentration will not be calculated for such hours, unless some approximation is built into the model. The high percentiles of pollutants from ground level sources (for example road traffic) often occur in such calm conditions, and are therefore difficult to model with confidence. Anemometers should be capable of measuring very low wind speeds; ultrasonic anemometers are especially well suited to this.

A3.159 Most Gaussian-type models do not use the lines in the meteorological data set which have calm winds in its calculations, so they will be missing the instances when concentration values may be at their highest. For example, ADMS-Urban and ADMS-Roads set the minimum wind speed to 0.75 m/s.

A3.160 The United States Environmental Protection Agency (USEPA) type models assume that all wind speeds recorded as between 0.5-1 m/s are treated as 1 m/s. For wind speeds less than 0.5 m/s the following rules are applied:

- If the averaging period is one hour, wind speeds less than 0.5 m/s are ignored and those lines of meteorological data are skipped.

- If the averaging period is eight hours, at least six lines of meteorological data out of eight consecutive lines must have wind speeds greater than 0.5 m/s. The lines with winds less than 0.5 m/s will be ignored, and the period average will be approximated to the 8-hour mean.
- If the averaging period is 24 hours, at least 18 lines out of 24 consecutive lines must have wind speeds greater than 0.5 m/s. The lines with wind speeds less than 0.5 m/s will be ignored, and the period average will be approximated to the 24-hour mean.

A3.161 This treatment is often referred to as the 75% rule for USEPA models, and is used for calms and missing hours. In the case of a 24 hour averaging period, the model will ignore up to six invalid hours (18/24 real wind speeds = 75%). The resulting concentration is calculated by summing those 18 valid hours and dividing by 18. If you have ten calms, than the model sums the 14 valid hours and divides by 18. This may therefore produce a dilution effect.

A3.162 It is recommended that a meteorological data file is tested within a dispersion model and the relevant output log file is checked as this will confirm the number of missing hours and calm hours calculated by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedences.

Calculation of percentiles and/or number of exceedences

A3.163 Some of the objectives allow the air quality standard to be exceeded for a certain number of hours in the year. For example, the short-term objective for NO_2 allows a concentration of 200 µg/m^3 to be exceeded for 18 hours in the year. Such Air Quality Objectives are always expressed in terms of the number of exceedences, and not percentile values.

A3.164 If a full year of sequential hourly meteorological data are available (8760 hours) for modelling, a predicted concentration of 200 µg/m^3 (after allowing for background) may be exceeded on no more than 18 hours. If a dispersion model is run to calculate the hourly mean concentrations, and assuming that the model does indeed carry out the calculation for every single line of meteorological data (including the calms), the 19th highest concentration equates to a 99.8th percentile. (This is analogous with a monitor measuring an hourly concentration for every hour in the year without any loss of data or malfunction.)

A3.165 There are two difficulties if the air quality objective is expressed in terms of the number of exceedences, rather than a percentile concentration:

- Observational meteorological data often have many hours of data missing. If the recorder has managed to capture only 6000 hours (for example), the 19th highest hourly mean concentration will not be equivalent to the 99.79th percentile. In this case, the 19th highest concentration would equate to a 99.70th percentile of *the available meteorological data* (assuming a calculation is carried out for every line of meteorological data). The 99.79th percentile of *the available meteorological data* would actually allow only 13 exceedences.
- Some models do not carry out a calculation for those lines which have inadequate data, for example, missing wind direction or cloud cover. Using the example above, the 6000 hours of meteorological data may have contained 1000 hours which were invalid or inadequate. A model may be used which ignores these hours. The 19th highest concentration of 5000 hours equates to a 99.64th percentile of *the meteorological data processed.* The 99.79th percentile of the *available meteorological data which can be processed by the model* would actually allow only 11 exceedences.

A3.166 Therefore, it is important to know how the model employed treats missing hours of meteorological data, inadequate or invalid lines of data, and also how it treats the calms, particularly if predicting the number of exceedences.

A3.167 When there are data for less than 90% of hours in a year (including missing, invalid and calm hours), the modelled results should be expressed as percentiles, and not as number of exceedences. If there are more than 90% of hours in the year available, then the results may be expressed as either percentiles or number of exceedences.

A3.168 Using the 90% valid meteorological data availability criterion, the percentile statistic is constrained to no less than 99.78% for NO_2. For other pollutants which have objectives expressed as a maximum permissible number of exceedences of an air quality standard (for example, sulphur dioxide (SO_2), PM_{10}), the same guidance can apply. For example, for SO_2, if less than 90% of the meteorological hours are available for model calculations, the 99.9th percentile statistic should be calculated, rather than allowing for 35 exceedences of the 15-minute mean concentration. For PM_{10} in England, Wales and Northern Ireland at least 90% of valid days need to be available for modelling if allowing 35 exceedence days; otherwise, the 90th percentile of the available meteorological days should be calculated. For assessment against the 2010 daily mean PM_{10} objective in Scotland (which allows only seven exceedence days per annum) it is recommended that the 98th percentile statistic should be calculated rather than the number of exceedences.

A3.169 The examples for NO_2 described above are summarised in Box A3.4, with a few additional scenarios.

Box A3.4: Use of Meteorological data and estimation of percentiles or number of exceedences.

# of lines of meteorological data recorded (adequate and valid lines only)	# of lines of calms	Does model calculate for calm hours	# of hours actually included	% of hours actually included	Available hour less than or greater than 90%	What statistic should be modelled?		
						> 18 Exceedences?	99.8th Percentile?	Annual Mean
8760	0	Yes	8760	100%	>90%		✓	✓
8760	1000	Yes	8760	100%	>90%	✓	✓	✓
8760	500	No	8250	94%	>90%	✓	✓(≈ 99.8th)	✓
8760	1000	No	7760	86%	<90%	✗	✓	✓
8000	0	yes	8000	91%	>90%	✓	✓(≈ 99.78th)	✓
8000	1000	yes	8000	91%	>90%	✓	✓(≈ 99.8th)	✓
8000	1000	no	7000	88%	<90%	✗	✓	✓
7000	500	Yes	7000	80%	<90%	✗	✗	✓
6000	0	Yes	6000	68%	<90%	Do Not Use		
6000	1000	yes	6000	68%	<90%	Do Not Use		
6000	1000	no	5000	57%	<90%	Do Not Use		

A3.170 In general, it is recommended that meteorological data with percentage of useable hours greater than approximately 90% should be used, especially when predicting high percentiles as relevant for short-term impacts from stacks. Where only the annual mean is predicted, data capture requirements may be reduced to 75%. However, meteorological data files with significant gaps representing periods of a few weeks at a time should be avoided, for example, no recording during three months over winter (data capture 75%). In these cases, missing data may affect the predictions for both short-term and long-term concentrations.

Use of numerical weather prediction data

A3.171 The Met Office uses the Unified Model (UM) for numerical weather prediction[78]. The model is run at difference scales – global and mesoscale – and the output data are archived. The Met Office has software which can be used to interpolate the data for a desired position. The data can be provided by the Met Office formatted ready for use in dispersion modelling. However, currently the data are not well tested for review and assessment purposes. Therefore, where a local authority considers using Numerical Weather Prediction (NWP) data, a comparison of the results with standard observations data (OBS) may be considered helpful. It is recommended that a comparison of modelled predictions against local monitoring data is also undertaken in order to determine if the model performs differently, or better, if using NWP data. Annual means and relevant percentile values should be evaluated. Local authorities can contact the LAQM support helpdesk for further advice.

A3.172 Preliminary comparison of OBS and NWP data for modelling dispersion from a single stack source suggest that the variability of the predicted results is no greater than that expected when comparing data between different OBS sites. However, comparisons using NWP based on road traffic (ie, low level sources) have not yet been undertaken and it is not known if there is greater variability for these types of sources.

A3.173 Numerical Weather Prediction may be a useful alternative to OBS data where a specific situation arises, for example, where there are no suitable meteorological data available, or where OBS data are affected by local hills or valleys and other obstacles, and may not therefore represent general meteorological conditions at the location to be modelled. Numerical Weather Prediction data may also be useful in coastal areas or location with complex terrain features as the structure and atmospheric stability may be better represented, for example where there are no OBS data from the area. Detailed comparisons of the meteorological data needed for dispersion modeling, such as wind speed and direction, cloud cover, boundary layer depth, and atmospheric stability, have been carried out, which give reasonable confidence in the use of NWP data, provided that care is taken to assess the local geography and recognise the limitations associated with each type of data, OBS and NWP[79].

A3.174 As there has been limited use of NWP data for the assessment of air quality, additional care must be taken when running models with these data. This includes consideration of combining terrain effects and surface roughness assumptions required by dispersion models with the use of NWP. At present, the resolution of mesoscale datasets produced by the UM is 12 km, and urban areas are not recognised sufficiently. Therefore, NWP mesoscale data can be regarded as representative of the locality in which the town sits, but more like a rural dataset than urban in character. Many OBS sites are well exposed sites outside towns and do not reflect the urban effects either. Where they exist, urban centre observations are fraught with the difficulty of representative siting. In the future, the UM model grid size is likely to be reduced further and the urban effects will be seen more explicitly in the data.

[78] www.metoffice.gov.uk/research/nwp/numerical/unified_model/unified_model.html

[79] Papers by Middleton D R available for two conferences, harmo 11 and harmo 12, available at www.harmo.org

A3.175 Development of the UM model is ongoing and the representative scales are changing regularly. The level of detail represented in numerical weather models like the UM is dependant upon the grid scale. Therefore, it is important to ensure that the time and version (for example, "mesoscale") and the grid scale (for example, approximately 12 km) of the UM model run are known. Datasets for the same grid location will change over time as further refinements are included in the UM.

A3.176 Where a local authority considers using NWP data, a comparison of the results with OBS data may be considered helpful. The Met Office and Local Authority Air Quality Support Helpdesk can be contacted for further advice.

Which years should be modelled?

A3.177 There will be some difference in the prediction of the contribution of sources when using different years of meteorological data. However, this will vary between site, sources modelled, and averaging period being predicted. Previous information provided in LAQM.TG(03) Annex 3 suggests that the variability is unlikely to be more than 30%.

A3.178 For the purposes of review and assessment only one year of meteorological data need be used. The year of data used should be the same for:

- emissions estimates;
- monitoring data;
- background estimates; and
- meteorological data.

A3.179 The year of meteorological data (and year of assessment) should not be more than five years old. However, local authorities should bear in mind that when undertaking the review and assessment, the reporting year is generally expected to be the previous calendar year. For example, when undertaking a detailed assessment during 2007, the year of assessment would be expected to be 2006 as a full year of meteorological data will be available, as well updated source information, and monitoring data (including assessment of bias correction factors for diffusion tubes).

A3.180 Where a local authority decides to assess air quality concentrations over a number of years, for each year chosen, the meteorological data file, background concentration, source data and monitoring should be collated. Local authorities should bear in mind that the choice of year of meteorological data may have less influence compared to the background pollutant contributions which can vary considerably from one year to another. Decisions regarding requirements for AQMAs and areas of exceedence should be based on the worst-case year of assessment. Predictions for future years should also be based on the worst-case year.

A3.181 Where point sources are modelled, the main effect of different meteorological years will be in relation to the location of the maximum predicted concentrations. For the purposes of review and assessment, local authorities are not expected to model using five years of meteorological data, and only one year is required. Authorities can take account of changes in wind directions for different years by assuming the maximum concentrations may occur within a 45 degree arc to either side of where the maximum concentration is predicted. Where an authority decides to use multiple years of data (three or more), then it is recommended that the results for all years are reported, any decisions are based upon the worse-case year. Local authorities are advised to read sections A3.197 to A3.215 of this Annex when modelling point sources.

A3.182 Decisions on declaration of AQMAs are often based on both monitoring and modelling, and consideration of recent trends of monitoring against predicted concentrations will assist authorities when making these decisions.

Consideration of background concentrations

A3.183 Estimates of background concentrations may be based on local monitoring (both continuous monitoring and diffusion tubes), on national mapping of background (see Chapter 2 of Main Document), and in some cases on modelled background concentrations where detailed emissions inventories have been produced as part of modelling. Where possible, mapped and modelled background concentrations should be compared against local monitoring data to confirm there is good agreement.

Background and road traffic sources

A3.184 Screening tools will generally require only a single estimate of background concentrations, (for example the DMRB requires the annual average) and do not account for variability in hourly background concentrations. However, many dispersion models allow users to provide more detailed background concentrations, and in some cases certain model setups may require hourly background information.

A3.185 Where predictions are undertaken for the annual mean, it is suitable to use annual mean background concentrations. However, where local information is available, hourly backgrounds may be used and model suppliers can advise on the format of data requirements.

A3.186 Where a local authority is undertaking dispersion modelling of road traffic sources and does not include a diurnal pattern of traffic emissions, an annual average background should be used.

A3.187 In many cases, empirical relationships and equations are used and these are often based on the annual average contribution of sources, with an estimate of annual average background concentrations. In these cases, local authorities do not need to consider hourly background concentrations. However, where models undertake the conversion of NO_X to NO_2 (for example using chemical reaction schemes), hourly background concentrations should be included.

A3.188 Local authorities will also use dispersion models to predict concentrations in future years. The way to project annual mean background concentrations to future years is set out in Chapter 2 of the main document. Local authorities will also need to project hourly background data for future years where these values are used in an assessment, and in the absence of more detailed projection factors, the hourly background may be adjusted using the projection factors derived from the annual mean data.

A3.189 Many models to convert NO_X to NO_2 require an estimate of background ozone (O_3). Ozone concentrations are variable across the UK, and trends in concentrations are unclear. However, where O_3 information is required, some projection of O_3 concentrations will be necessary for the prediction of concentrations in future. One method for this is to consider the total oxidant concentrations (NO_2 + O_3). This should be determined, for example as an annual average, for the current year of assessment by adding the annual average NO_2 and O_3 concentrations. Projection factors for NO_2 background can be used to adjust the NO_2 proportion to the relevant year. Assuming that the total oxidant in future years remains the same, the O_3 proportion of the total oxidant would be increased. The estimated O_3 concentration for the future year should then be used where required.

A3.190 Hourly and daily background PM_{10} concentrations may also be projected to future years using the approach set out in Chapter 2 of the main document, however, it must be recognised that there are uncertainties with this method as there is currently no known relationship between long-term annual projections and short-term concentrations in future years.

Background and point sources

A3.191 Similarly for road traffic sources, annual average or hourly sequential background concentrations may be used when predicting the concentrations due to stacks. As the main focus for point sources is usually the shorter term objectives (with high percentiles or number of exceedences to be predicted) rather than the annual mean, a more detailed consideration of background is often required.

A3.192 Where a local authority has only average emissions estimates (and no pattern of variable emissions) for point sources, then average estimates of background concentrations should be used. This is described in more detail below in order to allow local authorities to account for predictions of short-term percentiles.

A3.193 The Environment Agency (EA) provides information on methods for combining background and the process contribution of sources[80] in relation to the relative contributions of these sources, and the risk of exceeding the relevant air quality objectives.

A3.194 The estimates of the process contribution and the estimate of background concentrations should match the relevant air quality objective environmental assessment level (EAL). For short-term air quality objectives, it is not meaningful to add percentiles of process contribution to percentiles of background as the meteorological conditions under which high ground level concentrations from a stack occur will not coincide with those that lead to high background concentrations.

A3.195 For the assessment of annual mean concentrations the annual mean contribution of the process can be added to the annual mean estimate for background. Depending on the information available, the annual mean estimates may be based on variable emissions data and hour by hour background information, or simple statistics. However, the focus for review and assessment purposes is the assessment of the shorter term concentrations including 24-hour, 1-hour and 15-minute mean averaging periods.

A3.196 The preferred method of adding background contributions to point source process contribution is to add hourly background (from a suitable background monitoring station) to the hour-by-hour predicted process contribution. This is an option available in most commonly used dispersion models. However, detailed hour by hour consideration of background and process contribution may not be required in the first instance. Local authorities may use the methods provided below in A3.197 to A3.215 to account for background concentrations when modelling point sources[81], however further detailed modelling may be required, which includes the hour by hour consideration of background and process contribution, depending on the predicted results. It must however be noted that the methods below cannot be used determine the location or extent of an AQMA. This is discussed further in section A3.215.

[80] Environment Agency Science Report SC030174/1 SR1 and SR2 October 2006. www.environment-agency.gov.uk

[81] Environment Agency Science Report SC030174/1 SR1 and SR2 October 2006. www.environment-agency.gov.uk

How do I consider background when predicting sulphur dioxide from point sources?

A3.197 For the purposes of predicting SO_2 concentrations due to point sources the following approach is recommended in the first instance.

A3.198 The 99.9th percentile of total 15-minute mean SO_2 is equal to the maximum of either equation a or b below:

a) 99.9th percentile 15-minute mean background SO_2
+
twice annual mean process contribution SO_2

or

b) 99.9th percentile 15-minute mean process contribution
+
twice annual mean background contribution

A3.199 The 99.7th percentile of total 1-hour SO_2 is equal to the maximum of either equation c or d below:

c) 99.7th percentile hourly mean background SO_2
+
twice annual mean process contribution SO_2

or

d) 99.7th percentile hourly mean process contribution
+
twice annual mean background contribution

A3.200 The 99th percentile of total 24-hour mean SO_2 is equal to the maximum of either equation e or f below:

e) 99th percentile 24-hour mean background SO_2
+
twice annual mean process contribution SO_2

or

f) 99th percentile 24-hour mean process contribution
+
twice annual mean background contribution

A3.201 The approach described above is likely to be conservative compared to comparing hour by hour predictions with hour by hour background. Where this approach suggests that the concentrations exceed 75% (for example, if the total predicted 99.9th percentile of 15-minute mean SO_2 concentrations is greater than 200 $\mu g/m^3$) of the air quality objectives a more detailed assessment will be required. This may include the consideration of variable hourly emissions, and/or the addition of hour by hour background to hour by hour predicted process contributions.

What if my model does not predict 15-minute mean concentrations?

A3.202 Some dispersion models do not predict 15-minute mean concentrations, and normally predictions of 15-minute mean concentrations should be solely relied upon. Therefore, the 99.9th percentile of hourly means can be multiplied by 1.34 to derive the 99.9th percentile 15-minute mean required in the equations above. Where a stack is very tall (>75m) a factor of two should be considered. Where a model provides the predicted 99.9th percentile of 15-minute means this should be compared against that derived by factoring the 99.9th percentile hourly mean and higher value should generally be used.

How do I consider background when predicting nitrogen dioxide from point sources?

A3.203 For the purposes of predicting NO_2 concentrations due to point sources the following approach is recommended in the first instance:

A3.204 The 99.8th percentile total hourly NO_2 is equal to the minimum of either equation g or h below:

g) *99.8th percentile hourly background total oxidant*

\+

0.05 x 99.8th process contribution NO_X

or

h) *The* ***maximum of either:***

h1 *99.8th percentile process contribution NO_X*

\+

twice x annual mean background NO_2

or

h2 *99.8th percentile hourly background NO_2*

\+

twice annual mean process contribution NO_X

In the above equations, the total oxidant is the sum of O_3 and NO_2 (as NO_2 equivalents) and should be based on summing the hour by hour concentrations from a suitable background monitoring site in order derived the 99.8th percentile.

A3.205 The approach described above is likely to be conservative compared to adding hour by hour predictions with hour by hour background. Where this approach suggests that the concentrations exceed 75% of the air quality objectives (equivalent to 150 µg/m^3) a more detailed assessment will be required, which may include the consideration of variable hourly emissions (as opposed assuming continuous operations), and/or the addition of hour by hour background to hour by hour predicted process contributions. However, the approach presented above is suitable for the detailed assessment of point sources as part of review and assessment.

How do I consider background when predicting PM_{10} from point sources?

A3.206 The 98th percentile total 24-hour mean PM_{10} (Scotland) is equal to the maximum of either equation i or j below:

> *i) 99th percentile 24-hour mean background PM_{10}*
>
> *+*
>
> *twice annual mean process contribution PM_{10}*

or

> *j) 98th percentile 24-hour mean process contribution*
>
> *+*
>
> *twice annual mean background contribution*

A3.207 The 90th percentile total 24-hour mean PM_{10} is equal to the maximum of either equation k or l below:

> *k) 90th percentile 24-hour mean background PM_{10}*
>
> *+*
>
> *annual mean process contribution PM_{10}*

or

> *j) 90th percentile 24-hour mean process contribution*
>
> *+*
>
> *annual mean background contribution*

Note: for the 90th percentile for 24-hour PM_{10} the method does **not** incorporate twice the annual mean contribution of the process or background.

A3.208 The approach described above is likely to be conservative compared to adding hour by hour predictions with hour by hour background. Where this approach suggests that the predicted increase in the 98th percentile (Scotland) or 90th percentile above the background is more than 50% of the available headroom (the difference between the objective and background), then a more detailed assessment will be required. This may include the consideration of variable hourly emissions to further refine the source contributions, and/or the addition of hour by hour background to hour by hour predicted process contributions. However, the approach presented above is suitable for the detailed assessment of point sources as part of review and assessment.

I don't have a continuous background monitor in my area so how can I estimate the relevant percentile of background?

A3.209 The nearest background monitoring, for example one operated within the AURN, can be used to determine the relationship between the annual mean and the relevant percentile. This relationship can then be applied to the data for the area required such as annual mean monitoring, or mapped background concentrations.

How do I avoid double counting of my process contribution?

A3.210 The reports provided by the EA suggest that the majority of AURN background monitoring sites are suitable to assess background concentrations of annual mean NO_X and PM_{10}, without the need to avoid double counting. However, there may be some locations where significant process contributions are expected, such as areas close to steel works and some power stations. The contribution of the process at the background monitoring site may be predicted, and compared to the measured concentration. Where the process contribution is greater than approximately 10% of the background, it may assumed that the background from this location is not suitable and some double counting is likely to occur. For SO_2, the contribution of industrial sources to background SO_2 is much larger than that for NO_X and PM_{10}, and therefore some double counting is more likely.

A3.211 Further consideration of the background contribution is likely to be required where the air quality objective is approached.

A3.212 The background maps provide the estimated source contribution of point sources within a grid square and this may be used to adjust the background concentrations. However, where the contribution is due to multiple sources, it would not be appropriate to remove all of the point source component as this may reduce background concentrations by too much.

A3.213 Where an area has multiple point sources, removing the contribution of one source may be more difficult and it is recommended that values of Defra mapped background are selected from those grid squares outside the maximum process contribution footprint.

A3.214 Additional methods to remove process contributions from background sites include consideration of wind and pollution roses in order to identify and remove those hours where a significant contribution from a point source has occurred.

Can I produce concentration contours using these methods for adding background to stack contributions?

A3.215 The methods provided in A3.197 to A3.208 may be used to determine the requirements for further detailed dispersion modelling and to determine if the air quality objectives are likely to be exceeded or not. However, these simple methods of combining background do not provide a suitable method to determine the location and extent of exceedences. Therefore, when deciding on the extent of the AQMA, using the methods above will require a much larger AQMA to be declared than may be necessary. Therefore, it is recommended that local authorities proceeding to a declaration based on stack emissions sources alone carry out more detailed modelling incorporating hourly background concentrations to better define the extent of the AQMA.

Fugitive and other sources

A3.216 There may be occasions where other sources of pollution are identified through the checklists provided in the main body of this guidance. These sources may include (but are not limited to):

- intensive poultry farms;
- railways;
- ports;
- waste transfer stations;
- airports;
- domestic solid fuel burning;
- mineral extraction sites;
- construction sites.

A3.217 The checklists and nomograms provided should be used to determine if a more detailed investigation of these sources is needed. Dispersion modelling of these types of sources is likely to include multiple sources, for which emissions estimates will be required. Annex 2 provides information on the sources of data available to assist in emissions estimates for different sources through the NAEI (www.naei.org.uk/emissions/index.php) and Emission Factors Database (EFD).

A3.218 It will be important to obtain the appropriate activity data for these types of sources and the operators and/or regulator of sites should be contacted in order to obtain relevant information.

A3.219 Fugitive emissions generally arise at ground level and are difficult to quantify. Typically these are treated as area or volume sources, where emission rates can be estimated. Operators may be able to assist in the estimation of emissions due to fugitive losses from a site or process through mass balance calculations. In the case of storage tanks emissions, material balance calculations may be more appropriate. Where these emissions are required to be estimated for relevant pollutants, local authorities can contact the Local Authority Air Quality Support Helpdesk for further assistance.

A3.220 The Local Authority Air Quality Support Helpdesk can be contacted for further advice regarding modelling and estimation of these types of sources. However, due to the complex nature of many of these sources, including variability of activity and uncertainty of emissions estimates, monitoring will be play an essential role in the assessment of the air quality concentrations in their vicinity.

A3.221 It is recommended that monitoring is undertaken in order to determine the requirement for more detailed studies, and this monitoring can assist in the verification of any modelling undertaken. Monitoring will also assist authorities in determining the extent of any exceedences of air quality objectives, and in the confirmation of the need for the declaration of any AQMAs. However, modelling alone of these sources alone is likely to be insufficient as the uncertainties around the emissions estimates and source parameters are not well defined.

A3.222 Local authorities may find the Environment Agency Data Analysis Software useful when considering the results of monitoring undertaken around some of these types of sources. The Data Analysis Software is a spreadsheet based toolbox that can be easily used to produce wind roses, pollution roses, time-averaged data and diurnal, weekly and monthly profiles and is available by email at: steven.oliver@environment-agency.gov.uk.

Model validation, verification, adjustment and uncertainty

A3.223 Model validation refers to the general comparison of modelled results against monitoring data carried out by model developers. The models used in review and assessment should have some form of published validation assessment available and/or should be recognised as being fit for purpose by the regulatory authorities.

A3.224 However, in most cases, the validation studies performed by model developers are unlikely to have been undertaken in the area being considered. Therefore, it is necessary to perform a comparison of the modelled results versus monitoring results at relevant locations. The results of this comparison must be included in Review and Assessment reports, and is referred to here are model verification.

A3.225 The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons:

- estimates of background concentrations;
- meteorological data uncertainties;
- uncertainties in source activity data such as traffic flows, stack emissions and emissions factors;
- model input parameters such as roughness length, minimum Monin-Obukhov; and overall model limitations; and
- uncertainties associated with monitoring data, including locations.

A3.226 Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

A3.227 Throughout the review and assessment process it has been recognised that in many cases an adjustment of modelled results is required in order ensure that the final concentrations presented are representative of monitoring information from an area.

A3.228 It is important that local authorities review the results of their modelling carefully and bear in mind that model adjustment is not the first step in improving the performance of a dispersion model. Before adjustment of a model is applied, local authorities should check their model setup parameters and input data in order reduce the uncertainties. Common improvements that can be made to a "base" model include:

- checks on traffic data;
- checks on road widths;
- checks on distance between sources and monitoring as represented in the model;
- consideration of speed estimates on roads in particular at junctions where speed limits are unlikely to be appropriate;
- consideration of source type, such as roads and street canyons;
- checks on estimates of background concentrations; and
- checks on the monitoring data.

A3.229 Once reasonable efforts have been made to reduce the uncertainties of input data for a model, further comparison of modelled and monitored results can be undertaken. Where discrepancies still remain, local authorities may need to consider adjusting the model.

A3.230 The modelled results from industrial sources alone are not expected to be adjusted. It is recognised that appropriate monitoring around stacks may not be available to allow verification of the modelled results. Furthermore, the comparison of a stack model at one monitoring location does not necessarily provide a good indication of the model performance, particularly as the location at which peak concentrations are predicted, will vary from year to year, due to changes in meteorological conditions, and may not be represented by the monitoring data. Where long-term monitoring is available it should be compared against the modelled results and commented upon.

A3.231 The results of dispersion modelling of point sources may not agree with the results of monitoring for a number of reasons including:

- uncertainties in emissions estimates;
- difficulties in determining emissions profiles;
- model parameters related to complex effects such as buildings and terrain; and
- meteorological data.

A3.232 Local authorities comparing modelled and monitored results for a stack can contact the Local Authority Air Quality Support Helpdesk for further advice and assistance.

A3.233 For the purposes of Review and Assessment, model adjustment is generally only required for road traffic modelling, as opposed to stack modelling.

What type of sites should be used for verification?

A3.234 Kerbside sites are not recommended for the adjustment of road traffic modelling results as the inclusion of these sites may lead to an over-adjustment of modelling at roadside sites. However, in exceptional circumstances, where kerbside sites are relevant for exposure, for example properties fronting directly onto the road, then kerbside sites may be used for these types of locations.

A3.235 Dispersion models may perform differently at kerbside, roadside and background sites. For example, models may predict reasonable concentrations towards background sites, but may under-predict at locations closer to the roadside. In most cases, local authorities are concerned with the predictions closer to roadside sites as these are at more risk of exceeding the air quality objectives and model verification is generally based on these locations.

A3.236 Where a model has been used to predict background concentrations (for example based on an emissions inventory), the modelled background concentrations should also be verified and where necessary adjusted.

A3.237 Where local authorities use national background maps within models, these should first be compared against any local monitoring to check they are representative of the area. In most cases there is good agreement with local monitoring, but some locations may not agree. Local authorities are not expected to verify and adjust the national background maps. Where these estimates do not agree with local monitoring, either local monitoring may be used, or local authorities may consider adjusting the background maps. The Local Authority Air Quality Support Helpdesk should be contacted for advice on adjusting national maps.

A3.238 In addition to the consideration of roadside and background sites during model verification, local authorities should also consider separating different types of locations when comparing modelling and monitoring. For example, modelling undertaken for roadside sites in urban areas may require a different adjustment to modelling undertaken for roadside sites near motorways or trunk roads in open settings. In some cases, local authorities may also identify some urban sites such as street canyons, which perform differently to more typical urban locations. Where large differences in an adjustment factor are determined for different types of location, local authorities should consider undertaking separate adjustments within a model area in order to avoid over or under-predicting at the different types of location. For example, adjusting modelling results close to a motorway based on verification and adjustment at street canyon sites could lead to a large over-prediction of results.

What type of monitoring data should be used for verification and adjustment?

A3.239 All monitoring used for verification and/or adjustment of modelling results should be undertaken to the standards described in Annex 1 (Monitoring).

A3.240 For the verification and adjustment of NO_X/NO_2 a combination of continuous monitoring and diffusion tubes is recommended. As described above, some types of sites can perform differently, and it is considered better to have multiple sites at which to verify results rather than just one continuous monitor. The use of one continuous monitor alone to derive the adjustment factor for a model is not recommended as the monitoring site may not be representative of other locations modelled, and the adjustment factor derived will be heavily dependent on the source to receptor relationship as represented by the meteorological data file used in the dispersion model.

A3.241 Where only diffusion tubes are available for model verification annualisation of any short-term datasets should be undertaken as described in Annex 1 (Monitoring). Longer-term diffusion tube monitoring is preferred to short-term studies and it is recommended that local authorities implement more diffusion tube monitoring in locations identified as requiring Detailed Assessments. For example, if a single junction is identified for a Detailed Assessment, based on the checklists provided in the main body of the guidance, or the results of a single diffusion, then more diffusion tubes should be placed at relevant locations around the junction as soon as possible. This will provide the local authority with more information on the spatial variation of concentrations, and will assist when model verification is undertaken.

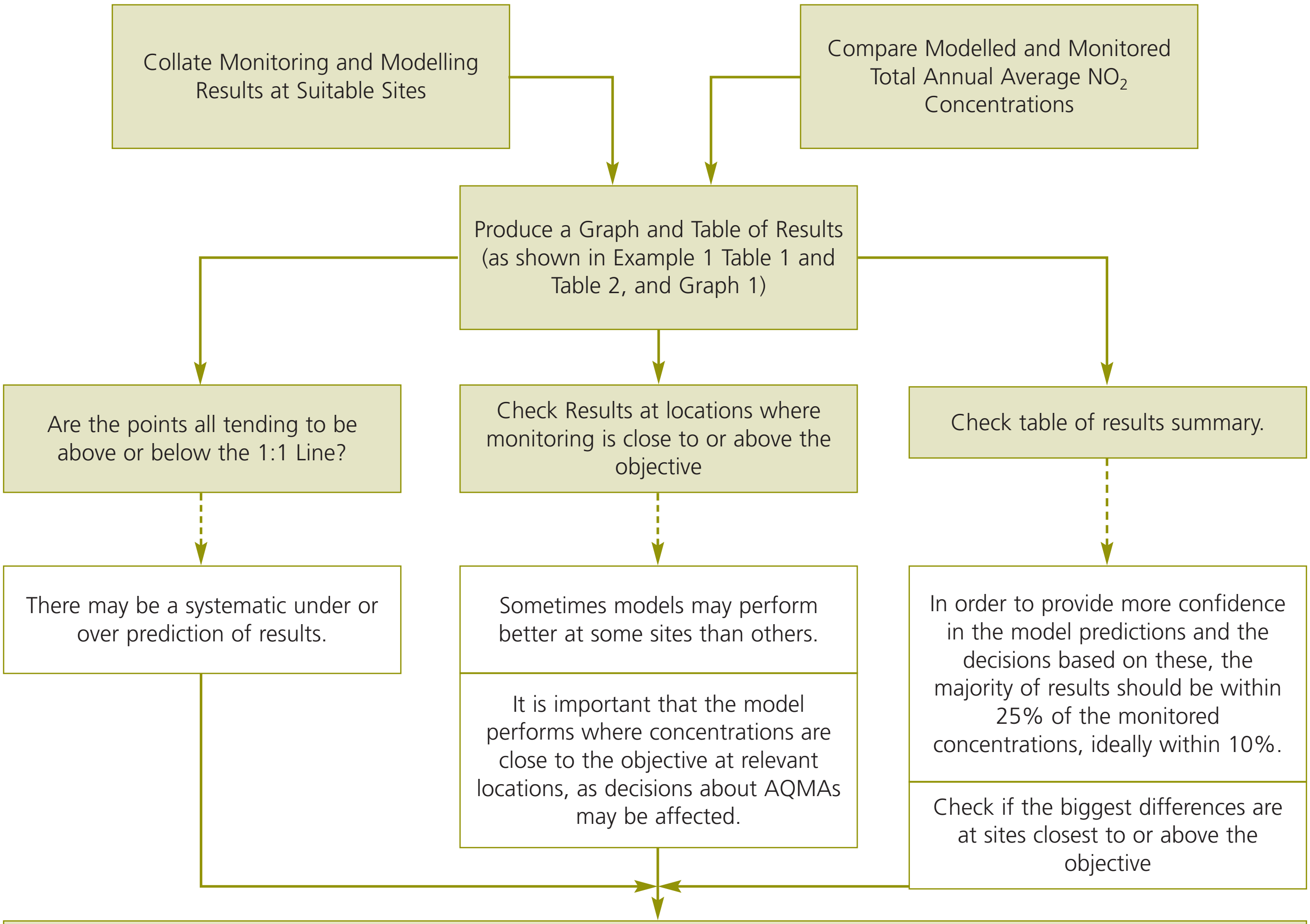
How do I convert nitrogen oxides to nitrogen dioxide?

A3.242 Methods for the conversion of NO_X to NO_2 are described in Chapter 2 of this Guidance. Many dispersion models are able to predict NO_2 based on various options including chemical reaction schemes and empirical functions. Where a local authority uses a model to predict NO_2 directly, Box A3.5 should be used to check that the model performance is suitable.

Box A3.5: Initial Comparison of Modelled and Monitored Total NO_2 Concentrations

These comparisons may be performed when using NO_2 concentrations predicted by dispersion models directly (including background assumptions and chemical conversions).

If a model is used to predict the road contribution of NO_X only or the comparison of modelled and monitored NO_2 indicates that model adjustment is required, then Box A3.6 should be used to verify and adjust the NO_X concentrations before they are used within empirical equations or models.



If your checks confirm that:

- there is no systematic under or over prediction;
- predictions at sites where monitoring shows concentrations are close to the objective show good comparison; and
- the majority of results are within 25% (or 10%) of monitored concentrations.

then you do not necessarily need to adjust your modelling results. However, you may consider model adjustment as this can lead to further improvements in the results obtained, for example where all results move to within 10% of monitored concentrations.

Otherwise you will need to consider altering the model inputs and rerunning in order to improve the results of the comparison and verification. You should ensure that checks on model input parameters include aspects such as background assumptions, receptor locations, source setup (street canyons, widths), and traffic data assumptions (for example speeds). It is also important to check that the units of measurements are consistent (you are not comparing ppb with µg) and that monitoring data are also checked again to ensure locations, averaging and annualisation are correct.

Box A3.6 provides some guidance to assist local authorities in adjusting the road traffic contribution.Check if the biggest differences are at sites closest to or above the objective.

How do I verify and adjust my modelling?

A3.243 The process of verifying and possible adjusting models can be a difficult process. Boxes A3.5 and A3.6 set out some of the common steps to be taken in order to assist local authorities in understanding if their modelling is appropriate (ie representative), and to help identify when adjustment of models may be required. This information is provided for NO_X/NO_2 of road traffic sources, but the same methods can be applied to PM_{10} modelling. However, local authorities generally have much more limited PM_{10} monitoring sites, and may only have one site. Therefore, care needs to be taken when applying model adjustment based on one monitoring site only as the adjustment may not be representative of other locations.

A3.244 In the absence of any PM_{10} data for verification, it may be appropriate to apply the road-NO_X adjustment to the modelled road-PM_{10}. If this identifies exceedences of the objective, then it would be appropriate to monitor PM_{10} to confirm the findings.

A3.245 When only road traffic sources have been modelled, the predicted concentration from the model, without any background, should be referred to as the "road source contribution". The road source contribution can be estimated for both monitored and modelled data by subtracting the background concentration from the total concentration. This may be for NO_X, NO_2 and PM_{10}.

A3.246 As described above, there are a number of reasons why modelling and monitoring results differ. When modelling road traffic sources, errors are likely to apply to both the road source contribution and background contributions, however, it is common to apply the adjustment to the road source contribution. A number of examples of model verification of NO_X/NO_2 and adjustment based on the NO_X road contribution are also presented below in examples 1 to 3, whilst example 4 shows where background modelling has also been adjusted. The examples are:

- Example 1 No model adjustment is necessary
- Example 2 Diffusion tubes are used to adjust the NO_X road contribution
- Example 3 Continuous monitoring data are used, and different adjustments
- Example 4 Adjustment of both background and road contribution NO_X.

A3.247 When model adjustment is undertaken this should be based on NO_X and not NO_2. Where diffusion tubes are used in the calculation of the model adjustment, NO_X will need to be derived from NO_2. A tool for this purpose is provided at www.airquality.co.uk/archive/laqm/tools.php.

A3.248 Local authorities are reminded that adjustment of modelling should not be based on the total NO_X (or NO_2) concentrations unless the adjustment is very small (for example within 5%). This is because any adjustment of the total concentration would also be applied to the background contribution. In many cases background is based on national maps or local monitoring, adjustment of this component could results in unrepresentative estimates of the background concentrations across the area. Such adjustment could result in unrealistic estimates of different source contributions and may affect the outcome of source apportionment studies undertaken as part of further assessments and action plans.

A3.249 It is important to remember that a number of assumptions are made when undertaking model adjustment and it should be recognised that any adjustment carried out is a reflection of the specific scenario modelling and the availability and quality of input data and monitoring data.

A3.250 Local authorities are encouraged to contact the Local Authority Air Quality Support Helpdesk for advice and assistance during the verification process.

Box A3.6: Comparison of road nitrogen oxides contributions followed by adjustment

The recommended method for converting NO_X to NO_2 and vice versa is described in Chapter 2. The modelled NO_X must be verified (which may include adjustment) before they are used within empirical equations or models.

The adjustment of NO_X is often carried out on the component derived from local Road Traffic emissions – the Road Contribution.

If continuous monitoring is included within the model verification, then it is recommended that you check that the method used for converting NO_X to NO_2 applies at the monitoring site. Where the monitored NO_2 differs significantly from that derived using the conversion method, users may find additional adjustment is required as part of the model verification in order to correct for these differences.

Produce a table of information on monitored and modelled data including:

background NO_X and NO_2 used in the model, the modelled road contribution to NO_X (from road sources), and the monitored road contribution NO_X, and NO_2

Table 3 of Example 2 can be used as a template.

→ The road contribution to NO_X (or NO_2) is derived by subtracting the background NO_X (or NO_2) from total NO_X or NO_2.

Where monitoring is based on diffusion tubes only, the NO_X can be derived using the tools described in Chapter 2 of the guidance.

↓

At each comparison site, calculate the ratio of Monitored Road Contribution to Modelled Road Contribution NO_X.

Table 4 of Example 2 can be used as a template.

→ This information may help identify sites which may be performing differently than others. These sites can then be investigated and inputs to the model may be varied to improve the performance of these sites. Alternatively, these ratios can be used to separate locations which may be street canyons, from more open or typical urban sites, eg, the ratio is often much higher at sites which could be considered street canyons (as they have limited dispersion) and separate adjustments may be required.

↓

Prepare a graph of modelled versus monitored road contribution NO_X. Include a trend line. Derive the equation of the trend line.

Graph 2 of Example 2 shows the trendline and equation, whilst Graph 3 provides the adjusted road contribution NO_X.

→ The equation of the trend line should be in the format of

$y = mx$ (intercept at 0)

y is monitored road contribution NO_X and

x is modelled road contribution NO_X.

m is the regression correction factor to apply to the modelled road contribution NO_X

Apply the adjustment factor for road contribution NO_X at all sites (Graph 3) and derive Total NO_2 Concentrations based on the method described in Chapter 2.

→ It can be useful to reproduce a graph of adjusted road contribution NO_X versus monitored road contribution.

The graph can help easily identify any sites which appear to perform less well than others.

Apply the adjustment factor for road contribution NO_X at all sites (Graph 3) and derive Total NO_2 Concentrations based on the method described in Chapter 2.

→ Perform the same checks described in Box A3.5 (check position of points to 1:1 line, check results close to the objective, check table of results summary..

Example 1: Adjustment of the model is not necessary

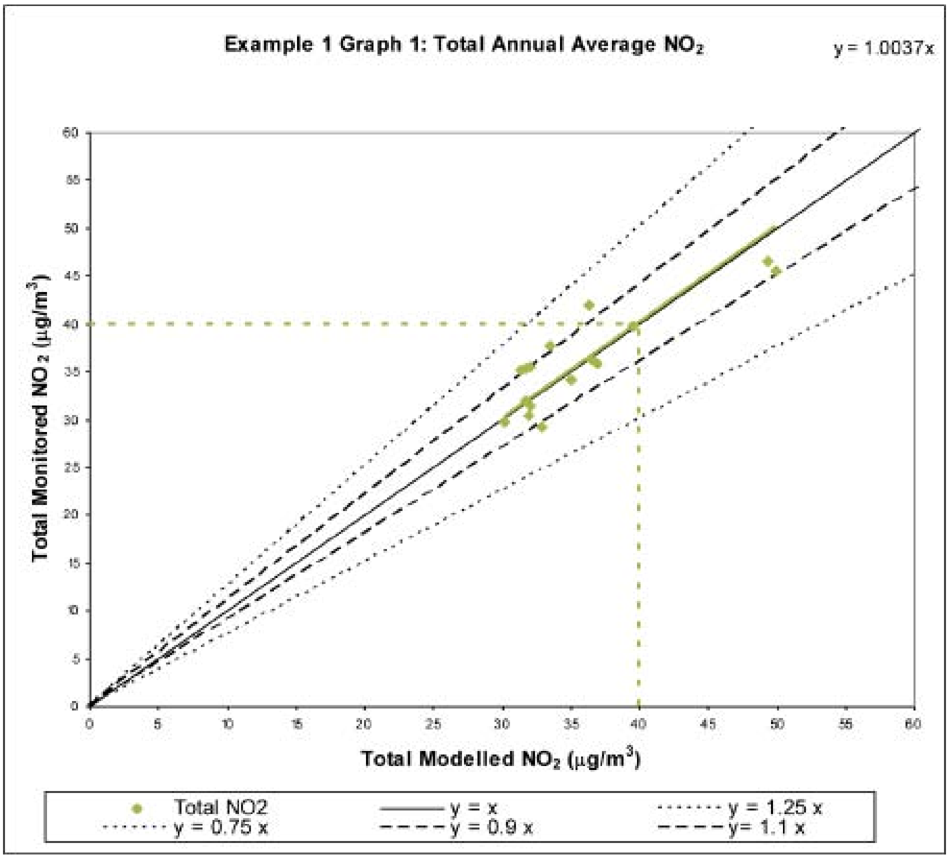
Example 1 Table 1: Comparison of modelled and monitored nitrogen dioxide concentrations

Site ID	Monitor type*	Site type+	Site description	Background NO_2	Monitored total NO_2	Modelled total NO_2%	Difference [(modelled - monitored)/ monitored] x100
1	CM	R	Built up urban	26.2	46.5	49.4	6.2
2	DT	R	Built up urban	26.2	42.0	36.3	-13.5
3	DT	R	Built up urban	26.2	37.7	33.4	-11.3
4	DT	R	Built up urban	26.2	45.6	49.9	9.5
5	DT	R	Built up urban	26.2	39.7	39.5	-0.4
6	DT	R	Built up urban	26.2	34.2	35.0	2.4
7	DT	R	Built up urban	26.2	36.3	36.4	0.3
8	DT	R	Built up urban	26.2	35.8	36.9	3.1
9	DT	R	Built up urban	26.2	29.8	30.1	1.2
11	DT	R	Built up urban	26.2	35.1	31.4	-10.5
12	DT	R	Built up urban	26.2	29.2	32.9	12.6
13	DT	R	Built up urban	26.2	32.0	31.7	-0.8
14	DT	R	Built up urban	26.2	30.5	31.9	4.7
15	DT	R	Built up urban	26.2	31.4	32.1	2.1
16	DT	R	Built up urban	26.2	35.4	31.8	-10.3
17	DT	R	Built up urban	26.2	35.5	32.0	-9.7

* CM = Continuous Monitor, DT = Diffusion Tube, + R = Roadside

Example 1 Table 2: Summary table nitrogen dioxide

Within +10%	3
Within -10%	8
Within +-10%	**11**
Within +10 to 25%	1
Within -10 to 25%	4
Within +-10 to 25%	**5**
Over +25%	0
Under -25%	0
Greater +-25%	**0**
Within +-25%	**16**



In this example, the dispersion model has been used to predict NO_2 concentrations directly. A comparison of modelling and monitoring at all available monitoring sites, including continuous monitor and diffusion tubes, suggests that the model is performing well at all locations. The difference between modelled and monitored are all within 25% of each other (in this case all are within 15%).

Importantly, the model is showing no overall tendency to over or under-predict at sites close to or above the objective – sites 2 and 3 are under-predicting, while sites 1 and 4 are over predicting.

Graph 1 shows the modelled total NO_2 versus Monitored Total NO_2 concentrations, and a linear regression line (through zero) has been derived. The equation of this line is 1.0037 and could be used to further adjust the Modelled Total NO_2 concentrations. However, in this case the adjustment is so minor that it is not required.

Example 2: Diffusion tubes are used to adjust the nitrogen oxides road contribution

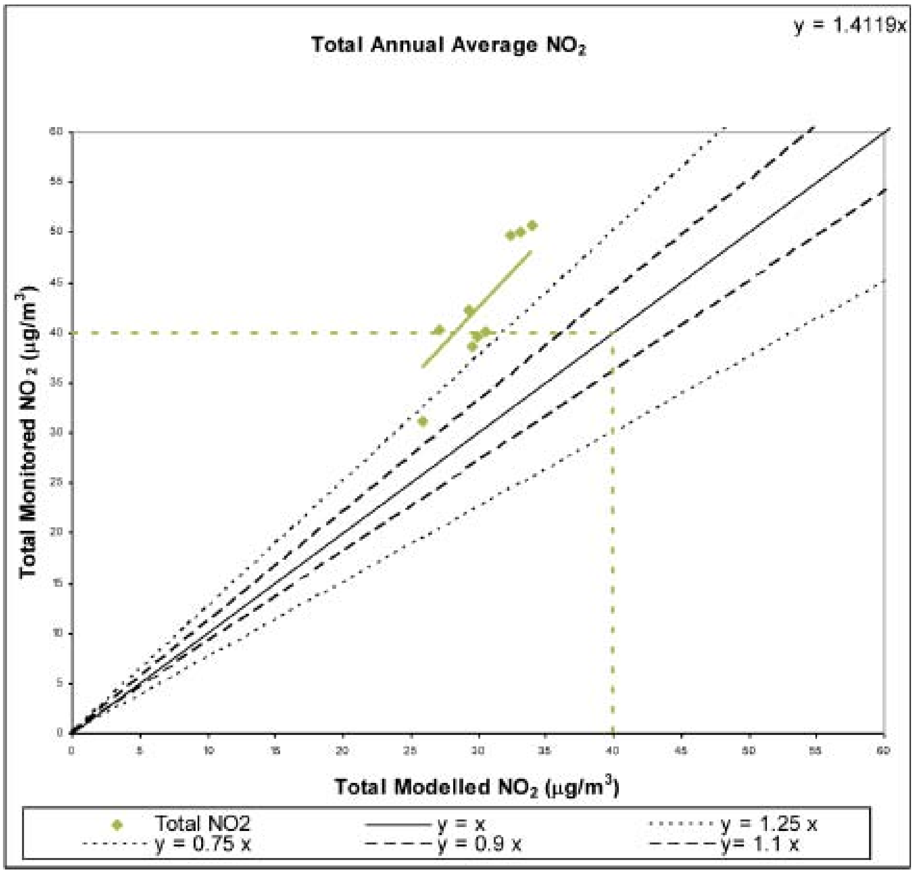
Example 2 Table 1: Comparison of modelled and monitored nitrogen dioxide concentrations

Site ID	Monitor type*	Site type+	Site description	Background NO_2	Monitored total NO_2	Modelled total NO_2	% Difference [(modelled - monitored)/ monitored] x100
1	DT	R	Urban A road	18.3	50.7	34.0	-33
2	DT	R	Urban A road	18.3	40.2	27.1	-33
3	DT	R	Urban A road	18.3	50.0	33.1	-34
4	DT	R	Urban A road	18.3	31.2	25.9	-17
5	DT	R	Urban A road	18.3	40.1	30.5	-24
6	DT	R	Urban A road	18.3	42.3	29.3	-31
7	DT	R	Urban A road	18.3	49.7	32.4	-35
8	DT	R	Urban A road	18.3	38.6	29.6	-23
9	DT	R	Urban A road	18.3	39.6	29.9	-24

* CM = Continuous Monitor, DT = Diffusion Tube, + R = Roadside

Example 2 Table 2: Summary table nitrogen dioxide

Within +10%	0
Within -10%	0
Within +-10%	**0**
Within +10 to 25%	0
Within -10 to 25%	3
Within +-10 to 25%	**3**
Over +25%	0
Under -25%	5
Greater +-25%	**5**
Within +-25%	**3**



In this example, results based on the modelled NO_2 taken from the dispersion model are clearly under-predicting at all sites. At the majority of sites the difference between modelled and monitoring concentrations is greater than 25%. The local authority would be unable to base any decisions related to LAQM on these results and needs to investigate the modelled results further as described in Box A3.5. No further improvement of the modelled results could be obtained on this occasion and the local authority must adjust the model.

Local monitoring data suggest that the background assumptions used are suitable, and the adjustment of the model is based on the road source contribution of NO_X as described in Box A3.6.

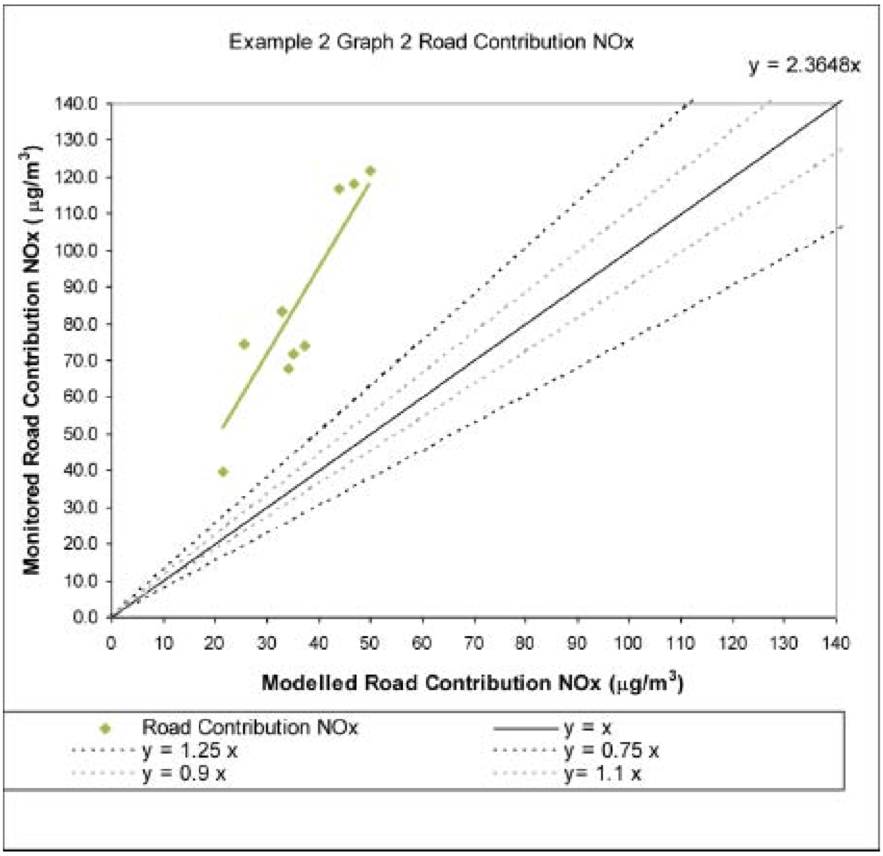
Example 2 Table 3 provides the relevant data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution to NO_X. Example 2 Graph 2 provides a comparison of the Modelled Road Contribution NO_X versus Monitored Road Contribution NO_X, and the equation of the trendline based on linear regression through 0. As this example uses diffusion tubes only, the Total Monitored NO_X concentration has been derived by back calculating NO_X from the NO_X/NO_2 relationship.

Example 2 Table 3

Site ID	Monitored total NO_2	Monitored total NO_X	Background NO_2	Background NO_X	Monitored road contribution NO_2 (total – background)	Monitored road contribution NO_X (total – background)	Modelled road contribution NO_X (excludes background)
1	50.7	146.2	18.3	24.6	32.4	121.6	50.0
2	40.2	98.9	18.3	24.6	21.9	74.3	25.6
3	50.0	142.8	18.3	24.6	31.7	118.2	46.7
4	31.2	64.2	18.3	24.6	12.9	39.6	21.6
5	40.1	98.5	18.3	24.6	21.8	73.9	37.2
6	42.3	107.8	18.3	24.6	24.0	83.2	33.0
7	49.7	141.4	18.3	24.6	31.4	116.8	44.1
8	38.6	92.4	18.3	24.6	20.3	67.8	34.1
9	39.6	96.4	18.3	24.6	21.3	71.8	35.2

Example 2 Table 4

Site ID	Ratio of monitored road Contribution NO_X/modelled road contribution NO_X	Adjustment factor for modelled road contribution	Adjusted modelled road contribution NO_X	Adjusted modelled total NO_X (incl. background NO_X)	Modelled total NO_2 (based on empirical NO_X /NO_2 relationship)	Monitored total NO_2	% Difference [(modelled - monitored)/ monitored] x100
1	2.43	See Example 2 Graph 2	118.2	142.8	50.0	50.7	-1
2	2.90		60.6	85.2	36.8	40.2	-8
3	2.53		110.4	135.0	48.3	50.0	-3
4	1.83		51.1	75.7	34.3	31.2	10
5	1.99		87.9	112.5	43.4	40.1	8
6	2.52		78.0	102.6	41.1	42.3	-3
7	2.65		104.2	128.8	47.0	49.7	-5
8	1.99		80.7	105.3	41.7	38.6	8
9	2.04		83.2	107.8	42.3	39.6	7
		2.365					



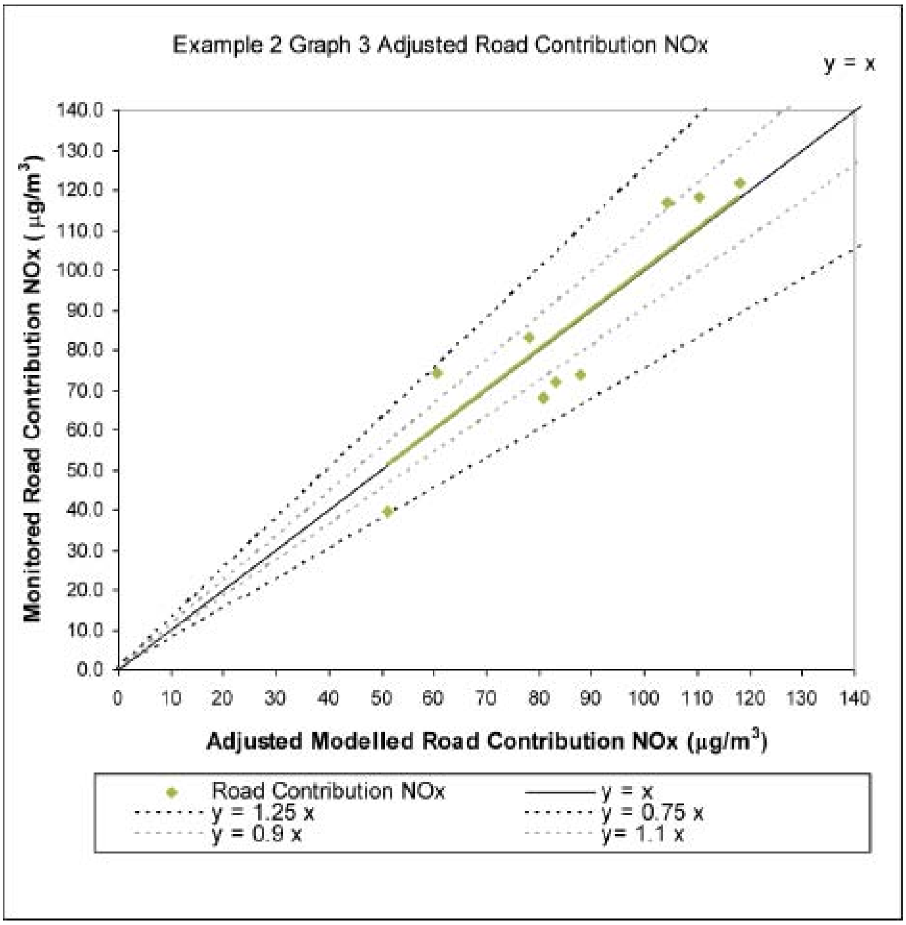
The Ratio of Monitored and Modelled Road Contribution NO_X at each location is also provided in Table 4. The ratios at all sites are similar indicating that the model is performing similarly at all of these sites, but there is some variability of the ratio.

Site location information indicates that all of the sites are in an urban area with an A road. In this case, using these individual ratios does not suggest that any sites need to be separated and adjusted based on different factors.

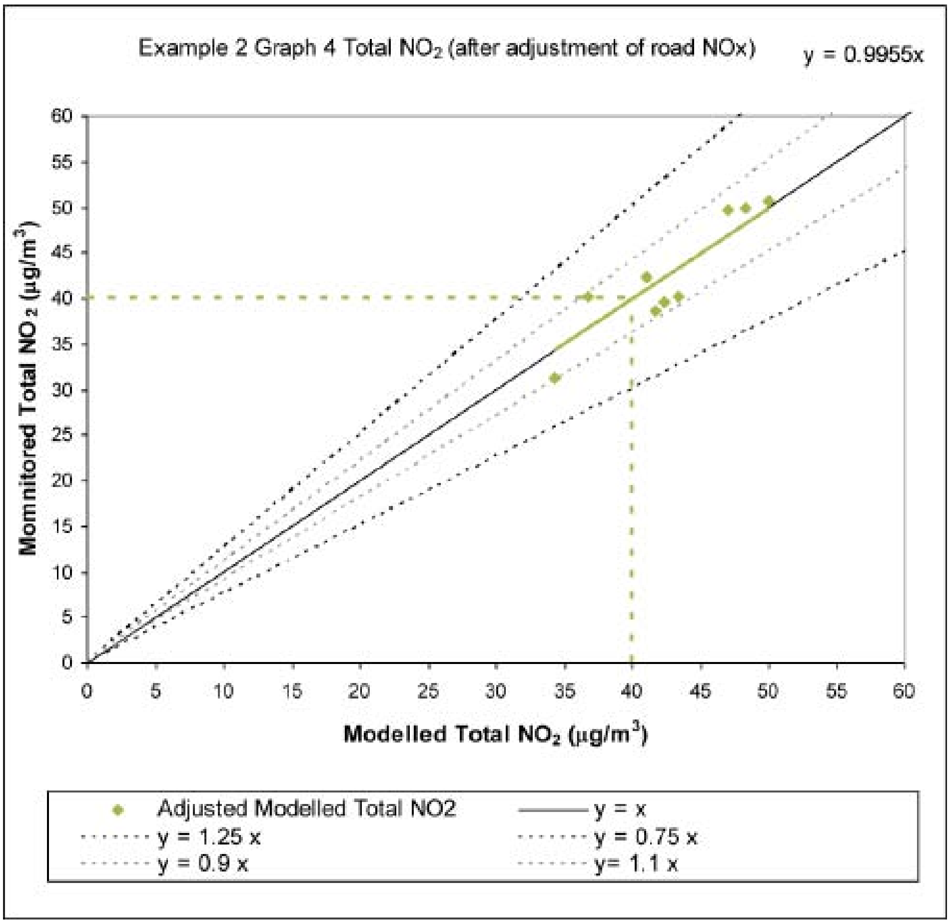
The equation of the trend line from Graph 2 is used to adjusted the Modelled Road Contribution NO_X at all sites and results compared in Graph 3.

The next step is to add background NO_X to the Adjusted Modelled Road Contribution NO_X and then convert to NO_2.

A comparison of Adjusted Modelled Total NO_2 versus Monitored Total NO_2 is repeated as shown in Graph 4 and Table 5.



Example 2: Summary table 5	
Within +10%	3
Within -10%	5
Within +-10%	**8**
Within +10 to 25%	1
Within -10 to 25%	0
Within +-10 to 25%	**1**
Over +25%	0
Under -25%	0
Greater +-25%	**0**
Within +-25%	**9**



A comparison of Adjusted Modelled Total NO_2 and Monitored Total NO_2 suggests that the adjusted model is performing well at all locations. The difference between modelled and monitored are all within 25% of each other (in this case all but one site is within 10%).

It must be remember that in this case the NO_X / NO_2 relationship has been used when determining the Adjustment factor for the model and therefore a good comparison of modelled and monitored results would normally be expected. As described in Table 4 the ratio of Monitored Road Contribution NO_X and Modelled Road Contribution NO_X is similar at all verification sites, where these individual ratios vary considerably, then the overall performance of the final comparison would show greater differences.

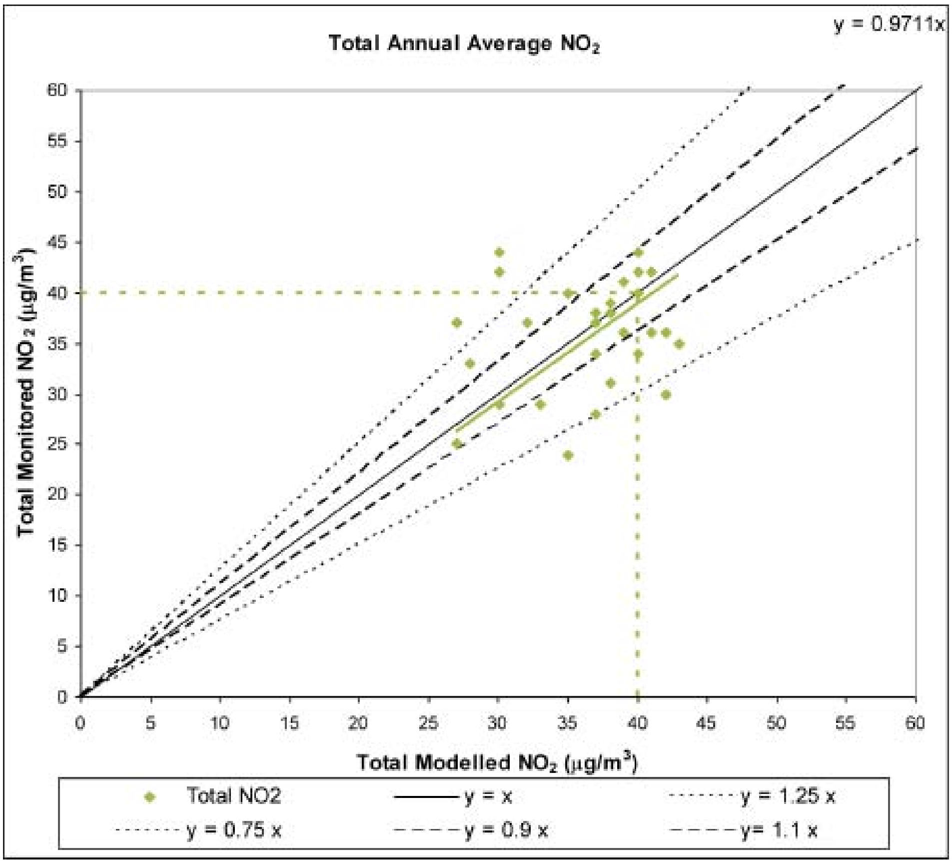
Importantly, the adjusted model is showing no overall tendency to over or under-predict at sites close to or above the objective. Graph 4 shows the modelled total NO_2 versus Monitored Total NO_2 concentrations, and a linear regression line (through zero) has been derived. The equation of this line is close to 1 but this is expected as NO_X / NO_2 relationship has formed part of the verification and adjustment calculations in this case.

Example 3: Continuous monitoring data are used, and different adjustments

Example 3 Table 1: Comparison of modelled and monitored nitrogen dioxide concentrations

Site ID	Monitor type*	Site type+	Site description	Background NO_2	Monitored total NO_2	Modelled total NO_2	% Difference [(modelled - monitored)/ monitored] x100
1	CM	R	built up urban	22	44.0	30.0	-31.8
2	CM	R	urban	22	29.0	30.0	3.4
3	CM	R	urban	22	41.0	39.0	-4.9
4	CM	R	urban	22	31.0	38.0	22.6
5	CM	R	urban	22	42.0	41.0	-2.4
6	CM	R	urban	22	38.0	37.0	-2.6
7	CM	R	built up urban	22	42.0	30.0	-28.6
8	DT	R	urban	22	38.0	38.0	0.0
9	DT	R	urban	22	40.0	35.0	-12.5
10	CM	R	urban	22	25.0	27.0	8.0
11	DT	R	urban	22	37.0	32.0	-13.5
12	DT	R	urban	22	42.0	40.0	-4.8
13	DT	R	urban	22	34.0	37.0	8.8
14	DT	R	urban	22	36.0	42.0	16.7
15	DT	R	urban	22	37.0	37.0	0.0
16	DT	R	urban	22	36.0	39.0	8.3
17	DT	R	urban	22	29.0	33.0	13.8
18	DT	R	urban	22	24.0	35.0	45.8
19	DT	R	urban	22	28.0	37.0	32.1
20	DT	R	urban	22	35.0	43.0	22.9
21	DT	R	urban	22	44.0	40.0	-9.1
22	DT	R	urban	22	36.0	41.0	13.9
23	DT	R	urban	22	34.0	40.0	17.6
24	DT	R	built up urban	22	37.0	27.0	-27.0
25	DT	R	urban	22	39.0	38.0	-2.6
26	DT	R	urban	22	30.0	42.0	40.0
27	DT	R	urban	22	40.0	40.0	0.0
28	DT	R	urban	22	34.0	37.0	8.8
29	DT	R	urban	22	33.0	28.0	-15.2

* CM = Continuous Monitor, DT = Diffusion Tube, + R = Roadside



Example 3 Table 2 Summary table nitrogen dioxide	
Within +10%	8
Within -10%	6
Within +-10%	**14**
Within +10 to 25%	6
Within -10 to 25%	3
Within +-10 to 25%	**9**
Over +25%	3
Under -25%	3
Greater +-25%	**6**
Within +-25%	**23**

In Example 3, results based on the modelled NO_2 taken from the dispersion model vary across the modelled area. Whilst many of results are within 25% of the monitored concentrations, there are a number of sites with differences greater than 25%. The local authority is concerned that some areas where monitoring is exceeding are being under predicted based on this model setup, for example Sites 1 and 7, but also notes that performance is good at other locations.

Upon reviewing locations of monitoring, the local authority has determined that three of the sites may be in street canyons which is resulting in poor dispersion and elevated concentrations. These locations (shown in Table 1) also appear to be underpredicting the most, and monitoring in these locations are also all above or approaching the air quality objective.

The local authority needs to calculate the model adjustment, but needs to bear in mind that different adjustments may be required if the modelling continues using the current model setup. As there are eight continuous monitors within the urban area, the local authority will first calculate its adjustment based on these data, and then compare the adjusted model results with the diffusion tube monitoring for the area.

Tables 3 and 4 provide the necessary information at each of the continuous monitoring sites.

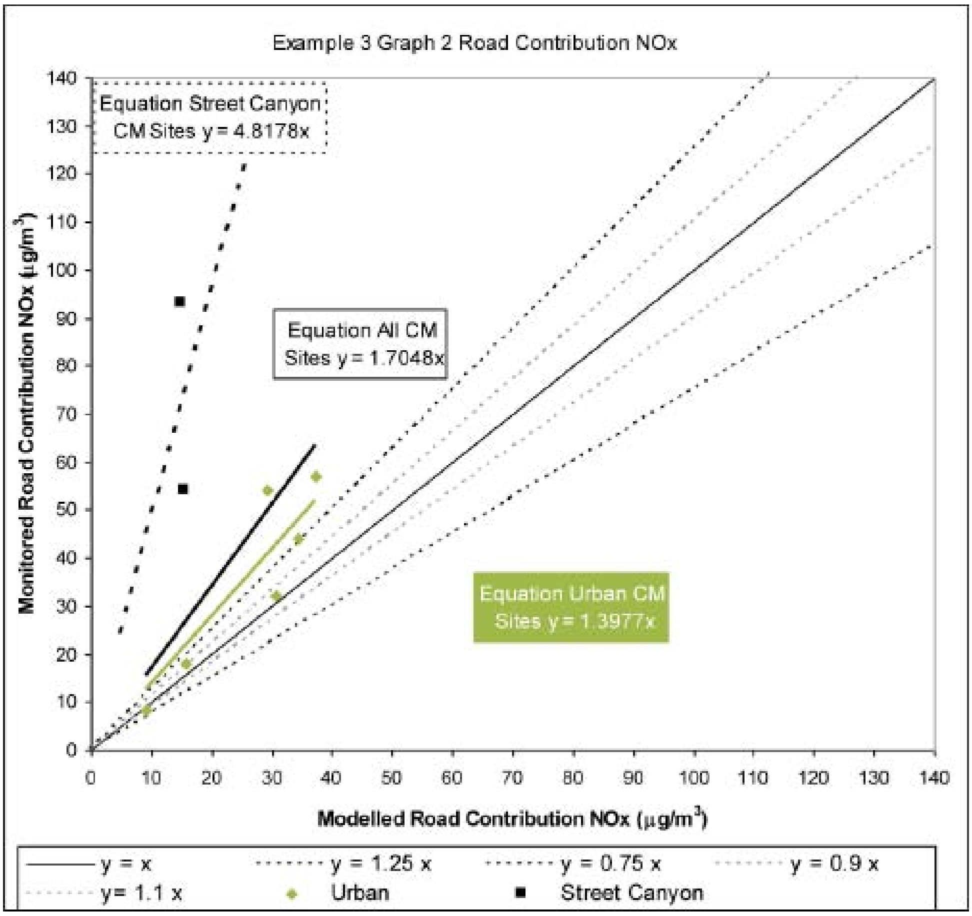
Adjustment factors for Road Contribution NO_X were calculated separately for the general urban locations and the sites which are thought to be within street canyons –as shown within Graph 2. It can also be seen in Table 4 that the adjustment factors at the sites thought to be street canyons (sites 1 and 7) are significantly higher than the other sites.

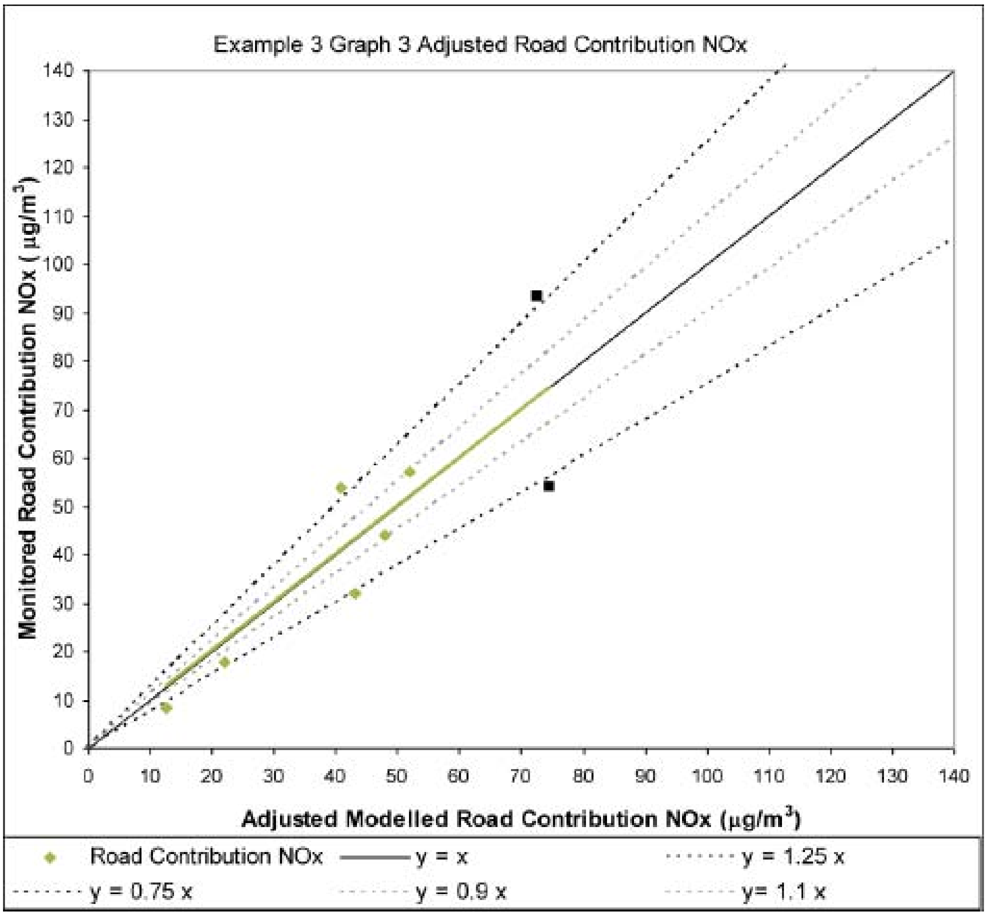
Whilst regression is used to determine the adjustment factors for the urban sites, a simple average has been used for the street canyons as there are only two points.

The resulting Adjusted Road NO_X at the continuous monitoring sites is provided in Graph 3, and the Adjusted Total NO_2 concentration at ALL monitoring sites is provided in Graph 4 and Summary Table 5.

Example 3 Table 3							
Site ID	Monitored total NO_2	Monitored total NO_X	Background NO_2	Background NO_X	Monitored road contribution NO_2 (total – background)	Monitored road contribution NO_X (total – background)	Modelled road contribution NO_X (excludes background)
1	44.0	124.0	22	31	22.0	93.0	15.0
2	29.0	49.0	22	31	7.0	18.0	15.7
3	41.0	75.0	22	31	19.0	44.0	34.3
4	31.0	63.0	22	31	9.0	32.0	30.7
5	42.0	88.0	22	31	20.0	57.0	37.2
6	38.0	85.0	22	31	16.0	54.0	29.2
7	42.0	85.0	22	31	20.0	54.0	15.4
8	25.0	39.3	22	31	3.0	8.3	9.1

Example 3 Table 4							
Site ID	Ratio of monitored road contribution NO_X/modelled road contribution NO_X	Adjustment factor for modelled road contribution	Adjusted modelled road contribution NO_X	Adjusted modelled total NO_X (incl. background NO_X)	Modelled total NO_2 (based on empirical NO_X /NO_2 relationship)	Monitored total NO_2	% Difference [(modelled - monitored)/ monitored] x100
1	6.20	Two Adjustments Derived: urban and street canyon	72.8	103.8	43.1	44.0	-2.1
2	1.15		21.9	52.9	29.4	29.0	1.5
3	1.28		48.0	79.0	36.9	41.0	-10.0
4	1.04		42.9	73.9	35.5	31.0	14.6
5	1.53		52.0	83.0	38.0	42.0	-9.6
6	1.85		40.8	71.8	35.0	38.0	-8.0
7	3.51		74.7	105.7	43.5	42.0	3.6
8	0.92		12.7	43.7	36.0	25.0	43.8
All Sites		**1.705**	This adjustment is for all sites but has not been used.				
Urban Sites		**1.398**					
Street Canyons		**4.85**	This adjustment is not based on regression but the average of the two ratios				


Example 3 Graph 2 Road Contribution NOx
Equation Street Canyon CM Sites y = 4.8178x
Equation All CM Sites y = 1.7048x
Equation Urban CM Sites y = 1.3977x
Monitored Road Contribution NOx (µg/m³)
Modelled Road Contribution NOx (µg/m³)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
y = x
y = 1.25 x
y = 0.75 x
y = 0.9 x
y= 1.1 x
Urban
Street Canyon


Example 3 Graph 3 Adjusted Road Contribution NOx
Monitored Road Contribution NOx (µg/m³)
Adjusted Modelled Road Contribution NOx (µg/m³)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Road Contribution NOx
y = x
y = 1.25 x
y = 0.75 x
y = 0.9 x
y= 1.1 x

Care needs to be taken when determining different adjustment factors for a model. It is important that information about the site location, the monitoring data, and the set up of the source within the model is reviewed as part of the verification. In some cases, a very high adjustment factor may be determined for a particular site but upon reviewing information about the site a local authority may conclude that there is nothing that reasonably explains the difference. These types of sites should not just be excluded from model verification and adjustment as they reflect part of the model performance and uncertainty.

Where very high adjustment factors are calculated at sites it is worth checking for errors in the model and ensuring the correct traffic data have been provided. Simple errors such as road links being in the wrong place, or not reflecting the distance to the receptor correctly, can lead to very high adjustment factors.

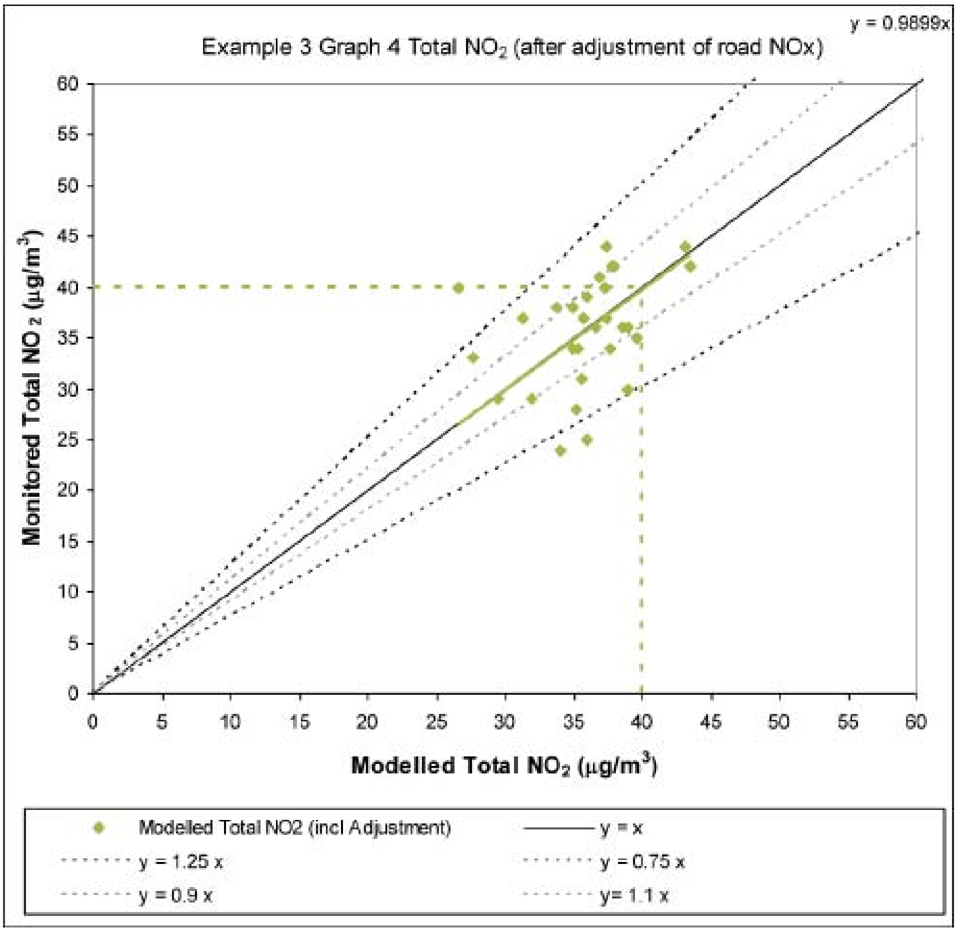
However, local authorities are reminded that providing unreasonable data inputs in order to reduce model adjustment factors is not an acceptable approach. For example, assuming the average speed of a road of 5kph at all times is not a suitable method of reducing the adjustment factor of a model as the inputs and emissions estimates are unreasonable, and using this type of method could cause difficulties in future work, including source apportionment.

Example 3 Table 5 Comparison of modelled and monitored NO_2 concentrations

Site ID	Monitor type*	Site description	Monitored total NO_2	Adjusted modelled total NO_2	Adjusted % difference [(modelled - monitored)/ monitored] x100	Original % difference [(modelled - monitored)/ monitored] x100
1	CM	built up urban	44.0	43.1	-2.1	-31.8
2	CM	urban	29.0	29.4	1.5	3.4
3	CM	urban	41.0	36.9	-10.0	-4.9
4	CM	urban	31.0	35.5	14.6	22.6
5	CM	urban	42.0	38.0	-9.6	-2.4
6	CM	urban	38.0	35.0	-8.0	-2.6
7	CM	built up urban	42.0	43.5	3.6	-28.6
8	DT	urban	25.0	36.0	43.8	0.0
9	DT	urban	38.0	33.7	-11.3	-12.5
10	CM	urban	40.0	26.6	-33.5	8.0
11	DT	urban	37.0	31.3	-15.5	-13.5
12	DT	urban	42.0	37.8	-10.1	-4.8
13	DT	urban	34.0	35.4	4.0	8.8
14	DT	urban	36.0	39.0	8.3	16.7
15	DT	urban	37.0	35.7	-3.6	0.0
16	DT	urban	36.0	36.6	1.6	8.3
17	DT	urban	29.0	32.0	10.3	13.8
18	DT	urban	24.0	34.0	41.7	45.8
19	DT	urban	28.0	35.2	25.7	32.1
20	DT	urban	35.0	39.7	13.3	22.9
21	DT	urban	44.0	37.5	-14.9	-9.1
22	DT	urban	36.0	38.6	7.2	13.9
23	DT	urban	34.0	37.6	10.6	17.6
24	DT	built up urban	37.0	37.3	0.9	-27.0
25	DT	urban	39.0	36.0	-7.7	-2.6
26	DT	urban	30.0	38.9	29.7	40.0
27	DT	urban	40.0	37.2	-6.9	0.0
28	DT	urban	34.0	34.9	2.7	8.8
29	DT	urban	33.0	27.6	-16.2	-15.2

Example 3 Table 6 Summary table	
Within +10%	8
Within -10%	6
Within +-10%	**14**
Within +10 to 25%	4
Within -10 to 25%	5
Within +-10 to 25%	**9**
Over +25%	4
Under -25%	1
Greater +-25%	**5**
Within +-25%	**23**

The adjusted results show better comparison at the majority of sites, and the model is performing better at higher concentrations. The local authority will need to identify other locations within the model that could be street canyons and apply the higher adjustment at these locations. It is recommended that diffusion tube monitoring is undertaken in those locations identified.



Example 4: Adjustment of both background and road contribution nitrogen oxides

In this example, a dispersion model has been used in conjunction with a emissions inventory for a large number of sources within an urban area to model concentrations of NO_X across the urban area. Background concentrations are therefore being modelled based on the emissions inventory data. It is therefore necessary to verify that the predicted background contributions are suitable, and also to assess if any adjustment of the modelled road contribution is required.

All sites used for the model verification and adjustment are continuous monitors. The background site is not influenced by roads and it has been determined that any road contribution at the site would be negligible.

Example 4 Table 1

Site ID	Monitored background NO_2	Monitored background NO_X	Modelled background NO_X	Modelled road contribution NO_X (excludes background)	Monitored total background NO_X – modelled background NO_X
1	30.0	50.7	19	0	31

A constant error in the background model has been estimated at 31 µg/m^3 and this will be applied at all locations. Where other background sites available across the model area, it may be possible to undertake a comparison and derive an equation for the adjustment of modelled background.

A comparison of modelled and monitored road contribution NO_X is also undertaken (as in examples 1 – 3) in order to determine if adjustment of this part of the model is required. In this example it is important to note that the background used is an adjusted modelled background that varies at each receptor location across the model area. Table 2 shows the comparison of the road contribution NO_X, and the regression is displayed in Graph 1.

Example 4 Table 2

Site ID	Monitored total NO_2	Monitored total NO_X	Modelled background NO_X	Adjusted modelled background NO_X	Monitored road contribution NO_X (total – background)	Modelled road contribution NO_X	Ratio of monitored/ road NO_X/ modelled road NO_X
1	78.6	288.0	41.6	72.6	215.4	129.4	1.66
2	51.4	122.6	35.1	66.1	56.5	32.3	1.75
3	44.5	125.2	43.6	74.6	50.6	45.0	1.12
4	41.6	93.3	29.0	60.0	33.4	4.0	8.34

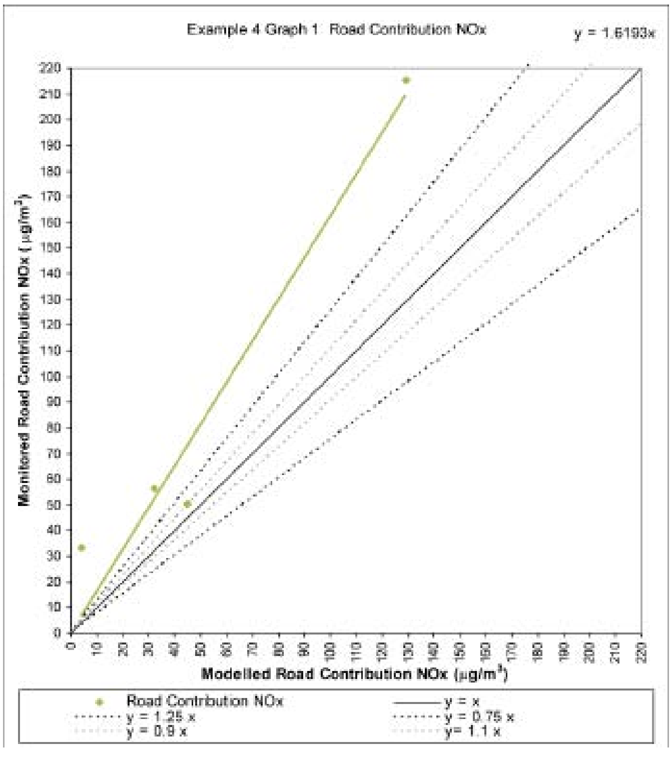
Whilst regression is used for the calculation of the adjustment of the road contribution it is important to note the following: The ratio of monitored road NO_X to modelled road NO_X at site 4 is significantly different than those at for sites 1 – 3. In this case the local authority needs to be careful to understand the locations of the different sites as site 4 appears to be a background site within the model when the modelled road contribution NO_X is considered (4 μg/m^3 NO_X versus 30 – 130 μg/m^3 at other sites). The local authority should check that there is no error in the model set up in the first instance before proceeding with model verification.

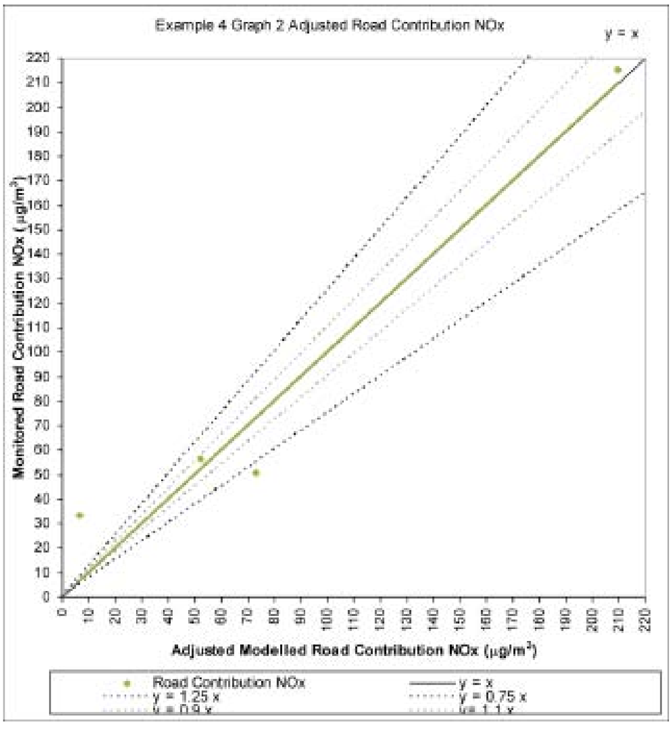
When considering Graph 1, the regression may be affected by Site 1 which represents a significantly greater contribution of road NO_X than other sites within the verification study. Whilst the ratio of monitored road NO_X and modelled road NO_X are similar at sites 1-3, when site 1 is excluded from the verification the adjustment factor for the modelled road contribution NO_X changes from 1.619 to 1.373. However, as mentioned above, the ratio at site 4 is significantly different, but exclusion of this site from the regression does not lead to a significant change in the adjustment factor (1.614 excluding site 4 versus 1.619 for all sites).

The local authority would be advised to determine if more monitoring locations are available to provide information between the upper and lower range of modelled concentrations as this would assist in understanding the spread of results, and would provide a comparison at a greater number of sites within the model area.

As all of the monitoring locations are continuous monitoring, the local authority may consider it beneficial to include diffusion tubes within the verification exercise, as this would provide a greater number of data points within the calculation. However, as a minimum, the local authority should present the final modelled NO_2 concentrations at its diffusion tube sites as well and provide a graph and summary table of modelled versus monitored NO_2 concentrations across the model area (not just at continuous monitoring locations) as this will provide more clarity regarding how the model is performing across the model area being considered. This information may lead to a further review of the model verification and a different adjustment factor.

Local authorities should present the above comparison for sites within their modelling study areas, and this should include those occasions where verification has been undertaken at sites outside of their model areas.





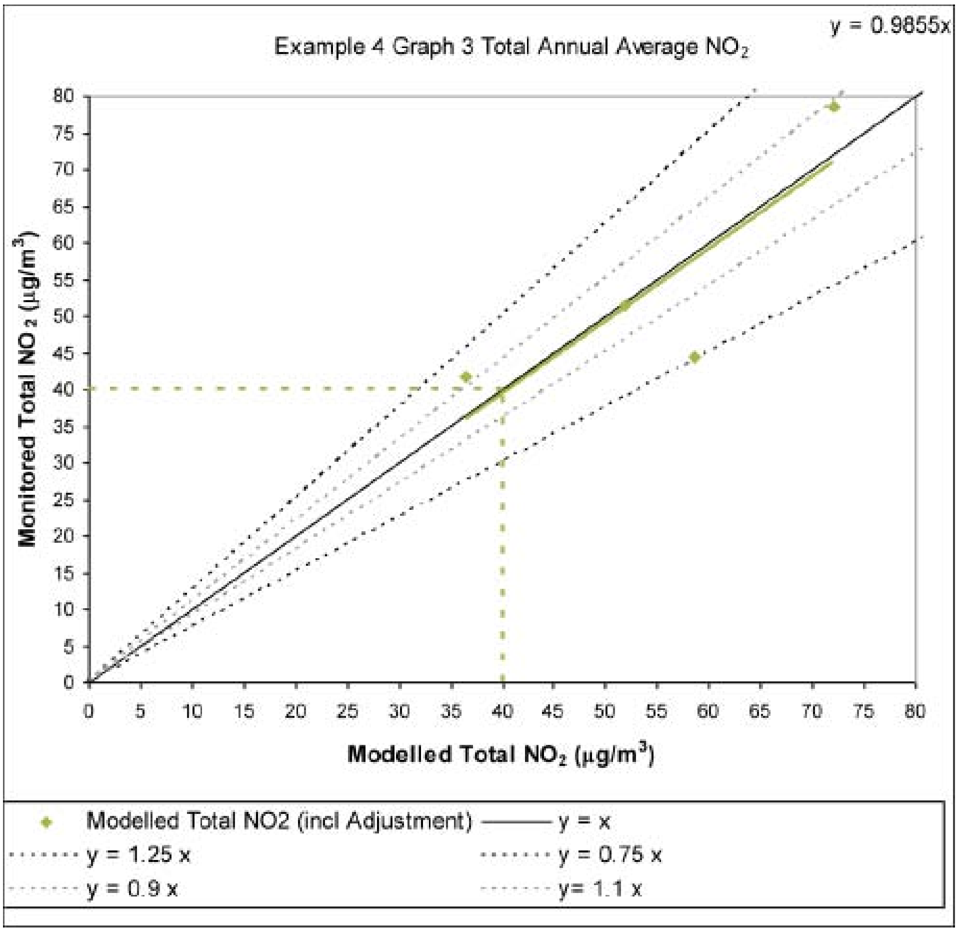
The local authority has applied the modelled road NO_X adjustment factor derived from sites 1-4 as shown in Graph 2. The total modelled NO_X (which includes the adjusted road contribution and the adjusted background contribution) has been converted to NO_2. Table 3 shows the final modelled NO_2 results, and table 4 provides a summary. Graph 4 shows the total modelled NO_2 versus total monitored NO_2.

Example 4 Table 3						
Site ID	Monitor type*	Site type+	Site description	Monitored total NO_2	Modelled total NO_2	% Difference [(modelled - monitored)/ monitored]x100
1	CM	R	general urban	78.6	72.0	-8.4
2	CM	R	general urban	51.4	51.9	1.0
3	CM	R	general urban	44.5	58.5	31.5
4	CM	R	general urban	41.6	36.5	-12.3

* CM = Continuous Monitor, + R = Roadside

Example 4 Table 4 Summary table	
Within +10%	1
Within -10%	1
Within +-10%	**2**
Within +10 to 25%	0
Within -10 to 25%	1
Within +-10 to 25%	**1**
Over +25%	1
Under -25%	0
Greater +-25%	**1**
Within +-25%	**3**

Whilst most model results are well within 15% of monitoring results, the local authority should be careful when interpreting results at Site 3, and at similar types of location as there is significant over-prediction at this locations. This may results in the authority determining a larger AQMA than may be required. It is recommended that the local authority compare results at a wider number of sites including diffusion tubes.



Model uncertainty

A3.251 Local authorities may wish to evaluate their model performance, where possible, in order to establish confidence in model results. The total uncertainty associated with the model could be associated with a variety of factors including[82]:

- model uncertainty – due to model formulations;
- data uncertainty – due to errors in input data, including emissions estimates, background estimates and meteorology; and
- variability – randomness of measurements used.

A3.252 A number of statistical procedures are available to evaluate model performance and assess the uncertainties. A recent detailed study[83] about estimating the model uncertainty recommended that a subset of statistical parameters be used to describe the general uncertainties of dispersion models. The statistical parameters include (but are not limited to):

- the correlation coefficient;
- fractional bias; and
- Root Mean Square Error (RMSE).

A3.253 These parameters estimate how the model results agree or diverge from the observations. These calculations can be carried out prior to, and after adjustment, or based on different options for adjustment, and can provide useful information on model improvement. The formulae for correlation coefficient, fractional bias and RMSE and are provided in Box A3.7.

Box A3.7: Methods and formulae for description of model uncertainty

Statistical parameter	Formula	Comments	Ideal value
Correlation Coefficient	$r = \left[\dfrac{\sum_{i=1}^{N} (Obs_i - Avg.Obs)(Pred_i - Avg.Pred)}{Stedv.Obs \times Stedv.Pred} \right]$	It is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00
Root Mean Square Error	$RMSE = \sqrt{\dfrac{1}{N} \sum_{i=1}^{N} (Obs_i - Pred_i)^2}$	RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared.	0.01
Fractional Bias	$FB = \dfrac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$	It is used to identify if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.	0.0

Definitions:

i = the number of observation compared, 1, 2, 3 …. N, *N* = total number of observations compared, *Obs* = observed concentration, *Pred* = predicted concentration, *Avg.Obs* = average of all observed concentrations, *Avg.Pred* = average of all predicted concentrations, *Stdev.Obs* = standard deviation of observed concentrations, *Stdev.pred* = standard deviation of predicted concentrations

[82] Morgan, M.G., Henrion, M., 1990. Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis. New York: Cambridge Univ. Press

[81] Carlos Borrego, Ana Isabel Miranda, Ana Margarida Costa, Alexandra Monteiro, Joana Ferreira, Helena Martins, Oxana Tchepel, Ana Cristina Carvalho, 2006. Cross-Cutting 2: Uncertainties of Models & Monitoring. Report produced for EU under project Air4EU

A3.254 These statistical methods could be used for the following comparisons:

- To compare the observations against the predictions from a given model in order to evaluate its performance and uncertainty.
- To compare the observations with the predictions from a number of set ups of a given model, often termed model sensitivity. This may help to identify which model set up performs better. An example may be comparing the outcomes of modelling based on different sets of meteorological data.
- To compare the observations with predictions from different models. This will show which model performs better for a given scenario.

A3.255 In the first instance, where a local authority wishes to assess the uncertainty of a model, RMSE is quite simple to calculate providing an estimate the average error of the model in the same units as the observations. The RMSE is often easier to interpret than other statistical parameters and many local authorities may find calculation of the RMSE the most useful of the other parameters.

A3.256 If the RMSE values are higher than ±25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 objective of 40 µg/m^3, if an RMSE of 10 µg/m^3 or above is determined for a model, the local authority would be advised to revisit the model parameters and model verification. Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4 µg/m^3 for the annual average NO_2 objective.

A3.257 Based on the examples of model verification presented above, information on the three basic statistics identified for model uncertainty has been calculated and provided in Box A3.8.

Box A3.8

Example	Statistic	Results before verification and adjustment	Results after verification and adjustment	Comments (view examples for full details of verification and adjustment)
1	RMSE (µg/m^3)	2.9	n/a	No model adjustment was required
	Correlation	0.87	n/a	
	Fractional Bias	0.010	n/a	
2	RMSE (µg/m^3)	12.9	2.6	RMSE reduced
	Correlation	0.92	0.92	Remains same as adjustment based on regression through zero at all sites
	Fractional Bias	0.338	-0.007	Reduced towards 0
3	RMSE (µg/m^3)	6.3	5.3	RMSE reduced (though still above 10% of objective)
	Correlation	0.22	0.36	Slightly improved (different adjustments applied)
	Fractional Bias	-0.017	-0.005	Reduced towards 0

A3.258 The fractional bias of the model may be used in order to identify if the model exhibits a systematic tendency to over or under predict. However, care should be taken when using this statistic particularly where local authorities are concerned about the performance of the model at concentrations close to the air quality objective being assessed. The fractional bias provides the tendency of the whole model to under or over predict and local authorities should consider the performance at each sites as described in the model verification examples provided above.

A3.259 The correlation coefficient could be applied particularly in cases where large datasets such as hourly observations and predictions are being compared but this is not recommended for smaller datasets. It is generally less useful for smaller datasets, and can be controlled by single points at the upper or lower ranges of datasets.

A3.260 However, local authorities are reminded that it is important to check that a model is performing where concentrations close to the relevant objective are being considered. For example, a model may over-predict at background locations, but under-predict at higher concentrations close to the objective. Therefore the average performance of a model is not necessarily a good description of the performance at all locations. Local authorities should consider this as decisions related to declaration of AQMAs may be affected.

A3.261 Local authorities are not required to assess the uncertainty of their model predictions, however the statistical methods provided will assist in providing more confidence in model results and the decisions based on the results. The Local Authority Air Quality Support Helpdesk may be contacted for further information on the calculation of model uncertainty.

Annex 4: Abbreviations

AADT	Annual Average Daily Traffic (vehicles per day)
AAS	Atomic absorption spectroscopy
AEOLIUS	Assessing the Environment Of Locations In Urban Streets
AQEG	Air Quality Expert Group
AQMA	Air Quality Management Area
ATC	Automatic Traffic Count
AURN	Automatic Urban and Rural Network (air quality monitoring)
BAM	Beta Attenuation Monitor
BQPA	Bus Quality Partnership Arrangement
BST	British Summer Time
CEN	European Committee for Standardisation
CFD	Computational Fluid Dynamics
CO	Carbon Monoxide
COBA	Cost Benefit Analysis
CV	Coefficient of variation
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges, produced by the Highways Agency
DOAS	Differential Optical Absorption Spectroscopy
DTM	Digital Terrain Model
EA	Environment Agency
EAL	Environmental Assessment Level
EF	Emission Factor
EFD	Emissions Factor Database
EFT	Emissions Factor Toolkit
EPER	European Pollutant Emissions Register
E-PRTR	European Pollutant Release and Transfer Register
EXEMPT	EXcess Emissions Planning Tool
FAQ	Frequently Asked Questions
FDMS	Filter Dynamics Measurement System
GC	Gas Chromatography
GIS	Geographical Information Systems
GMT	Greenwich Mean Time
GPS	Global Positioning System
HDV	Heavy Duty Vehicles, ie, all vehicles more than 3.5 tonnes including Heavy Goods Vehicles and buses
HECA	The Home Energy Conservation Act
HFO	Heavy Fuel Oil
HGV	Heavy Goods Vehicles
ICPMS	inductively coupled plasma mass spectrometry
IPC	Intregrated Pollution Control
IPPC	Integrated Pollution Prevention and Control
IPRI	Northern Ireland Industrial Pollution and Radiochemical Inspectorate
kph	Kilometres per hour
LA	Local Authorities
LAEI	London Atmospheric Emission Inventory
LAPPC	Local Air Pollution Prevention and Control

LAQM	Local Air Quality Management
LDF	Local Development Framework
LDV	Light Duty Vehicles
LGV	Light Goods Vehicles
LTP	Local Transport Plan
LTS	Local Transport Strategies (in Scotland)
LIP	Local Implementation Plans (in London)
mph	Miles per hour
mppa	million passengers per annum
NAEI	National Atmospheric Emissions Inventory
NFR	Nomenclature For Reporting
NIEA	Northern Ireland Environment Agency
NO	Nitrogen monoxide, also termed Nitric oxide
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides ($NO + NO_2$)
NTM	National Traffic Model
NWP	Numerical Weather Prediction
O_3	Ozone
OBS	standard observations data
OS	Ordnance Survey
PAHs	polycyclic aromatic hydrocarbons
PI	Pollution Inventory
PM_{10}	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut-off at 10 µm aerodynamic diameter and which transmits particles of below this size
$PM_{2.5}$	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut-off at 2.5 µm aerodynamic diameter and which transmits particles of below this size
PM_1	Airborne particulate matter passing a sampling inlet with a 50% efficiency cut-off at 1 µm aerodynamic diameter and which transmits particles of below this size
ppb	Parts per billion (1,000,000,000)
ppm	Parts per million (1,000,000)
QA/QC	Quality Assurance and Quality Control
RDS	Regional Development Strategy
RMSE	Root Mean Square Error
RSD	Relative Standard Deviation
SEPA	Scottish Environment Protection Agency
SNAP	Selected Nomenclature for Air Pollution
SO_2	Sulphur dioxide
SSF	Smokeless Solid Fuel
STP	Standard Temperature and Pressure
TEOM	Tapered Element Oscillating Microbalance
TRAMAQ	TRAffic Management and Air Quality Research Programme
TRC	Traffic Regulation Condition
TSP	Total Suspended Particulate
UVF	Ultra-Violet Fluorescence
UM	Unified Model
USEPA	United States Environmental Protection Agency
VCM	Volatile Correction Model
VOC	volatile organic compound

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