

MAYOR OF LONDON

**LONDON LOCAL AIR QUALITY
MANAGEMENT (LLAQM)**

Technical Guidance 2016 (LLAQM.TG (16))

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CHAPTER 1: Introduction – London Local Air Quality Management (LLAQM)

- 1.01 This technical guidance - London Local Air Quality Management (LLAQM) Technical Guidance – has been prepared by the Greater London Authority (GLA) to support London boroughs in carrying out their duties under the Environment Act 1995 and connected regulations.
- 1.02 It supersedes all previous LAQM guidance applicable to London boroughs, the most recent being the national technical guidance LAQM.TG(09), which supported all UK local authorities to fulfil their duties as part of the LAQM system and has now been updated by Defra (national technical guidance LAQM.TG(16)).
- 1.03 This guidance applies only to London’s 32 boroughs (and the City of London), whilst LAQM.TG(16) applies to all other UK local authorities.
- 1.04 LAQM is the statutory process by which local authorities monitor, assess and take action to improve local air quality. Where a local authority identifies areas of non-compliance with air quality objectives, and there is relevant public exposure, there remains a statutory need to declare the geographic extent¹ of non-compliance as an Air Quality Management Area (AQMA) and to draw up an Air Quality Action Plan (AQAP) detailing remedial measures to address the problem. A general introduction to the system is provided in the associated LLAQM Policy Guidance document (LLAQM.PG(16))².
- 1.05 Air quality in the capital is devolved to the Mayor of London, who has a supervisory role, with powers to intervene and direct local authorities in Greater London under Part IV of the Environment Act 1995. In support of these devolved powers, the Mayor has established a London-specific LAQM system (LLAQM) for the effective and coordinated discharge of their respective responsibilities under Part IV of the Act.

Who Should Read this Document?

- 1.06 Although the LLAQM technical guidance is largely based on the updated national guidance LAQM.TG(16), it does incorporate London-specific elements of the LAQM system. Therefore, the primary users will be London boroughs technical officers charged with air quality duties under the regulations cited above. Secondary users will include transport, planning and policy officials. Other UK local authorities outside London should refer to the separate LAQM.TG(16) and associated Policy Guidance documents published by Defra and the Devolved Administrations.

What has Changed?

- 1.07 The LAQM system across the UK has changed. Whilst Wales and Northern Ireland are still to consider changes to LAQM and continue to work according to the previous regimes, the GLA has followed a similar approach to England and Scotland, adopting a new streamlined approach which places greater emphasis on action planning to bring forward improvements in air quality and to include local measures as part of EU reporting requirements. It also sees the introduction of an air quality Annual Status Report (ASR) to reduce the burden of the cycle of Updating and Screening

1 Authorities must declare the area of exceedance as a minimum but can declare an area that is wider if they wish.

2<https://www.london.gov.uk/what-we-do/environment/environment-publications/draft-london-local-air-quality-management>

Assessments, Progress Reports, Detailed Assessments, and Further Assessments³.

- 1.08 London boroughs will continue to appraise air quality, with the main emphasis on those pollutants shown to be challenging in respect of compliance – nitrogen dioxide (NO₂), particulate matter (PM₁₀) and sulphur dioxide (SO₂), whilst introducing a new role for London boroughs to work towards reducing levels of PM_{2.5}.

Structure

- 1.09 The structure of this LLAQM technical guidance allows for updates to be applied on an on-going basis and is ordered in such a way that ensures the focus is on measures and public reporting.
- 1.10 This guidance supports the wider central government shift towards evidence-based action planning for the benefit of public health and wellbeing. To aid London boroughs in this, existing air quality tools and measures have been updated where necessary, outdated technical or policy guidance has been removed, and new products and supporting material have been added to help local authorities assess the impact of measures – for example, on NO₂ concentrations at roadside locations.

NO₂, PM₁₀ and SO₂

- 1.11 At the core of LLAQM delivery are three pollutant objectives; these are: nitrogen dioxide (NO₂), particulate matter (PM₁₀) and sulphur dioxide (SO₂). All current Air Quality Management Areas (AQMAs) across the UK are declared for one or more of these pollutants, with NO₂ accounting for the majority. In Greater London, AQMAs are declared for NO₂ and PM₁₀ in equal proportions. It is a statutory requirement for local authorities to regularly review and assess air quality in their area and take action to improve air quality when objectives set out in regulation cannot be met.

PM_{2.5}

- 1.12 London boroughs have a new flexible role in working towards reducing emissions and concentrations of PM_{2.5} which is a very important area of focus due to the well-documented health impacts and the risk of failing to meet legal limits. Chapter 5 of LLAQM.PG(16) provides more examples on the interpretation of this role.
- 1.13 When they revise their Air Quality Action Plans (AQAPs) London boroughs must define how they are working towards reducing levels of PM_{2.5}, with a clear explanation as to the reasoning. This guidance therefore provides support to London boroughs with regards to some of the approaches available for considering PM_{2.5} within the LLAQM system, including measures known to be especially effective in reducing PM_{2.5}, and how to make best use of available monitoring and modelling data. It does not prescribe what the approach should be; it is for the borough in consultation with its public health officials to consider how it wishes to define this role and what approach to take, based upon the local circumstances and public health priorities. This flexibility of approach is intended to allow London boroughs to steer towards focussing upon clear actions with attainable targets to tackle PM_{2.5} alongside other air pollutants. Reference should also be made to the Public Health England document on estimating local mortality burdens associated with particulate air pollution⁴. Further details are provided in Chapter 2.

Benzene, 1,3-Butadiene, Carbon Monoxide and Lead

³ Further Assessments have already been removed via statute in England, Wales and Scotland. Whilst Further Assessments are still a formal requirement under Part III of the Environment (Northern Ireland) Order 2002, in practice, NI Policy Guidance recommends that Further Assessments not be submitted as separate documents but taken forward in parallel with the development of Air Quality Action Plans.

⁴ <https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution>

1.14 Reflecting feedback under the LAQM review process the UK Government has decided to retain benzene, 1,3-butadiene, carbon monoxide and lead in regulations for England; therefore these remain applicable to London boroughs. However, in recognition of the fact that all of the objectives for these pollutants have been met for several years and are well below the national air quality objectives, London boroughs do not have to report on these pollutants unless local circumstances indicate that these pollutants need to be addressed.

Table 1.1 – Air Quality Objectives in England - LLAQM

Pollutant	Objective	Averaging Period
Nitrogen dioxide (NO ₂)	200µg/m ³ not to be exceeded more than 18 times a year	1-hour mean
	40µg/m ³	Annual mean
Particulate Matter (PM ₁₀)	50µg/m ³ not to be exceeded more than 35 times a year	24-hour mean
	40µg/m ³	Annual mean
Particulate Matter (PM _{2.5})	Work towards reducing emissions/concentrations of fine particulate matter (PM _{2.5})	Annual mean
Sulphur dioxide (SO ₂)	266µg/m ³ not to be exceeded more than 35 times a year	15-minute mean
	350µg/m ³ not to be exceeded more than 24 times a year	1-hour mean
	125µg/m ³ not to be exceeded more than 3 times a year	24-hour mean
Benzene (C ₆ H ₆)	16.25µg/m ³	Running annual mean
	5µg/m ³	Annual mean
1,3-Butadiene (C ₄ H ₆)	2.25µg/m ³	Running annual mean
Carbon Monoxide (CO)	10mg/m ³	Maximum daily running 8-hour mean
Lead (Pb)	0.5µg/m ³	Annual mean
	0.25µg/m ³	Annual mean

LLAQM System Streamlined Approach

1.15 The LLAQM system adopts a streamlined approach in order to review and assess air quality, utilising the submission of a single ASR in place of the phased approach previously used.

1.16 The Secretary of State expects local authorities in Greater London to participate in the LLAQM system and to have regard to any advice or guidance issued by the Mayor of London as to the performance of their LLAQM functions.

1.17 London boroughs should submit a single Annual Status Report (ASR), accompanied by a public-

facing Annual Status Summary Report (ASSR), to be made available on their website to help promote air quality locally. The ASR and ASSR replace all other reports which previously had to be submitted as part of the LAQM system including the Review and Assessment and Action Plan Progress Reports, Updating and Screening Assessments (USAs) and Detailed Assessments. AQAPs remain as separate.

- 1.18 London boroughs are required to submit the ASR and ASSR by 30 April⁵ each year in the format of a mandatory template.
- 1.19 The ASR is designed to allow sufficient understanding in the analysis of pollutant occurrence to support the identification of new non-compliant areas (i.e. ‘hot spots’) and to report on progress within existing AQMAs. The template approach does not preclude the flexibility to provide detailed or extra analysis where this has taken place. For instance, annexes may be adjoined to the ASR.

Public Exposure

- 1.20 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.
- 1.21 For the purposes of LAQM, regulations state that exceedances 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”.
- 1.22 For the purpose of assisting London boroughs, some examples of where the objectives should, and should not apply, are summarised in Box 1.1. These examples are not intended to be comprehensive, and it is expected that local knowledge will often be required. If in doubt, further guidance may be obtained from the LAQM Support Helpdesk (see Box 1.2).

Box 1.1 - Examples of Where the Air Quality Objectives Should Apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
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⁵ The GLA will advise on any changes to this on an ad hoc basis (the deadline will be extended in 2016, for example).

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 ⁶ .	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.	

Air Quality Management Areas Declared Across the UK and in Greater London

- 1.23 As of January 2016, there are more than 700 AQMAs currently declared across the UK (nearly 600 of which are in England). Of these, the vast majority (over 90%) are related to road traffic emissions, where attainment of the annual mean objective for NO₂ is considered unlikely, sometimes in association with exceedances of the 24-hour mean PM₁₀ objective, or (especially in Scotland) the annual mean PM₁₀ objective.
- 1.24 Within Greater London, all boroughs have declared an AQMA, all of them related to road traffic emissions (although a small number of these AQMAs are due to the combination of road traffic and industrial sources). Nearly all AQMAs declared by London boroughs relate to both the NO₂ annual

⁶ 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

mean and PM₁₀ 24-hour mean objectives, although a few AQMAs also include the NO₂ 1-hour mean or the PM₁₀ annual mean objectives. There has been no AQMA declared for any of the SO₂ objectives. The vast majority of AQMAs declared by London boroughs encompass the whole borough. Other AQMAs declared include part of the borough, or stretches of main roads / busy junctions.

1.25 Further information is available on the AQMA website⁷.

Air Quality Focus Areas

1.26 As nearly all AQMAs currently declared in Greater London encompass a large area, typically including the whole or main parts of the borough, they do not necessarily help to target action in the most problematic areas. To assist local authorities targeting air pollution hotspots within each London borough as part of action planning, the GLA identified Air Quality Focus Areas (AQFAs), based on detailed dispersion modelling of NO₂ and PM₁₀ and analysis of population exposure. As a result, AQFAs are a good indication of locations of high human exposure where national air quality objectives are exceeded.

1.27 The AQFAs, which were carefully identified by the GLA, address the concerns that were raised by London boroughs within the LAQM review process and through analysis of forecast air pollution trends. They are not intended to be an exhaustive list of hotspot locations within Greater London, but indicate where the GLA believe air quality issues are the most acute.

1.28 Preliminary work by the GLA led to the identification of 187 AQFAs - at least one in each of the London boroughs. To further improve the process, the GLA will work with London boroughs to review these AQFAs, starting in 2016. This will include a review of existing focus areas and consideration of the inclusion of additional focus areas, undertaken in consultation with boroughs. This may also include identification of AQFAs in industrial areas with high population exposure, where this is supported by the borough and the Environment Agency.

1.29 AQFAs will be kept under periodical review and London boroughs will be able to participate in any future reviews. In order to ensure that focus areas are considered during action planning, London boroughs are asked to consider focus areas when reviewing their AQAP, and further detail on this can be found in Chapter 2, below.

Further information

1.30 London boroughs can obtain further information and guidance from the LAQM Support Helpdesk operated on behalf of Defra and the Devolved Administrations (see Box 1.2).

Box 1.2 – LAQM Support Helpdesk for Local Authorities

Helpdesk	Operated by	Details
LAQM Support Helpdesk	Bureau Veritas	Email: laqmhelpdesk@uk.bureauveritas.com Website: http://laqm.defra.gov.uk/ 0800 032 7953

⁷ Air Quality Management Areas website available at <http://uk-air.defra.gov.uk/aqma/>

CHAPTER 2: Air Quality Action Plans (AQAP)

Introduction

- 2.01 Every local authority that has an active AQMA is required under Part IV of the Environment Act 1995 to provide an AQAP as a means to address the areas of poor air quality that have been identified within the AQMA. The emphasis within AQAPs should be two-fold:
- to develop measures that will provide the necessary emissions reductions to achieve the air quality objectives within specified timescales; and
 - act as a live document which is continually reviewed and developed, to ensure current measures are progressing and new measures are brought forward.
- 2.02 Policy Guidance LLAQM.PG(16) states that an AQAP should ideally be prepared within **12 months**⁸ of an AQMA being declared. Once a draft has been prepared, the AQAP should be submitted to the GLA for initial appraisal. Following this stage, the AQAP should be finalised and again submitted to the GLA for approval.
- 2.03 The process of formulating an AQAP is now over a decade old and much has been achieved by local authorities in respect to the outcome of these plans, which has raised the profile of air quality within their authorities, and the formulation of joint partnerships and working that has led to the successful implementation of measures across a wide variety of differing circumstances, reflective of the different measures required to reduce emissions and improve air quality.
- 2.04 All London boroughs have declared an AQMA, and produced an AQAP. Therefore, there should be no need to develop a new AQAP. However, it is important that London boroughs update their existing AQAP every 5 years as a minimum, to reflect current policy and to improve their effectiveness.
- 2.05 The process of developing an AQAP, as detailed in this chapter, is not fundamentally different from previous Policy and Technical Guidance documents. The information below should be comprehensive, but local authorities seeking further support can refer to the LAQM Support website⁹, to assist in this process.
- 2.06 Whilst the core fundamentals behind developing an AQAP have not changed and therefore should be applicable to the AQAP update, it is important to ensure that the updating process continues to focus on the effective implementation and delivery of measures developed to address the specific local air quality issues. The GLA has published an AQAP template to assist London boroughs with the update of their AQAP and ensure a consistent format for AQAP reporting. Whilst use of the AQAP template is not mandatory, it is recommended that London boroughs make use of this template for new or substantial revisions to their AQAP. The template is available on the LAQM Support website¹⁰.
- 2.07 Furthermore, the ASR now also provides a consistent format for London boroughs to report on the progress of their AQAP and other supporting measures developed to reduce emissions towards

8 Northern Ireland policy guidance suggests 12 months.

9 <http://laqm.defra.gov.uk/action-planning/aqap-supporting-guidance.html>

10 <http://laqm.defra.gov.uk/review-and-assessment/report-templates.html>

achieving the air quality objectives.

How to Update an AQAP Efficiently?

2.08 A number of mechanisms and approaches should improve the focus of AQAPs and assist with their updating. When updating their AQAP, London boroughs must continue to check that they are adapted to the local situation and, most importantly, are still seen as part of an integrated package of measures, particularly in relation to linking with other key policy areas, notably:

- Land-use planning and sustainable development;
- Transport Planning, promoting sustainable transport, local transport management, integration with Local Implementation Plans (LIP);
- Climate change policies in relation to carbon management and reduction of greenhouse gas emissions; environmental assessments should consider impacts on air quality and climate change issues;
- Low Emission Strategies, which can be used as an integrated approach to promoting emissions reductions measures across a wide policy spectrum, benefiting both air quality and climate change;
- Public Health Outcomes (PHO) policy areas, which seek to promote health and wellbeing within the population with direct links to the promotion of physical exercise through walking and cycling initiatives (which reduce reliance on private vehicle use); and
- Education programmes which again seek to promote health and wellbeing through walking and cycling, but also the principles of sustainability.

2.09 Typically, the update of an AQAP should include the following points:

- 1) Provision of a strong governance and ownership. Set up a steering group with key stakeholders;
- 2) Review available modelling and monitoring data;
- 3) Review existing AQAP measures;
- 4) Make use of the Air Quality Action Matrix;
- 5) Integrate Air Quality Focus Areas;
- 6) Review and link with other local, regional and national policies and strategies;
- 7) Select final measures, based on all the above; and
- 8) Undertake consultation.

2.10 This process is discussed in more detail below.

1 - Governance and Ownership

2.11 The AQAP and any update to it should have a clear governance and ownership by the Borough, which extends to all parts of the AQAP, and includes all contributing departments and corporate. Ideally, a statement of support should be provided by the relevant Councillor with the portfolio of environment, or planning and development, and also a support statement from the Director of Public Health. The steering group should collaborate to identify:

- If there are existing programmes in other areas that will contribute to emissions reductions (or increases) that should be accounted for within the AQAP.
 - What may influence the local pollution situation in the near future (i.e. 5 to 10 years);
 - The future trends that are likely to contribute (regional emissions trends as well as local factors);
 - If there is sufficient information to clearly define effective measures;
 - If more technical assessment may be required before proceeding to updating the AQAP;
 - If emissions will naturally reduce sufficiently to achieve air quality objectives in the next 5 years, as a result of measures already in place;
 - What intervention measures are required, for example traffic management; and
 - How the benefits of successful programs/interventions will be maintained in the long term.
- 2.12 Early engagement with appropriate stakeholders throughout the AQAP updating process should help integrating the AQAP with other relevant policies and programmes at the local and/or London-wide level.
- 2.13 Of particular importance is ensuring that transport planners are engaged in the AQAP updating process, to ensure that it is integrated with LIPs or equivalent documents in a successful manner.
- 2.14 Where relevant, it is important to ensure continued dialogue with neighbouring boroughs who may share responsibilities for some preferred actions. TfL and/or the Environment Agency should also be consulted as key stakeholders where they may have an influence on local air quality. For example, TfL can influence the effect on air quality of their activities and those using the strategic road network through:
- Contributing to strategic planning;
 - Road improvements;
 - Integrating transport and encouraging sustainable travel;
 - Providing better information for improved operation; and
 - Working with local authorities to deliver the Air Quality Strategy.
- 2.15 Contact details for key external bodies are provided in Box 2.1.

Box 2.1 - Key External Body Contact Details

Organisation	Details
Environment Agency	Website: https://www.gov.uk/government/organisations/environment-agency Email: enquiries@environment-agency.gov.uk Tel: 03708 506 506
TfL	Website: https://tfl.gov.uk/ Email: via https://tfl.gov.uk/help-and-contact/?cid=contact

Organisation	Details
	Tel: 0343 222 1234

2 - Review Air Quality Modelling and Monitoring Data

- 2.16 When updating their AQAP, London boroughs should review the most recent modelling and monitoring data available, in order to establish the new air quality baseline. This will in turn inform the review of existing AQAP measures and the selection of new measures, where appropriate.
- 2.17 Modelled maps of pollutant concentrations at borough level, updated every 4 years by the GLA, should assist in determining the latest air quality levels. A review of recent trends in air pollution, based on local air quality monitoring data, should also provide useful information.
- 2.18 Both sources of data should help London boroughs reassess areas where the air quality objectives are being or are likely to be exceeded, which will assist in the review of AQAP measures.
- 2.19 The LAEI modelling package should be used to reassess the source contribution within areas of exceedance of the air quality objectives (pie charts provided can be inserted within the AQAP), and estimate the required reduction in pollutant emissions to attain the objectives. This will assist London boroughs to correctly target the most important sources, and to focus the principal measures within the AQAP.
- 2.20 However for this purpose, it may also be useful to carry out additional assessment, such as specific dispersion modelling at a more local scale, to provide more accurate evidence and inform the AQAP update.
- 2.21 The greater the level of detail in data and information gathered through screening assessments, detailed dispersion modelling and monitoring, the more confidence the authority can be that the proposed measures identified will be successful and will achieve the desired outcome.
- 2.22 Further information on source apportionment and calculation of reduction in emissions, including worked examples, are provided in Chapter 4 (respectively para 4.98 and para 4.108). Where alternative methods for source apportionment become available in due course these will be done so through the LAQM Helpdesk and users alerted as appropriate.

3 - Review Existing AQAP Measures

- 2.23 London boroughs should review the measures currently within the AQAP, whether they have been implemented, are currently ongoing, or have not yet been progressed. The review should identify those measures still considered relevant, and eliminate those unlikely to deliver air quality improvements, based on experience (both at local and national level).
- 2.24 The emphasis should be on keeping measures that can deliver the required level of emissions reductions to meet air quality objectives within clearly defined timescales that are considered acceptable to the GLA. The review should be an opportunity to summarise the efficiency of the existing AQAP, by identifying measures that:

- Have been implemented, but failed to improve air quality;
- Have been implemented, but for which any improvement has been difficult (or impossible) to quantify; and
- Have successfully been implemented, with a clear tracked record of improvement in air quality.

2.25 This should help London boroughs clearly identify current action planning issues, and reassess the potential of ongoing / still not implemented measures.

4 - Use the Air Quality Action Matrix

2.26 To assist London boroughs in the development and adoption of appropriate AQAP measures, an Air Quality Action Matrix has been developed¹¹. It brings together existing advice and actions London boroughs should consider when they need to develop actions to improve air quality to acceptable levels.

2.27 The measures suggested in the Air Quality Action Matrix are not mandatory; boroughs can simply select the most appropriate actions from the Matrix for inclusion in their AQAPs. Furthermore, boroughs are also free to include other measures (not contained in the Matrix) in their AQAP. However, boroughs are expected to consider the Air Quality Action Matrix as part of the process of updating their AQAP. In order to demonstrate that it has been considered, when submitting their draft AQAPs, boroughs should also submit a brief summary of which Matrix measures have been discounted for inclusion and why, for the purposes of information and transparency.

5 - Review the Air Quality Focus Areas

2.28 When updating their AQAP, London boroughs should consider the revised Air Quality Focus Areas (AQFAs) which will be identified in 2016. Boroughs should concentrate actions and project delivery that will affect these areas as far as is practicable.

2.29 AQFAs are intended to be an additional element of the LLAQM system, designed to ensure that action is focused in areas of both high pollution and exposure where reasonable/practicable. However, focusing on AQFAs should never occur to the detriment of delivering action planning measures within AQMAs.

2.30 AQFAs are intended as tools to help London boroughs deliver action, not to create additional bureaucracy. London boroughs will therefore not be subject to any restrictions or requirements regarding these areas. Whilst action in AQFA's is strongly encouraged, there is no expectation that any one specific action will need to be undertaken in these areas.

6 - Review and Link with Other Local, Regional and National Policies and Strategies

¹¹ The Air Quality Action Matrix can be found at: <https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/working-boroughs>

- 2.31 It is important to identify and assess AQAP measures within the following Government policy areas (likely to already be in operation), which could affect air quality. Early consideration of this will provide a strong foundation for the AQAP update, whilst also helping to minimise potential conflicts with other policy areas:
- National and Regional Air Quality Plans;
 - Climate Change and Carbon reduction programmes;
 - Sustainability Strategies;
 - Low Emission Strategies;
 - Transport Policy;
 - Noise Action Plans;
 - Procurement Policies;
 - Planning Policies;
 - Public Health; and
 - Education.
- 2.32 It is recommended that consideration of wider existing plans and measures be done in a way as not to lose the focus of the AQAP – which is namely that of identifying the problems in air quality and the associated measures to improve air quality within the Borough. Links to other policy areas should therefore be concise.
- 2.33 Please note that it is not a requirement to undertake a Strategic Environmental Assessment or a Habitats Regulation Assessment for your AQAP.

7 - Select Final Measures

- 2.34 Based on all points discussed above, London boroughs should be able to prioritise actions and implement the most adequate measure to tackle air pollution levels across their borough, taking into account their legal duties under Part IV of the Environment Act 1995 and European law.
- 2.35 Once agreed and validated by all stakeholders, the AQAP should include details on the way their success will be measured, which will help determine whether additional measures may be required at a later stage.
- 2.36 Each measure within AQAPs should include details of the key indicators to use within further reports to track their delivery within agreed timescales.
- 2.37 Progress on implementing individual measures within AQAPs will need to be reported in the ASR with reference to the updated AQAP.

8 - Undertake Consultation

- 2.38 London boroughs will need to consider the extent and degree of consultation required whilst updating their AQAP. Whilst some degree of local consultation is strongly recommended, it is at

the discretion of the local authority as to what form this should take. For example, consultations may be undertaken with interested local organisations and bodies (e.g. residents and local businesses affected by the AQAP measures), and/or via an online consultation questionnaire. Such consultation may be done jointly with the statutory consultation, or could be done locally prior to the undertaking of consultation with statutory bodies.

Local Consultation

- 2.39 The previous section (see para 2.32) on links to key policy areas and establishing local steering groups outlined a process that should facilitate local consultation. In many cases local consultation can be planned so that all relevant stakeholder groups are engaged as appropriate.
- 2.40 Boroughs may choose to engage with key stakeholder groups, prior to final statutory consultation and adoption of the plan.

Statutory Consultation

- 2.41 The process for statutory consultation is outlined in Chapter 4 of Policy Guidance LLAQM.PG(16). This makes clear that London boroughs are required to undertake statutory consultation with the named consultees when either preparing or revising their AQAP.
- 2.42 Please note that the Greater London Authority will need to approve final (post consultation) AQAPs before they are published.

PM_{2.5} and Action Planning

- 2.43 This section provides guidance to London boroughs on integrating measures that will help to reduce PM_{2.5} concentrations into their AQAPs.
- 2.44 The AQAP provides the basis for London boroughs to report upon their commitments to, and actions being undertaken to, reduce PM_{2.5} at the local level. Any evidence that may be used to benchmark progress on reducing PM_{2.5} emissions, concentrations, or associated health effects, can also be detailed in the ASR.

Linkages between Air Quality and Public Health

- 2.45 There is a clear public health case for local action on air quality. London local authorities now have a duty to take steps to improve the health of people in their local areas. This new duty, together with the inclusion of the PM_{2.5} indicator in the Public Health Outcomes Framework (England), creates an excellent opportunity for that case to be made more effectively within local authorities and communities. Specifically, the reform of public health services means that there is the potential to become key local champions of air quality improvement, by informing and influencing peers in local transport, planning, sustainability and other departments, and by getting the message out to the general public.

- 2.46 To facilitate this, Defra commissioned research to develop a toolkit to help local authorities and public health professionals tackle air pollution in their area with a particular focus on PM_{2.5}¹². The toolkit provides a one-stop guide to the latest evidence on air pollution; guides to using existing tools to appraise the scale of the air pollution issue in your area; advice as to how to appropriately prioritise alongside other public health priorities and communication tools to ensure air pollution is on the local agenda.
- 2.47 Integral to a successful process is the development of communication methods for localised air quality and health impact information. Communication guides were developed through a series of workshops and interviews. Participants included Directors of Public Health, public health professionals, local authority air quality managers and members of the public.
- 2.48 The toolkit comprises the following key guides:
- Getting to grips with air pollution – the latest evidence and techniques;
 - Understanding air pollution in your area;
 - Engaging local decision-makers about air pollution;
 - Communicating with the public on air pollution; and
 - Air Pollution: an emerging public health issue: Briefing for elected members.

Identifying Areas for PM_{2.5} Action

- 2.49 Due to its extremely small size, PM_{2.5} can travel for long distances in the air and it is estimated that as much as 40% to 50% of the levels found in any given area can be from sources outside a local authority's direct boundary¹³. Nevertheless, this means that the contribution of local sources to total PM_{2.5} levels is significant (typically 50% or more), and therefore local actions to reduce PM_{2.5} emissions will have a significant beneficial impact with regard to overall PM_{2.5} concentrations.
- 2.50 London boroughs are encouraged to make use of all available sources of information to aid the identification of any 'hot-spot' areas of elevated PM_{2.5} concentrations within the borough. Such information will aid the direction of actions to specific priority areas that are most in need of reductions in PM_{2.5} levels, and allow measures to be targeted to the identified PM_{2.5} issues. It will also allow to benchmark progress in reducing PM_{2.5} levels due to local authority action.
- 2.51 Increased frequency of PM_{2.5} monitoring is encouraged where possible, particularly where it has been identified as a priority. However there is no obligation or expectation that boroughs should fund additional PM_{2.5} monitoring. London boroughs not already undertaking PM_{2.5} monitoring should make use of other existing sources of information to aid identification of any PM_{2.5} 'hot-spots' in order to focus on action. This should include updated maps of PM_{2.5} concentrations across Greater London, which will be provided to London boroughs by the GLA every four years, following the update of the London Atmospheric Emissions Inventory (LAEI).
- 2.52 Methods available to London boroughs that may assist in the identification of the key areas for,

¹² <http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18580>

¹³ Fine Particulate Matter (PM_{2.5}) in the United Kingdom. Air Quality Expert Group (AQEG) Report. 2012. <https://www.gov.uk/government/publications/fine-particulate-matter-pm2-5-in-the-uk>

and the required degree of, PM_{2.5} focus are discussed below. Whichever approach or degree of action is taken with regards to PM_{2.5}, a clear rationale should be provided in the AQAP.

Monitoring

- 2.53 It is acknowledged that many London boroughs do not presently monitor PM_{2.5} concentrations; as there has been no statutory requirement to review and assess PM_{2.5} for LAQM purposes (and this is still the case within the LLAQM system), since PM_{2.5} is not incorporated into LAQM Regulations. Whilst an increase in PM_{2.5} monitoring across Greater London, and the UK in general, is desirable given the links to the Public Health Outcomes Framework, it is also recognised that the costs involved¹⁴ can be prohibitive.
- 2.54 Further discussion on suitable methods for monitoring PM_{2.5} is provided in Chapter 4 (para 4.143).

Modelling

- 2.55 As part of the LAEI modelling package, updated by the GLA every 4 years from 2016 onwards, London boroughs will be provided with borough-wide modelled PM_{2.5} concentration maps, which will assist London boroughs in determining the degree and nature of any required action to reduce PM_{2.5} levels. This package will also include source apportionment for PM_{2.5} emissions.

Other Supporting Information

- 2.56 There are also several sources of existing information that may assist London boroughs in evaluating PM_{2.5} at the local level. This includes, but is not limited to:
- **National PM_{2.5} Monitoring.** There are approximately eighty PM_{2.5} monitoring stations within the AURN, including eleven within Greater London¹⁵. These can be found on the UK-Air website¹⁶. Monitoring data from sites located either close to or within London boroughs will provide a good indicator as to likely PM_{2.5} concentrations within the boroughs. It will be important to understand the implications of the monitoring site classification which is being used as a surrogate for local PM_{2.5} concentrations, e.g. whether background, roadside or other. This is discussed further in Chapter 4 (section 2);
 - **National PM_{2.5} Modelling.** As discussed in Chapter 4 Section 1 (para 4.72), Defra maintains national background maps, which are provided for each 1km × 1km grid square across the UK. By plotting the PM_{2.5} mapped data for the appropriate base year, PM_{2.5} concentrations can be identified within each London borough. Although considered quite coarse resolution, such information may prove useful to London boroughs in directing actions to areas that are

14 <http://uk-air.defra.gov.uk/networks/monitoring-methods?view=mcerts-scheme>

15 <http://uk-air.defra.gov.uk/networks/network-info?view=aur>

16 <http://uk-air.defra.gov.uk/networks/find-sites?view=advanced>

most in need of reductions in PM_{2.5} levels. Source apportionment data contained in the background maps will also aid in understanding the relative contributions of the mapped emissions sources¹⁷.

- **Ratio of PM₁₀ to PM_{2.5}** In the absence of any PM_{2.5} monitoring data, London boroughs can use one of the methodologies provided in Chapter 4 Section 1 (paras 4.111 to 4.115) to provide an indication of PM_{2.5} concentrations.
- **PM_{2.5} Assessment in Planning and Environmental Permitting.** Where necessary, air quality impact assessments submitted in support of a planning application may include quantitative assessment of PM_{2.5} emissions associated with proposed development. Applications for environmental permits either submitted to the Environment Agency (for Part A1 regulated processes) or directly to local authorities (Part A2 or Part B regulated processes) may also provide similar information. This could provide further evidence in the form of additional monitoring data and/or model predicted PM_{2.5} concentrations at specific locations within the local authority area.
- **Public Health Indicators for PM_{2.5}** These will provide a useful indication as to the burden associated with concentrations of PM_{2.5} within each London borough. For example, population-weighted annual average concentrations of anthropogenic PM_{2.5} are provided for all lower tier and unitary local authorities within England¹⁸. These are combined to produce figures at upper tier, regional and national level so that attributable fractions of annual all-cause adult mortality associated with long-term exposure to current levels of anthropogenic PM_{2.5} can be calculated at those scales also.

2.57 The above approaches are provided for reference purposes only. They are intended to provide an illustration of the various approaches available to London boroughs to help ensure actions to reduce PM_{2.5} concentrations are targeted to the key areas of concern, and that measures are developed commensurate with the scale and nature of the PM_{2.5} issues within London boroughs.

Local Action to Reduce PM_{2.5}

2.58 For the effective targeting of local action to help reduce PM_{2.5} concentrations, it is important to first understand the source apportionment to total PM_{2.5}. Although this will vary by location, and it is acknowledged that there will be limited local PM_{2.5} source apportionment studies (if any), consideration should be given to taking action that will address PM_{2.5} associated with the following:

- **Primary PM_{2.5} Sources (approximately 19% of UK total¹⁹).** Comprising anthropogenic emissions from combustion (industrial processes and road traffic exhausts) and non-combustion processes (e.g. fugitive emissions from agricultural and industrial material handling; non-exhaust emissions from vehicles - tyre and brake wear, and road abrasion); and
- **Secondary PM_{2.5} Sources (approximately 13-20% of UK total¹⁹).** Not all of the

17 <http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html>

18 The Department for the Environment and Rural Affairs (Defra) intends to make these figures available on its website in future years.

19 Mitigation of United Kingdom PM_{2.5} Concentrations. Air Quality Expert Group (AQEG) Report. 2013. <http://uk-air.defra.gov.uk/library/aqeg/publications>

particulate matter found in the atmosphere has been directly emitted into the atmosphere by primary sources. Secondary PM_{2.5} is formed in the atmosphere by chemical reactions involving primary emitted precursor species, with each secondary PM component thus having its own primary PM precursor or precursors. In general, the most important secondary inorganic aerosols are sulphate (formed by oxidation of gaseous SO₂), nitrate (formed by oxidation of gaseous NO₂), and ammonium (formed by oxidation of gaseous ammonia – NH₃). Secondary organic aerosols are dominated by the oxidation of certain volatile organic compounds (VOCs).

2.59 Measures to tackle PM_{2.5} can be broadly separated along mobile, stationary sources and area or fugitive sources. Table 2.1 provides examples of some of the measures that can be implemented to specifically reduce PM_{2.5} emissions. These are measures that London boroughs may already be taking to address other pollutants such as PM₁₀ and NO_x. London boroughs should therefore review any existing measures already currently being implemented to determine whether they are already taking positive action to reduce PM_{2.5} emissions; such benefits should be reported in the ASR.

Table 2.1 – Example of Measures to Tackle PM_{2.5}

Source Type	Measure
Mobile Source Measures	<ul style="list-style-type: none"> • On-road diesel engine retrofits for public service and heavy goods vehicles using Euro standards • Non-road mobile machinery diesel engine retrofit, rebuild/replace with diesel particulate filter (DPF); this can be reduced through by enforcement of the NRMM LEZ • Anti-idling programmes for HGV, locomotive, and other mobile sources; • Transportation control measures including transportation demand management and transportation systems management strategies; • Programmes to reduce emissions or accelerate retirement of high emitting vehicles; • Emissions testing and repair/maintenance programs for on-road vehicles; • Emissions testing and repair/maintenance programs for non-road heavy duty vehicles and equipment; • Programmes to expand use of cleaner burning fuels - use of sulphur-free diesel, biofuels and alternative fuels such as compressed natural gas.

Source Type	Measure
Stationary Source Measures	<ul style="list-style-type: none"> • Process change measures (modification to raw materials, process technologies and operations, and the use of cleaner fuels) • Process management (improvement to operations such as cleaning up dust spillages, preventing dust escaping to ambient air and introducing more efficient combustion) - measures to reduce fugitive dust from industrial sites; • Stationary diesel engine retrofit, rebuild or replacement, with particle filter; • New or upgraded emission control requirements for direct PM_{2.5} emissions at stationary sources (e.g. electrostatic precipitators, fabric filters, scrubbers and cyclones; improved monitoring methods); • New or upgraded emission controls for PM_{2.5} precursors at stationary sources (e.g. wet/dry scrubbers); • Energy efficiency measures to reduce fuel consumption.
Area Source Measures	<ul style="list-style-type: none"> • Smoke management programmes to reduce domestic coal use; • Reduce emissions from woodstoves and fireplaces; • Regulate commercial cooking operations; • Further reduce solvent usage or solvent substitution.

The Format and Content of Air Quality Action Plans

2.60 When updating their AQAP, London boroughs should ensure that it includes the following information, a minimum:

- **Quantification of impacts of proposed measures** including, where feasible, expected emission and/or concentration reductions (either locally obtained and/or via national monitoring/modelling statistics). It is important that London boroughs show how they intend to monitor and evaluate the effectiveness of the plan;
- **Clear timescales**, including milestones and expected outcomes, which the borough and other delivery partners propose to implement the measures within the AQAP; and
- **Defined roles and responsibilities** that detail how the borough and other delivery partners, including transport, planning and health departments, will take ownership of actions and in what capacity they will work together to implement and maintain the AQAP.

2.61 Although London boroughs are free to determine the format of their AQAP, they are encouraged to make use of the updated AQAP template provided by the GLA.

2.62 In any case, the AQAP should follow the structure below:

- **Introduction**, explaining the requirement and rationale for the AQAP. This should include placing the current AQAP in context relative to progress achieved by previous AQAP versions;
- **Summary of current air quality in the borough**. This should include information on any exceedances of the air quality objectives. Details of any AQMAs (current or proposed) should also be provided.
- **Borough's air quality priorities**. This should describe the Council's priorities and drivers

for pursuing some actions to improve air quality. This may include a description of the health context in the borough, major sources of pollutants (such as roads, airports and industry), the necessary reductions required to meet air quality objectives, the planning context (upcoming developments) and other Council policies, such as health and wellbeing, sustainability, economic development, transport, climate change or education.

Source apportionment dispersion modelling studies may assist in identifying priorities. For example, in an AQMA declared for NO₂ primarily due to emissions from road traffic and, e.g. if bus emissions are identified to contribute a high proportion of the total road-NO_x, AQAP measures that specifically target this source group should be prioritised.

If there are other documents or strategies that set out information on the local authority's approach to air quality, information (and any links) pertaining to them should be provided with details of how they have been accounted for within the AQAP.

This is an opportunity to lay out the Council's rationale and prioritisation.

- **Development and implementation of the AQAP.** This should include details of consultation undertaken during the development of the AQAP and feedback with regards to stakeholder engagement.

Details of the Steering Group should also be provided. This should include composition, the group's activity (e.g. number of meetings) and in what ways the Steering Group has pushed forward the implementation of the AQAP.

The members of the Steering Group should include local authority officers across the different Council's departments and may also include officers from neighbouring local authorities. The Steering Group would decide on engaging support from other outside bodies, businesses and local community groups to take the process forward.

Other local authority departments and external bodies should be constructively engaged in agreeing actions to improve air quality and meet the legal requirement to work towards air quality objectives.

The following, in particular, should engage constructively in improving air quality:

- Transport planners;
- local and national highway authorities;
- land use planners and town centre managers;
- environmental protection and energy management officers;
- waste managers;
- economic development, regeneration and tourism departments;
- corporate policy and resources; and
- Environment Agencies.

- **AQAP Progress.** A table of the measures being pursued by London boroughs as part of the AQAP should be provided.

Where relevant, the Council should add further detail with regards to the measures adopted in their AQAP, beyond the summary level information provided in the table. In particular if there are measures that are considered a priority or drawing out where local public support or action may be required.

- **Additional supporting appendices.** London boroughs should add additional supporting appendices as required. For example, where the selection of AQAP measures has been

supported by further studies, e.g. quantitative appraisal of AQAP measures through dispersion modelling, or other feasibility studies, this work should be included.

On-going Assessment of Progress – Keeping the AQAP Live

- 2.63 The success of the AQAP is dependent upon the on-going assessment and reporting of progress in the implementation of measures and the evidence acquired from on-going evaluation of the impacts of measures that are reported in the ASR. It can be difficult to directly assess reductions in emissions, therefore the use of monitoring to show the decline in pollutant concentrations attributed to the implementation of measures is an obvious basis on which London boroughs should provide evidence to show progress. However, for some measures, alternative indicators such as use of cycle schemes and passenger numbers on buses, can be used to report progress.
- 2.64 Progress against existing action and the introduction of new actions should be recorded annually in the AQAP progress report in the ASR.

Sources of Relevant Guidance

- 2.65 Additional guidance to assist local authorities with the update of their AQAPs includes the following documents:
- Policy Guidance LLAQM.PG(16);
 - LAQM Practice Guidance²⁰; and
 - Planning Practice Guidance on Air Quality²¹.
- 2.66 The LAQM Practice Guidance provides a steer on some of the more directly effective measures that local authorities can take to improve air quality. London boroughs may find it useful to refer to these additional Practice Guidance documents if they are considering establishing one of the schemes covered by the guidance. These Practice Guidance documents, which also refer to existing policy on economic principles and appraisal, include:
- Practice Guidance on economic principles for the assessment of local measures to improve air quality;
 - Practice Guidance on low emission zones;
 - Practice Guidance on measures to encourage the uptake of low emission vehicles;
 - Practice Guidance on measures to encourage the uptake of retro-fitted abatement equipment on vehicles;
 - Practice Guidance Worked Examples; and
 - Low Emissions Strategies (LES) Guidance.
- 2.67 Furthermore, a number of other useful guidance, reports, discussion papers, tools and examples of

²⁰ <http://laqm.defra.gov.uk/action-planning/aqap-supporting-guidance.html>

²¹ <http://planningguidance.planningportal.gov.uk/blog/guidance/air-quality/>

various good practice to assist in the AQAP process are available on the LAQM Support website²².

²² <http://laqm.defra.gov.uk/action-planning/aqap-supporting-guidance.html>

CHAPTER 3: Annual Status Report

Introduction

- 3.01 This chapter provides guidance to London boroughs in the preparation of air quality Annual Status Reports (ASR) and associated Annual Status Summary Report (ASSR). The ASR/ASSR replace the need to produce separate air quality Updating and Screening Assessments or Progress Reports, or Detailed Assessments.
- 3.02 The aim of the ASR is to simplify and streamline the LAQM system by combining the requirements of the Updating and Screening Assessment and Progress Report and, when required, additional supporting evidence. London boroughs need to prepare an ASR every year.
- 3.03 Provided that AQMAs are still in place, the ASR should also include a section discussing progress on AQAP measures.
- 3.04 The ASR/ASSR should be filed electronically using the LAQM Report Submission Website (RSW)²³. London boroughs should download the ASR/ASSR templates available on the RSW or LAQM Support¹⁰ websites, or the GLA website, complete offline, and upload on the RSW once completed. Once approved by the GLA, the ASR/ASSR should be placed onto the Council's website. If the GLA has concerns regarding the ASR conclusions, the borough will be invited to provide written comments justifying their decision within a specified deadline set out in the appraisal letter uploaded on the RSW.

Air Quality Monitoring Data within ASRs

- 3.05 Air quality monitoring data is still a crucial part of the LLAQM system, and it is important that London boroughs maintain their existing air pollution monitoring network, especially background monitoring, which provides useful information on long-term trends. Therefore, if London boroughs intend to decommission an air quality monitoring station, or significantly alter their existing monitoring network (i.e. moving existing or adding new sites), they must inform the GLA by providing 2 months' notice, stating the location and pollutants monitored and outlining the reason for the change.
- 3.06 The ASR should summarise local monitoring data collated by the Council over the past 7 years, and particularly focus on the last year of result, comparing these against the air quality objectives. The focus should be on NO₂, PM₁₀, PM_{2.5} and SO₂. Both long-term (i.e. annual means) and short-term (i.e. daily, hourly, or 15-min means) data should be reported and compared against the relevant objective.
- 3.07 The monitoring data should include both automatic monitoring analysers and (for NO₂) passive diffusion tubes. The ASR should only include a brief summary of monitoring data in the body of the report, with all technical information presented in Appendices, as per the template. Supporting technical information should include:
- Quality Assurance / Quality Control (QA/QC) information;

²³ <http://laqm.defra.gov.uk/1rsw/>

- Annualisation factors (to estimate annual means based on short-term monitoring results);
- Bias adjustment factors for NO₂ diffusion tubes;
- Other data corrections, such as Volatile Correction Model for PM₁₀ monitoring or, if required, NO₂ fall-off with distance correction to estimate the concentration at the nearest receptor representative of public exposure (see Chapter 4 for further information); and
- Monthly unadjusted NO₂ diffusion tube results for the most recent year.

Reassessment of AQMAs

3.08 As mentioned in para 1.24, all London boroughs have declared an AQMA, with the vast majority of AQMAs encompassing the entire borough. All current AQMAs across Greater London have been declared for the NO₂ and/or PM₁₀ objectives, but none for the SO₂ objectives. It is therefore not expected that any new AQMA will need to be declared across London, and anticipated changes are therefore likely to be limited to the following cases:

- Revocation of part or the entire AQMA for all or one pollutant (NO₂ / PM₁₀) and/or objective (long-term/short-term)
- Extension of current AQMAs (for those not encompassing the entire borough)
- No change in AQMA boundaries, but addition of a new pollutant and/or objective

3.09 London boroughs should reassess their AQMAs every four years only, based on:

- Results of air quality monitoring, as discussed above; and
- Concentration maps of NO₂, PM₁₀ and PM_{2.5}, which will be provided by the GLA, based on dispersion modelling of emissions across Greater London, compiled as part of the London Atmospheric Emissions Inventory (LAEI) database and made available on the GLA website²⁴.

3.10 Reassessment of AQMAs will start in 2020, coinciding with the LAEI update. London boroughs will be provided with concentration maps, made available at borough level, with a spatial resolution of 20m. These maps will be updated every four years based on dispersion modelling of updated emissions from the LAEI, carried out by the GLA. To assist with this, London boroughs will be provided with the following information:

- NO₂, PM₁₀ and PM_{2.5} annual mean concentration maps;
- Maps of NO₂ annual mean exceedance areas; and
- Pie charts of NO_x, PM₁₀ and PM_{2.5} emissions by source

3.11 The methodology to reassess AQMAs should be as follows:

- The first step should involve a trend analysis of air quality levels across the borough, based on available data from the Council's air quality monitoring network. The trend analysis should focus on the last 4 years of monitoring data, collated since the last assessment.
- For monitoring sites within the AQMA, the trend should identify whether there is any

²⁴ Data available at <http://data.london.gov.uk/dataset/llaqm-bespoke-borough-by-borough-air-quality-modelling-and-data>

significant change, which would require amending the AQMA. For example, if the AQMA has been declared for the NO₂ annual mean, and results are still exceeding the objective of 40µg/m³, the key criteria will be to determine whether there is a risk of exceeding the 1-hour mean objective as well. This should be based on a comparison with the 60µg/m³ threshold, as discussed in Chapter 4 (para 4.94).

- Conversely, if the trend clearly shows that concentrations within the AQMA have been below the relevant air quality objective, then London boroughs could consider revoking the AQMA for the relevant pollutant and objective. However, boroughs need to be reasonably certain that any future exceedances are unlikely. Therefore, revoking an AQMA should be based on at minimum, 3 years of robust monitoring data, to ensure that compliance with the objective is not due to the influence of meteorological conditions, for example (as these can lead to significant variations in air pollution from one year to the next).
- For monitoring sites outside the AQMA, the trend should identify whether there is a risk of exceeding any air quality objective. In that case, the borough should extend the AQMA accordingly to include the new areas of exceedance.
- If the monitoring shows that no changes are required, as discussed above, then the ASR should provide a statement, and no further information should be required.
- In case the monitoring data showed a change likely to lead to a change in the AQMA (partial/full revocation, extension of the AQMA, or new pollutant/objective added to the existing AQMA), London boroughs should use concentration maps produced by the GLA as part of the LAEI modelling package to support the decision with the available information. The maps should especially enable London boroughs to determine more accurately the new areas of exceedance, or, conversely, the areas meeting the air quality objectives. Therefore, London boroughs should be able to identify new areas to be incorporated within / excluded from their existing AQMA, or possibly support the decision to revoke the AQMA altogether, if the maps, in combination with the monitoring data trend, clearly indicate compliance with the objectives.

Actions to Improve Air Quality

3.12 This should be the core section of the ASR, focusing on the actions already implemented and/or actions that London boroughs plan to implement to work towards compliance with the air quality objectives.

Progress on Implementation of Action Plan Measures

3.13 If an AQAP has been produced and measures implemented, this section should provide information on how London boroughs have progressed / are progressing with the measures since last year. It should inform the reader on all measures completed, on-going, and planned. For measures completed or on-going, the ASR should summarise the impact on air quality, clearly highlighting successes and difficulties. For measures not yet implemented, the ASR should summarise the expected benefits on air quality, and link to the AQAP for further information.

3.14 The ASR template includes a summary table, which should help London boroughs report on AQAP progress. Note that boroughs do not have to report on all the actions included in the Air Quality Action Matrix within their ASR. Boroughs only need to report on the actions outlined in their own AQAPs

Cleaner Air Borough Status

- 3.15 London Boroughs are encouraged to report in this section of the ASR their progress against the six Cleaner Air Borough (CAB) Criteria:
- Political leadership;
 - Taking action;
 - Leading by example;
 - Using the planning system;
 - Integrating air quality into the public health system; and
 - Informing the public.
- 3.16 This will involve the completion of a short table, included in the ASR template.
- 3.17 The CAB status is linked to the Mayor's Air Quality Fund²⁵ (MAQF), a fund of approximately £20m delivered over 10 years. London boroughs which are designated as CABs will be prioritised for access to this fund, which is designed to finance projects aimed at the improvement of local air quality.
- 3.18 CAB status is also a useful communication and awareness tool to highlight and reward boroughs that are committed to taking action to improve air quality. To help raise awareness, a logo denoting CAB status is available for the local authorities use.
- 3.19 This section of the ASR is compulsory for those London boroughs who gained CAB status, should they wish to retain it. For London boroughs without CAB status, completion of this table is not compulsory, but London boroughs that demonstrate significant improvement toward, or achievement of, the criteria will then be designated as a CAB.
- 3.20 An annual review of the CAB status of each borough will be conducted, based on the information submitted in the ASR. A Borough will retain/gain their CAB status if they:
- Have completed the table;
 - Have demonstrated significant action against all six of the CAB criteria within their ASR; and
 - Are in fulfilment of all of their statutory duties and have provided any other information reasonably requested by the GLA (such as the details of Part B Processes for the LAEI).
- 3.21 Should these actions not be completed, CAB status may be revoked.

Additional Supporting Technical Information

- 3.22 As part of the ASR, London boroughs may also want to review and assess the main sources of pollution within the area. Prior to the implementation of the ASR, this was done as follows:
- The Review and Assessment Progress Report contained a list of changes/new sources of air

²⁵ Information available here: <https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/mayors-air-quality-fund>

pollution identified since the previous year. The Progress Report only needed to flag these up without any further action, so that these could be assessed in the following Updating and Screening Assessment report.

- The Updating and Screening Assessment required the local authority to screen any new or changed sources, to determine whether a Detailed Assessment was needed or not, before deciding whether a new AQMA was necessary or not. The screening assessment for each source was based on screening tools, such as the DMRB (Design Manual for Roads and Bridges) air quality screening tool (published by Highways England) for road traffic sources, or other screening tools for biomass and industrial sources.

3.23 Over the past few years, the vast majority of local authorities have not identified any significant changes in sources of air pollution, as most air quality hotspots across the UK have now been identified and well documented. As a result, the importance of screening assessments of new/changed sources has progressively reduced, and the focus has switched to air pollution monitoring data. It is therefore expected that this trend will continue.

3.24 Therefore, London boroughs are not required to report such changes in air pollution within the main body of the ASR. However, if deemed necessary, they may wish to screen such sources to determine whether their impact on air quality is deemed significant and include these in an Appendix. In that case, screening assessments should only be presented in Appendix. London boroughs should be able to identify the need for a screening assessment using the information provided in Chapter 4, Section 1 – Screening Tools and Methodology.

Annual Status Summary Report

3.25 The Annual Status Summary Report (ASSR) is intended to be the public facing section of the ASR. London boroughs are invited to prepare this section using the ASSR template provided on the RSW²³, LAQM Support or GLA websites. This way, it can be produced as a standalone document, which can then be published locally. The ASSR should aim at summarising, in simple terms, the following:

- What are the key air quality issues within the local authority's area;
- How air quality monitoring data collated by the borough compare to the air quality objectives, including a trend analysis;
- What are the recent key improvements achieved through action planning measures; and
- What will be the next priorities for the borough to continue working towards meeting the air quality objectives.

CHAPTER 4: Technical Supporting Information

Introduction

- 4.01 This chapter brings together a series of tools and other supporting information to help London boroughs producing their yearly ASR. Where appropriate, the general approach and methodology is described, and worked examples are provided, with reference to associated online tools available on the LAQM Support website. London boroughs should ensure that they use the latest version of tools and are strongly recommended to register for automatic updates with the LAQM Support Helpdesk²⁶.
- 4.02 This chapter is split into four main topics, as follows:
- Screening Tools and Methodology;
 - Air Quality Monitoring; and
 - Emission Calculations.

1 – Screening Tools and Methodology

- 4.03 This section provides the methodology and associated tools that London boroughs should use to screen sources of pollutions as part of the Annual Status Report (ASR), if significantly new or changed sources are identified.
- 4.04 After over 15 years of LAQM, it is recognised that, from now on, screening assessments required for the purpose of Review and Assessment are unlikely to be as numerous as in the early stages of the LAQM system, for the following reasons:
- All local authorities have now completed 5 rounds of Updating and Screening Assessments since 2003. This means that most current sources likely to give rise to exceedances of the air quality objectives should have been screened at least once;
 - All sources of concern identified in previous rounds should have been further assessed and conclusions reported in previous Detailed Assessments, generally based on detailed dispersion modelling of emissions or air quality monitoring campaigns;
 - For those sources confirmed to lead to exceedances, AQMAs should have been declared, and AQAPs implemented to tackle air pollution and work towards meeting the objectives. It is unlikely that many local authorities will need to proceed to new screening assessments in the future for emissions sources within existing AQMAs; and
 - Many local authorities have installed permanent air quality monitoring sites (such as continuous monitoring analysers or NO₂ diffusion tubes) near those sources of concern that were borderline (i.e. sources below but close to the relevant screening criteria, or for which a Detailed Assessment has been carried out, which concluded that an AQMA was not required). Therefore, in most cases, existing air pollution monitoring networks have replaced the need to screen these sources. This is particularly true for road-traffic sources.
- 4.05 New or modified sources of emissions will usually be assessed for air quality and appraised by the

²⁶ <http://laqm.defra.gov.uk/helpdesks.html>

local authority as part of the planning application process. However, screening assessments may still be required for various reasons, including:

- Where new sources of pollution have been identified (in particular industrial sources, or new roads);
- Where emissions are likely to have increased significantly (for example, due to significant increases in traffic flows along major roads, or extensions of industrial facilities; or
- Where there is new exposure to air pollution (for example in case of new residential developments near busy roads).

4.06 The methodology that should be followed to screen air pollution sources is proposed in the section below, for each of the following categories:

- Road traffic sources;
- Non-Road Transport Sources (i.e. Airports, Railway and Ports);
- Industrial Sources;
- Commercial and Domestic Sources; and
- Fugitive or Uncontrolled Sources.

4.07 Annex B provides local authorities with a decision-making tree, aimed to facilitate the selection of the most appropriate screening method when assessing the impact of stack emissions on local air quality, either for planning purposes or local authority Review and Assessment.

4.08 In the context of screening sources of pollution as part of the ASR, London boroughs are expected to undertake such screening assessments when they have suitable local evidence or cause to believe that a new development or change in an existing emissions' source could result in one of these criteria being met. Such information should be reviewed on an annual basis.

Road Traffic Sources

4.09 It is expected that most roads of concern will already have been assessed (sometimes more than once) in previous rounds of Review and Assessment. The roads identified as likely to exceed the objectives have been through further assessment (based on detailed dispersion modelling) and, where exceedances have been confirmed, are all likely to be incorporated within existing AQMAs. As road traffic emissions represent the main issue faced by UK local authorities, as confirmed by the number of AQMAs declared solely for road traffic sources²⁷, most local authorities' monitoring networks are now mainly focused on monitoring concentrations along these roads of concern. It is therefore unlikely that local authorities would have missed any roads where the objectives are breached.

4.10 Nevertheless, local authorities may need to proceed with screening assessments in a number of cases, such as for newly built roads, roads where traffic flow conditions have changed significantly (i.e. increase in overall traffic flow, the flow of HDVs, or increase in congestion), where there is new exposure (i.e. newly built residential properties), or potentially if roads have

²⁷ Up-to-date statistics are available on the AQMA website at <http://uk-air.defra.gov.uk/aqma/summary>

not been properly screened for a number of years.

4.11 Attention only needs to be given to NO₂ and, in some case, PM₁₀. The assessment should consider roads that fall within any of the categories below:

- **Narrow congested streets with residential properties close to the kerb.** Concentrations are often higher in these areas, due to the combination of slow moving traffic with stop/start driving conditions, and street canyon effect due to buildings on either side of the road, preventing good dispersion of pollutants;
- **Busy streets where people may spend 1-hour or more close to traffic.** For example, streets with many shops and streets with outdoor cafes and bars;
- **Roads with high HDV flows.** Roads with unusually high proportion of buses and/or HGVs can lead to high concentrations, even if total traffic is not particularly high;
- **Junctions,** where concentrations are usually higher due to the contribution of multiple roads combined with increased emissions due to stop start driving conditions;
- **New roads constructed or proposed.** The approach to considering new roads will depend on whether or not an assessment was carried out in advance of building the new road;
- Roads with significantly changed traffic flows; and
- **Bus and coach stations.** If they are not enclosed, and there is relevant exposure nearby.

4.12 Details of the methodology to follow to screen all source categories as above are provided in Table 4.1. Note that a screening assessment should **not** be necessary for locations:

- within existing AQMAs declared for road traffic sources for the specific pollutant under consideration; or
- outside AQMAs where air quality monitoring data is already available, provided the monitoring site is representative of the worst-case exposure location, and data QA/QC is adequate.

Table 4.1 – Screening Assessment of Road Traffic Sources

Road Source Category	Pollutant of Concern	Objectives of Concern ⁽¹⁾	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
1 -Narrow congested streets with residential properties close to the kerb.	NO ₂	Long and Short-Term	5,000 vehicles/day- exposure within 2m from kerb - slow moving traffic with frequent stop/start	Roads matching criteria	Carry out NO ₂ monitoring survey ⁽²⁾ - Use results in next yearly LAQM report to determine whether an AQMA needs to be declared	Monitoring is recommended, as screening models generally fail to identify actual exceedances in these areas
2 - Busy streets where people may spend 1 hour or more close to traffic	NO ₂	Short-Term	10,000 vehicles/day - exposure within 5m from kerb >= 1-hour	Results of DMRB Screening Assessment ⁽⁴⁾ to identify annual mean concentrations > 60µg/m ³	Carry out monitoring survey ⁽²⁾ and/or detailed dispersion modelling - to identify annual mean concentrations > 60µg/m ³ ⁽³⁾	If AQMA already declared for NO ₂ annual mean, only amend AQMA and AQAP to include 1-hour mean
3 - Roads with a high flow of HDVs	NO ₂ / PM ₁₀	Long and Short-Term	2,500 HDVs/day - exposure within 10m from kerb (20m in conurbations > 2m inhabitants)	Results of DMRB Screening Assessment ⁽⁴⁾ to identify exceedances	Carry out monitoring survey ⁽²⁾ and/or dispersion modelling ⁽³⁾	If AQMA already declared for one of the objectives, only amend AQMA and AQAP to include the additional objectives exceeded
4 - Junctions	NO ₂ / PM ₁₀	Long and Short-Term	10,000 vehicles/day - exposure within 10m from kerb (20m in conurbations > 2m inhabitants)	Results of DMRB Screening Assessment ⁽⁴⁾ to identify exceedances	Carry out monitoring survey ⁽²⁾ and/or dispersion modelling ⁽³⁾	Where two or more roads intersect, the traffic flows from each arm of the junction should be summed to give a combined total, which should then be divided by two before comparison against the screening criteria.
5 - New roads constructed or proposed since the last round of Review	NO ₂ / PM ₁₀	Long and Short-Term	if no air quality assessment available from planning application - 10,000 vehicles/day - exposure within	air quality assessment available: exceedances predicted in submitted assessment	Declare AQMA / Carry out additional dispersion modelling beforehand if deemed necessary	

Road Source Category	Pollutant of Concern	Objectives of Concern ⁽¹⁾	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
and Assessment			10m from kerb (20m in conurbations > 2m inhabitants)	No air quality assessment available: results of DMRB Screening Assessment ⁽⁴⁾ to identify exceedances	Carry out monitoring survey ⁽²⁾ and/or dispersion modelling ⁽³⁾	If the new road has increased traffic flow on existing roads where concentrations are likely to be below but close to the objectives (typically within 10%), then these should also be assessed
6 - Roads with significantly changed traffic flows	NO ₂ / PM ₁₀	Long and Short-Term	25% traffic increase on roads > 10,000 vehicles/day - exposure within 10m from kerb (20m in conurbations > 2m inhabitants) - Roads previously identified at risk of exceeding (within 10% of objective)	Results of DMRB Screening Assessment ⁽⁴⁾ to identify exceedances	Carry out monitoring survey ⁽²⁾ and/or dispersion modelling ⁽³⁾	
7 - Bus and coach stations	NO ₂	Long and Short-Term	2,500 bus/coach movements/day ⁽⁵⁾ - exposure within 10m from kerb (20m in conurbations > 2m inhabitants)	Results of DMRB Screening Assessment ⁽⁴⁾ to identify exceedances	Carry out monitoring survey ⁽²⁾ and/or dispersion modelling ⁽³⁾	If AQMA already declared for NO ₂ annual mean, only amend AQMA and AQAP to include 1-hour mean.
⁽¹⁾ Long-term refers to annual mean - Short-term refers to 1-hour mean (for NO ₂) or 24-hour mean (for PM ₁₀)						
⁽²⁾ Monitoring survey should be carried out for a minimum 6-month period						
⁽³⁾ London boroughs may decide to declare an AQMA straightaway at this stage.						
⁽⁴⁾ See para 4.84 for details on the DMRB air quality screening tool and methodology						
⁽⁵⁾ A bus movement considers a bus either arriving, or leaving the station. A bus arriving then leaving therefore counts for 2 movements						

Non-Road Transport Sources

- 4.13 Non-road transport sources include airports, railways and shipping emissions. It is unlikely that many local authorities will have to proceed with a screening assessment of these sources, for the following reasons:
- These sources are limited in number, and therefore it is expected that existing sources will have been screened in previous rounds of Review and Assessment;
 - Since the inception of the LAQM system, only a handful of these sources required further assessment, and even less led to the declaration of an AQMA²⁸.
- 4.14 However, a summary of the methodology that may still be applied to screen these sources, if necessary, is described below. It is however recommended that local authorities contact the LAQM Support Helpdesk before reporting the screening assessment.
- 4.15 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. Assessments will only be required where new sources arise, where significant changes have occurred or if there is new relevant exposure near existing sources.

Airports

- 4.16 Aircraft are potentially significant sources of NO_x emissions, especially during take-off, and therefore the main risk is related to potential exceedances of the NO₂ air quality objectives. It is likely that all airports have been subject to a screening assessment in previous rounds of Review and Assessment; however, in case of significant changes (such as increase in airport capacity, or new population exposure near the airport), the local authority should be able to screen aircraft emissions from airports based on the following:
- Determine relevant exposure within 1km of the airport boundary;
 - If exposure has been identified, determine whether the airport total equivalent passenger throughput is more than 10 million passengers per annum (mppa). Freight should also be considered, and converted to equivalent mppa using 100,000 tonnes = 1 mppa;
 - Identify whether the background annual mean NO_x concentration is above 25µg/m³ in these areas.
- 4.17 If all of the above criteria are matched, then the local authority should conclude that there is a risk of exceedance of the NO₂ annual mean objective, and carry out an NO₂ monitoring survey (6-month period minimum) at relevant receptors to determine whether an AQMA should be declared. It is not recommended that local authorities carry out dispersion modelling of airport emissions for their screening purpose, as this can be time consuming and resource intensive, and results are likely to be subject to significant uncertainties. If an air quality assessment has been submitted by the airport operators, this should be reviewed and conclusions summarised as supporting information.

Railway

- 4.18 Diesel or coal fired stationary locomotives can give rise to high short-term SO₂ concentrations near railway stations or depots. Additionally, moving diesel locomotives can contribute to elevated short-term NO₂ concentrations close to the track. It is likely that all sources of concern have been

²⁸ The only AQMAs declared for non-mobile sources are the Great Central Railway AQMA declared by Charnwood Borough Council in 2004 for SO₂, and the Dover Docks AQMA declared in 2002 for the same pollutant due to shipping emissions. However the latter has been revoked in 2014.

assessed in previous rounds of Review and Assessment, given the few number of railway lines not yet electrified. However, in case of new exposure near the lines of concern, local authorities may need to reassess these, based on the following:

Stationary diesel or steam locomotives:

- Identify locations where diesel or steam locomotives are regularly (at least 3 times a day) stationary for periods of 15 minutes or more;
- Determine relevant exposure within 15m of the locomotives;

Moving diesel locomotives:

- Determine relevant exposure within 30m of the relevant railway tracks (Table 4.2 provides information on which lines should be considered);
- Identify whether the background annual mean NO₂ concentration is above 25µg/m³ in these areas.

4.19 If the above criteria are matched, then the local authority should conclude that these is a risk of exceedance of the SO₂ 15-minute mean objective (for stationary locomotives) or the NO₂ annual mean objective (for moving locomotives), and carry out a monitoring survey (6-month period minimum) at relevant receptors to determine whether an AQMA should be declared.

Table 4.2 – Rail Lines with a Heavy Traffic of Diesel Passenger Trains

Relevant Rail Lines
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 Junction
Leeds to Bradford only for about 1 mile to west of Leeds station
Glasgow to Edinburgh

Ports

4.20 It is likely that most sources of concern in London have been assessed in previous rounds of Review and Assessment, and no AQMA has been required due to port emissions within Greater London. Therefore, screening assessment of port emissions should not be necessary.

4.21 However, in cases of port expansion for cruise liners or other river traffic, specialist advice may be needed. The LAQM Helpdesk can be contacted for further advice on the methods available to quantitatively assess the potential impacts.

Non-Road Mobile Machinery

- 4.22 Non-Road Mobile Machinery (NRMM) refers to mobile machines, transportable industrial equipment or vehicles which are fitted with an internal combustion engine and not intended for transporting goods or passengers on roads.
- 4.23 Experience of assessing the exhaust emissions from NRMM and site traffic suggests that, with suitable controls and site management, they are unlikely to make a significant impact on local air quality. In the vast majority of cases they will not need to be quantitatively assessed – qualitative consideration (see further information in para 4.30 below) will likely provide sufficient screening. Where there is considered to be an elevated risk of local air quality issues arising from NRMM activities, please contact the LAQM Helpdesk for further advice on the methods available to quantitatively assess the potential impacts.
- 4.24 Pollutants emitted by NRMM that may have the most significant potential effects on local air quality are particulate matter (PM₁₀ and PM_{2.5}), and NO_x/NO₂. Within London, in 2010 the NRMM used on construction sites was responsible for 12% of NO_x emissions and 15% of PM₁₀ emissions in Greater London²⁹. Typically NRMM is associated with construction sites. There is thus a potential for NRMM emissions to adversely affect local air quality, the extent to which is dependent upon the following considerations:
- Duration of works and associated phasing plans;
 - Type and number of NRMM to be used on site;
 - Operating hours of NRMM;
 - Emissions standards to which NRMM comply;
 - Proximity of receptors to NRMM working areas; and
 - Existing background pollutant concentrations.
- 4.25 It should be noted that an increased density of construction sites within a borough, and/or ‘back-to-back’ schemes within the same or nearby geographical area, may lead to a more detailed consideration of the cumulative emissions. For this reason, London has introduced an NRMM Low Emission Zone.

NRMM LEZ

- 4.26 From 1 September 2015 NRMM of net power between 37kW and 560kW used in London will be required to meet the standards set out below, which are based upon engine emissions standards set in EU Directive 97/68/EC and its subsequent amendments. This will apply to both variable and constant speed engines for both NO_x and PM. From 1 September 2020, the standards will tighten.
- 4.27 There are two distinct areas where differing standards will apply, Greater London and the Central Activity Zone (CAZ)/ Canary Wharf³⁰.

From the 1st September 2015:

- NRMM used on any site within the Central Activity Zone or Canary Wharf areas will be required to meet Stage IIIB of EU Directive 97/68/EC.

²⁹ Greater London Authority (2014). The control of dust and emissions during construction and demolition - Supplementary Planning Guidance. Available at:

https://www.london.gov.uk/sites/default/files/Dust%20and%20Emissions%20SPG%208%20July%202014_0.pdf

³⁰ Map available at: <https://nrmm.london/nrmm>

- NRMM used on the site of any major development (defined as any site of upward of 10 dwellings or a site area of 0.5 ha for residential usage, or floor space of 1000m² or a site area of 1ha for mixed land use) within the wider Greater London area will be required to meet Stage IIIA of EU Directive 97/68/EC.

From the 1st September 2020:

- NRMM used on any site within the Central Activity Zone or Canary Wharf areas will be required to meet Stage IV of EU Directive 97/68/EC.
- NRMM used on any site within the wider Greater London area will be required to meet Stage IIIB of EU Directive 97/68/EC.

4.28 Local authorities will implement the NRMM LEZ through planning conditions attached to planning permissions or section 106 agreements. Local authorities should ensure the requirements are also carried through to the development air quality management plan.

4.29 All eligible NRMM should meet the standards above unless it can be demonstrated that the required machinery is not available or that a comprehensive retrofit to meet both PM and NO_x emission standards is not feasible. In this situation every effort should be made to use the least polluting equipment available including retrofitting technologies to reduce particulate matter emissions.

4.30 The following provides example measures of how NRMM emissions from construction sites may be minimised:

- Ensure all equipment complies with the appropriate NRMM standards by reorganising the fleet and replacing equipment where necessary;
- Where feasible, ensure further retrofit abatement technology is installed on existing NRMM equipment, e.g. Diesel Particulate Filters (DPFs);
- Ensure all vehicles switch off engines when stationary – no idling vehicles;
- Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where possible; and
- Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate).

4.31 However, it is recognised that some NRMM plant is not yet widely available in the numbers required to meet the above standards and that some options can be cost prohibitive. As such the GLA will publish a list of NRMM that is exempt from the policy³¹, which will be reviewed on an annual basis.

4.32 To enable enforcement of the LEZ, site managers within the NRMM LEZ will be required to maintain an inventory of all NRMM used at their site, the NRMM Register³². Local Authorities in London are encouraged to set up user accounts, through which they can monitor this register and ensure the relevant standards are being adhered to. Full guidance on this process is available online³³. Where a site that meets the criteria has not registered, the local authority planning

31 <https://nrmm.london/nrmm/about/nrmm-exemption-policy>

32 <https://nrmm.london/user-nrmm/register>

33 <https://nrmm.london/nrmm/how-use/local-authority>

enforcement officer should contact the site manager to request registration.

- 4.33 Where a site is using equipment that is non-compliant, it may be necessary to take further action. Penalties will depend on the individual borough and their planning enforcement teams.

Industrial Sources

- 4.34 Industrial sources are unlikely to make a significant contribution to annual mean concentrations, but may contribute to elevated short-term concentrations, which may lead to exceedances of the short-term air quality objectives (e.g. 15-minute mean for SO₂, 1-hour mean for NO₂ or 24-hour mean for PM₁₀). The assessment should consider the potential impact of specific industrial processes or chemical storage for all of the regulated pollutants. Generally, those most at risk of requiring further work are NO₂, PM₁₀ and potentially SO₂.
- 4.35 Details of the methodologies to use to screen industrial sources are provided in Table 4.3. Industrial sources to consider are broken into the following categories:
- Industrial installations; and
 - Major petrol storage depots and petrol stations.

Industrial Installations

- 4.36 London boroughs should screen industrial installations by using the Industrial Emissions Screening Tool available for download on the LAQM Support website³⁴.
- 4.37 This Excel tool has been developed to help local authorities determine, for each pollutant and air quality objective of concern, the maximum annual emissions from an industrial installation for which a risk of exceedance is unlikely. Therefore, the methodology consists of comparing the actual annual emissions for each industrial installation (identified using Table 4.3) against the maximum annual emissions calculated by the tool.
- 4.38 If actual emissions are greater than the maximum emissions, then the local authority should proceed to detailed dispersion modelling and/or monitoring³⁵.
- 4.39 The tool is based on a series of nomograms developed as part of previous LAQM Technical Guidance, but which are still considered relevant³⁶. It considers both industrial stack emissions and low-level, fugitive emissions. In order to use this tool, local authorities will need to gather the following information for each industrial installation requiring screening:
- Stack internal diameter;
 - Actual stack height above ground level;
 - Actual annual emissions for all pollutants of concern;
 - Where necessary, exit stack temperature
 - Where necessary, distance to nearest relevant exposure;

34 <http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html>

35 Supporting information to be submitted as an appendix in the next ASR.

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

- Height of nearby buildings, which may prevent good dispersion of the plume; and
 - Where necessary, background concentrations of the pollutant assessed.
- 4.40 Further information is provided in the tool. To determine background pollutant concentrations, local authorities should use suitable pollution monitoring sites nearby or, if unavailable, the UK background maps (see paras 4.71 to 4.73).
- 4.41 Before using the Industrial Emissions Screening Tool, London boroughs should consider the following:
- Emissions from combustion sources from low temperature (<100°C) and high temperature (>100°C) sources are treated separately, due to different buoyancy effects;
 - 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 shortest stack; and
 - Where there are complex sites, with many stacks, the screening tool is unlikely to be applicable, and authorities are advised to proceed to detailed dispersion modelling.
- 4.42 When using the Industrial Emissions Screening Tool, an effective stack height is calculated where necessary. Therefore, manual calculation of the effective stack height should not be required when using the tool, although for transparency the associated calculation method is provided in Box 4.1.

Box 4.1 - 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 3m 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:

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

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 (i.e. **U_{eff}** is negative) then treat the source as a ground level source.

Petrol Storage Depots and Petrol Stations

- 4.43 Major petrol fuel depots and petrol stations were identified in previous LAQM Technical Guidance as potential sources of concern, due to potential elevated emissions of C₆H₆ (benzene), especially if combined with higher levels from nearby busy roads. However, it is likely that all sources of concern have been assessed in previous rounds of Review and Assessment. No AQMA has been declared in the UK for this source since 2010 (when the last AQMA for benzene was revoked) and, therefore, new assessments are unlikely to be required.
- 4.44 However, in case of significant changes (new population exposure near the source), the local authority should be able to screen emissions using the following methodology:

Major Petrol Storage Depots:

- Use the Industrial Emissions Screening Tool for benzene. This would require identifying the following parameters (if unsure, the LAQM Support Helpdesk should be contacted):

- Distance to the nearest relevant exposure;
- C₆H₆ annual emissions from the source; and
- Height of release (i.e. stack height or ground level if fugitive source).

Petrol Stations:

- Follow the steps described in Table 4.3.

Table 4.3 – Screening Assessment of Industrial Sources

Source Category	Pollutant of Concern	Objectives of Concern	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
Industrial Installations	All Pollutants	Long and Short-Term	if no air quality assessment available from planning application - New source or existing source with significant increase (30%) in emissions - with population exposure nearby	air quality assessment available: exceedances predicted in submitted assessment	Declare AQMA / Carry out additional monitoring and/or dispersion modelling beforehand if deemed necessary	Contact the LAQM Support Helpdesk if unsure how to determine emissions
				No air quality assessment available: results of Industrial Screening Tool	Carry out monitoring and/or dispersion modelling	
Major Petrol Storage Depots	C ₆ H ₆	Long-Term	-	Results of Industrial Screening Tool	Carry out monitoring and/or dispersion modelling	
Petrol Stations	C ₆ H ₆	Long-Term	Petrol throughput > 2,000m ³ or 2 million litres per year - Near busy road (>30,000 vehicles/day) - Exposure within 10m from the pumps	Petrol stations matching criteria	Carry out monitoring and/or dispersion modelling	Ignore petrol stations fitted with Stage 2 recovery systems can be ignored. Ignore diesel throughput - only consider petrol

Commercial and Domestic Sources

- 4.45 These sources include gas-fired Combined Heat and Power (CHP) and biomass combustion sources (both from the commercial and domestic sectors), as well as other solid-fuel combustion sources (from the domestic sector only).
- 4.46 Details of the methodology to follow to screen these sources are provided in Table 4.4. The sources to consider are broken down into the following categories:
- Commercial and domestic gas-fired CHP combustion;
 - Commercial and domestic biomass combustion, which is further split into:
 - Individual installations; dealing with the assessment of large installations; and
 - Combined installations; dealing with the combined impact of smaller biomass installations.
 - Domestic other solid-fuel combustion.
- 4.47 It is important to note that, as part of the London Plan, the GLA has published a Supplementary Planning Guidance (SPG) document³⁷, which provides the minimum emission standards that boilers and CHP plant, proposed as part of new developments across London, should meet. The SPG, which provides emission standards for individual / communal gas and solid biomass boilers, as well as CHP plant, should be referred to by London boroughs assessing commercial or domestic combustion sources.

37 GLA, April 2014, Sustainable Design and Construction – Supplementary Planning Guidance. Available online at <https://www.london.gov.uk/what-we-do/planning/implementing-london-plan/supplementary-planning-guidance/sustainable-design-and>

Table 4.4 – Screening Assessment of Domestic Sources

Source Category	Pollutant of Concern	Objectives of Concern	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
Commercial and Domestic Gas-Fired CHP Combustion - Individual Installations	NO ₂	Long-Term (NO ₂)	Screen using the CHP Screening Tool (see paras 4.48-4.52)	Results of CHP Screening Tool	Carry out monitoring and/or dispersion modelling	<p>The CHP Screening Tool calculates only the contribution of the CHP process to the maximum NO₂ annual mean concentration at the worst-case location, i.e. does not take account of background NO₂ levels.</p> <p>A suitable background concentration should therefore be identified and added to the calculated CHP process contribution, for comparison against the annual mean objective.</p>
Commercial and Domestic Biomass Combustion - Individual Installations	NO ₂ / PM ₁₀	Long and Short-Term (NO ₂) / Short-Term (PM ₁₀)	Screen against Target Emission Rate from Biomass Calculator (see paras 4.53-4.58)	Results of Biomass Calculator	Carry out monitoring and/or dispersion modelling	Contact the LAQM Support Helpdesk if unsure how to determine actual maximum emissions rates

Source Category	Pollutant of Concern	Objectives of Concern	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
Commercial and Domestic Biomass Combustion - Combined Installations	PM ₁₀	Long and Short-Term	Screen against Threshold Emissions Density from Biomass Calculator (see paras 4.59 to 4.64)	Results of Biomass Calculator	Carry out monitoring and/or dispersion modelling	Report "Technical Guidance: screening assessment for biomass boilers" contains a more detailed description of the approach ³⁸ .
Domestic Other Solid-Fuel Combustion	SO ₂	Long and Short-Term	Density of coal burning premises = 100 per 500x500m area	Coal burning premises exceeding the criteria	Carry out monitoring and/or dispersion modelling	

38 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 at http://uk-air.defra.gov.uk/reports/cat18/0806261519_methods.pdf

Gas-fired CHP Combustion - Individual Installations

- 4.48 Gas-fired CHP combustion can lead to an increase in NO₂ emissions.
- 4.49 Local authorities should screen individual gas-fired CHP combustion installations by using the CHP Screening Calculator available for download on the LAQM Support website³⁴. The CHP tool considers emissions from natural gas and biogas firing CHP, from internal combustion engines and gas turbines.
- 4.50 The Excel tool has been developed to help local authorities determine the maximum annual mean NO₂ concentration contributed by the CHP stack at the point of maximum impact. Therefore, for each CHP installation identified (using Table 4.4) the methodology consists of adding the CHP process contribution as calculated by the tool to an appropriate background concentration, so that the resultant total annual mean NO₂ concentration can be compared against the annual mean air quality objective and the risk of a potential exceedance identified.
- 4.51 The tool is based on a number of nomograms developed as part of previous versions of LAQM Technical Guidance, which are still considered relevant³⁶. In order to use this tool, local authorities will need to gather the following information as a minimum for each of the CHP installations requiring screening - user-provision of other parameters will improve the reliability of the predicted result:
- The KW_e output of the CHP unit;
 - The physical stack height and diameter;
 - The height of the dominant nearby building; and
 - The distance to closest sensitive receptors (for low stacks).
- 4.52 Further information is provided in the tool. To determine background pollutant concentrations, local authorities should use suitable pollution monitoring sites nearby or, if unavailable, use the UK background maps (see paras 4.71 to 4.73)

Biomass Combustion - Individual Installations

- 4.53 Biomass burning can lead to an increase in PM₁₀ emissions and, compared to conventional gas-burning, can also result in an increase in the overall NO_x emissions.
- 4.54 Local authorities should screen individual biomass combustion installations by using the Biomass Calculator available for download on the LAQM Support website³⁴.
- 4.55 This Excel tool has been developed to help local authorities determine the maximum emission rate (in grammes per second) from a combustion installation for which a risk of exceedance of the relevant air quality objective is unlikely. Therefore, the methodology consists of comparing, for each biomass installation identified (using Table 4.4), the actual maximum emission rate for pollutants against the Target Emission Rate calculated by the tool.
- 4.56 If the actual emission rate is greater than the Target Emission Rate, then the local authority should proceed to a further assessment³⁵, based on detailed dispersion modelling.
- 4.57 The tool is based on a number of nomograms developed as part of the previous version of LAQM

Technical Guidance, which are still considered relevant³⁶. In order to use this tool, local authorities will need to gather the following information for each of the biomass installations requiring screening:

- Stack internal diameter;
- Actual stack height above ground level;
- NO_x and PM₁₀ actual maximum emission rates;
- Height of nearby buildings, which may prevent good dispersion of the plume; and
- NO₂ and PM₁₀ background concentrations around the installation.

4.58 Further information is provided in the tool. To determine background pollutant concentrations, local authorities should use suitable pollution monitoring sites nearby or, if unavailable, use the UK background maps (see paras 4.71 to 4.73).

Biomass Combustion – Combined Installations

4.59 There is also the potential that many small biomass combustion installations (including domestic solid-fuel burning), whilst individually acceptable, could in combination lead to unacceptably high PM₁₀ concentrations, particularly in areas where concentrations are close to or above the objectives.

4.60 Local authority officers should draw on their local knowledge to help decide whether the number of households burning biomass, or the commercial floorspace heated by biomass boiler, is of concern. Allowance should be made for combinations of domestic and commercial sources of solid fuels including biomass. Possible indicators of higher than average emissions densities resulting from solid fuel burning include:

- Complaints about nuisance dust or odour relating to burning;
- Visual signs of chimney smoke being emitted from several properties near to each other;
- Smell of burning solid fuel;
- Known high levels of sales of solid fuel via home delivery or local outlets; and
- Areas known to have limited or no access to mains gas.

4.61 Where local knowledge indicates a potential issue, local authorities should assess combined biomass impacts by using the Biomass Calculator available for download on the LAQM Support website³⁴.

4.62 The Excel tool has been developed to help local authorities determine the maximum emissions density (in kg/annum for a 500m² area) from combined combustion installations, for which a risk of exceedance of the relevant PM₁₀ air quality objective is unlikely. It is designed to be applied to emissions from the domestic and commercial sectors combined.

4.63 The procedure is as follows, with an example calculation set out in Box 4.2:

- 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 provided on the LAQM Support website³⁹.
- Count the numbers of each domestic heating appliance type in the identified 500m × 500m squares (equivalent to 25ha⁴⁰). Estimate the floorspace occupied (in hectares) in the service sector in each of the identified 500m × 500m 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 provided on the LAQM Support website³⁹. Sum the emissions from each of the domestic appliance types to give the total annual domestic emission from the 500m × 500m 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 500m × 500m square. Add the service sector emissions to the domestic emissions to give the total emissions from the square⁴¹.
- Estimate the fraction of space in the 500m × 500m 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 500m × 500m area).

4.64 If the emissions density from the square exceeds the relevant Threshold Emissions Density, then the authority will need to proceed to detailed dispersion modelling and/or monitoring.

4.65 Further information is provided in the tool. To determine background pollutant concentrations, local authorities should use suitable pollution monitoring sites nearby or, if unavailable, use the UK background maps (see paras 4.71 to 4.73).

³⁹ <http://laqm.defra.gov.uk/>

⁴⁰ 1 hectare (ha) = 10,000m²

⁴¹ 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

Box 4.2 – Combined Biomass Combustion Installations: Example of Calculation for Screening Assessment

Consider a 500m × 500m square (25ha) containing a new 6 hectare development of 400 houses on the outskirts of a large town. The houses are fitted with 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 500m × 500m 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 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 500m × 500m square does not contain premises burning solid fuels.

Using the estimates of annual emissions per household or hectare of service sector floorspace provided on the LAQM Support Website³⁹, the total emissions of PM₁₀ from the residential area is $(400 \times 1.4) + (50 \times 13.0) = 560 + 650 = 1,210$ kg. The total emissions of PM₁₀ from the school and the public house are $(0.2 \times 214) + (0.1 \times 12,453) = 43 + 1,245 = 1,288$ kg. The total emissions from all solid fuel sources are then $1,210 + 1,288 = 2,498$ kg.

The area of the 500m × 500m square occupied by solid fuel heated premises is $6 + 8 + 1 + 0.5 = 15.5$ hectares. Thus the fraction occupied is $15.5/25 = 0.62$. The emissions density is then $2,498 / 0.62 = 4,029$ kg /year.

The background PM₁₀ in the area is estimated from the national maps to be $21 \mu\text{g}/\text{m}^3$. From the Biomass Calculator, the threshold emissions density for a large town is 5,013 kg/year. In this case, the calculated emissions for the 500m × 500m square are less than the threshold and there is no requirement to carry out further assessment.

- 4.66 Where detailed modelling is then undertaken, whilst it may not be necessary to model emissions from individual properties, the 'emission areas' will need to be carefully defined. Simple aggregation of emissions into 1km or 500m grid squares is unlikely to provide a sufficient degree of resolution. In the absence of other supporting data, sensitivity analysis based on aggregated emissions at street level, or clusters of solid fuel-burning properties, should be undertaken to support the approach that is taken. Any such studies should be explicitly included in the associated report. Where the fuel -use survey has been designed with post-code references, these may be used to map the emissions data, and assist with the process of aggregation.
- 4.67 It is expected that the area of any predicted exceedances will lie within relatively close proximity to the emissions sources. Whilst the reduction in pollutant concentrations with increasing distance from roads is well documented, the variation in pollutant concentrations within, and close to solid fuel-burning areas, is not so well defined. It is therefore important to ensure that the receptor grid spacing used in any subsequent detailed modelling is of a sufficient resolution to identify the maximum pollutant concentrations. Sensitivity analysis on receptor spacing may be required to justify the final approach that is taken.

Fugitive or Uncontrolled Sources

- 4.68 Dust emissions from a range of fugitive and uncontrolled sources can give rise to elevated PM₁₀ concentrations.
- 4.69 Dust may arise from:
- onsite activities, such as handling of dusty materials, the cutting of concrete, etc;
 - wind-blown dust from stockpiles and dusty surfaces; or
 - the passage of vehicles over unpaved ground and along public roads affected by dust and

dirt tracked out from dusty sites;

4.70 Details of the methodology to screen fugitive sources of PM₁₀ are provided in Table 4.5. The assessment should be carried out if:

- The source has been identified as of potential concern, either from dust complaints (a single, verified complaint may be sufficient to trigger the need for a screening assessment), local knowledge (site inspection) or following an air quality assessment submitted as part of the planning application; and
- There is relevant exposure near the sources of emissions. The distance to consider depends on the local background PM₁₀ concentrations, as per Table 4.5, which can be determined from the UK background maps.

Table 4.5 – Screening Assessment of Fugitive or Uncontrolled Sources

Road Source Category	Pollutant of Concern	Objectives of Concern	Criteria	What to Report	Action if Screening Confirms Potential Issue	Notes
Fugitive or Uncontrolled Sources	PM ₁₀	Long and Short-Term	Exposure within 200m of the source of emission (up to 1km if background PM ₁₀ > 28µg/m ³)	Sources matching criteria	Carry out monitoring and/or dispersion modelling	If the relevant exposure is within 50m of an off-site road used to access the site and there are visible deposits on the road, then exposure along these sections of road, which may extend up to 1km from the site entrance, should also be considered, as long as the PM ₁₀ annual mean background concentration is above 25µg/m ³ .

Background Pollutant Concentrations

- 4.71 Contribution of emissions from assessed local pollutant sources (such as roads, stacks etc.) should be added to local background concentrations, to determine total pollutant concentrations. In many cases the background contribution will 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.
- 4.72 Background concentrations are expected to decline in future years as a result of Government and EU policies and legislation to reduce pollutant emissions⁴². In many instances it is strongly recommended that local authorities use the national background maps, which are provided for each 1km × 1km grid square across the UK. These maps are available on the LAQM Support website⁴³. 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.
- 4.73 For NO_x and PM₁₀, the various source contributions to the estimated background concentration in each 1km × 1km grid square are provided. Therefore, it is possible to remove all sources explicitly modelled. The contributions from emissions inventory sources are provided separately for the sources within or outside the grid square. 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.

Future Year Projections of Background and Roadside Concentrations

- 4.74 London boroughs may need to estimate background concentrations in specific years, or project forward results from air quality monitoring surveys. A number of different approaches can be used.
- 4.75 For 1,3-butadiene, benzene, CO and lead local authorities should use the Year Adjustment Calculator spreadsheet available on the LAQM Support website⁴⁴.
- 4.76 For background NO_x, NO₂ and PM₁₀, there is no need to apply adjustment factors, as the UK background maps include forecast background concentrations for each year between 2011 and 2030. To adjust monitoring data from background locations, the year adjustment factors appropriate to any 1km × 1km grid square can be simply calculated by comparing the maps for the two years in question.
- 4.77 However, this approach cannot be used to adjust measured roadside NO₂ concentrations, due to the differing proportions of primary NO₂ emissions assumed in each year. Instead, London boroughs should use the appropriate factors provided on the LAQM Support website³⁹.
- 4.78 Future year adjustment factors for measured roadside PM₁₀ also require a different approach, as set out in Box 4.3.

42 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

43 <http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html>

44 <http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#YAF>

4.79 Analyses of historical NO_x/NO₂ monitoring data have identified a disparity between the measured NO_x/NO₂ concentrations and the projected decline in concentrations associated with the NO_x/NO₂ emissions forecasts, particularly at roadside sites. Where existing forecasting information is used for decision making or Review and Assessment and Action Planning work, local authorities may wish to take account of the emerging findings on the performance of different vehicle types, the performance of Euro standards overall, and the expected effect on forecast background concentrations. Please contact the LAQM Helpdesk²⁶ for further information.

Box 4.3 – Projecting Measured Annual Mean Roadside PM₁₀ Concentrations to Future Years

Annual mean PM₁₀ 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/m³, for the measurement year from the national maps (if the background concentration is more than that measured then project forward using the approach in para 4.78).

Step 2: Subtract the background concentration (Total_PM₁₀) for the appropriate year from the measured concentration to determine the local PM₁₀ road concentration in that year.

$$\text{Measured} - \text{total background} = \text{local road concentration}$$

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+Cold_Start_in and Minor_Rd+Cold_Start_out
- Brake+Tyre_in and Brake+Tyre_out
- Road_Abrasion_in_15 and Road_Abrasion_out_15

$$\text{motorways} + \text{trunk A roads} + \text{primary A Roads} + \text{minor roads \& cold start} + \text{brake \& tyre} + \text{road abrasion} = \text{background road contribution}$$

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”.

$$\text{background road contribution in future year} \div \text{background road contribution in measurement year} = \text{year adjustment factor}$$

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.

$$\text{local road measured concentration} \times \text{year adjustment factor} = \text{local road concentration in future year}$$

Step 7: Identify the local background concentration in the future year from the national maps published on the LAQM Support website.

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.

$$\text{local road concentration} + \text{future year background} = \text{Total future year roadside PM}_{10} \text{ concentration}$$

Further assistance with this procedure and interpretation of the results can be obtained from the LAQM Support Helpdesk.

Worked Example (Box 4.3 Cont.)

The following worked example projects a hypothetical roadside PM₁₀ concentration of 32.90µg/m³ from 2015 (measured year) to 2020 (future year)^a:

Step 1: Total 2011-based background concentration for measured year 2015 = **22.51**

Step 2: 2015 Measured Concentration (32.90) - Total Background (22.51) = Local Road Concentration (**10.39**)

Step 3: For 2015: motorways in (0.00) + motorways out (0.02) + trunk A roads in (0.00) + trunk A roads out (0.00) + Primary A Roads in (0.02) + Primary A Roads out (0.05) + minor roads and cold start in (0.05) + Minor roads and cold start out (0.13) + brake & tyre in (0.15) + brake & tyre out (0.42) + road abrasion in (0.05) + road abrasion out (0.17) = Measurement year (2015) background road contribution (**1.06**)

Step 4: For 2020: motorways in (0.00) + motorways out (0.01) + trunk A roads in (0.00) + trunk A roads out (0.00) + Primary A Roads in (0.00) + Primary A Roads out (0.02) + minor roads and cold start in (0.02) + Minor roads and cold start out (0.05) + brake & tyre in (0.16) + brake & tyre out (0.46) + road abrasion in (0.05) + road abrasion out (0.18) = Future year (2020) background road contribution (**0.95**)

Step 5: Background road contribution in future year (**0.95**) ÷ background road contribution in measurement year (**1.06**) = Year adjustment factor (**0.90**)

Step 6: Local Road Measured Concentration (**10.39**) × Year adjustment factor (**0.90**) = Local Road concentration in future year (**9.35**)

Step 7: Total 2011-based background concentration for future year 2020 = **21.68**

Step 8: Local road concentration (**9.35**) + future year background (**21.68**) = **Total Future Year Roadside Concentration (31.03)**

^a Values are quoted to 2 decimal places only for the purposes of illustrating the calculation. All values are mass concentrations in units of µg/m³.

Exceedances and Percentiles

4.80 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 air quality objectives. However, for a strict comparison on this basis, there must be a minimum of 85% data capture throughout a calendar year⁴⁵. Where the measured data capture is less than 85%, short-term concentrations should be expressed as percentile values approximating the permitted number of exceedances. This should also be the case for dispersion modelling results if the model cannot calculate the number of exceedances or the meteorological dataset used contains less than 85% of valid observations for the year. Relationships between the permitted numbers of exceedances of short-period concentrations and the equivalent percentiles are provided in Table 4.6 below to help express results in relevant terms.

⁴⁵ An exceedance of short-term objectives may of course be demonstrated with a much lower data capture rate

Table 4.6 – Equivalent Percentiles to the Air Quality Objectives

Pollutant	Time Period	Permitted Exceedances	Equivalent Percentile
NO ₂	1-hour	18 per year	99.8 th percentile
PM ₁₀	24-hour	35 per year	90.4 th percentile
SO ₂	15-minute	35 per year	99.9 th percentile
	1-hour	24 per year	99.7 th percentile
	24-hour	3 per year	99.2 nd percentile

Fall-off in NO₂ Concentrations with Distance from the Road

- 4.81 NO₂ concentrations along roads are the focus of attention for many local authorities. However, it is not always 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.
- 4.82 Wherever possible, local authorities should ensure that monitoring locations are representative of exposure. However, where this is not possible, the NO₂ concentration at the nearest location relevant for exposure should be estimated, using the NO₂ fall-off with distance calculator available on the LAQM Support website⁴⁶.
- 4.83 When using the NO₂ fall-off with distance calculator, it is important to justify the distances used in the calculation tool, as there may be circumstances when it is appropriate to treat the edge of the road (described within the tool as being the ‘kerb’) as being the edge of the carriageway with flowing traffic rather than the physical kerb, e.g. on some urban roads where the first lane is used for parking and therefore the flowing traffic is away from the physical kerb. There may also be circumstances where parked cars are only present for a part of the day; in these cases the parked cars should be ignored if they are not present through the period 07:00 to 19:00, i.e. distances within the tool should be taken to the physical kerb whenever traffic passes near to the physical kerb through most of the day. For motorways, the ‘kerb’ is likely to constitute the edge of the inside lane and not the edge of the hard shoulder (excluding Smart Motorways whereby hard shoulder running is permitted).

Use of the Design Manual for Roads and Bridges Model

- 4.84 The Design Manual for Roads and Bridges (DMRB) Air Quality Screening Model is developed by Highways England. The latest version to use and procedures for its use are described on the LAQM Support Helpdesk website⁴⁷.
- 4.85 The DMRB model can be used to predict NO₂ and PM₁₀ annual mean concentrations.
- 4.86 Where the DMRB assessment indicates that exceedances of the objectives are likely, more detailed

⁴⁶ <http://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html>

⁴⁷ <http://laqm.defra.gov.uk/review-and-assessment/tools/modelling.html>

modelling work 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 is demonstrated, then this model may be sufficient to determine the area of exceedance 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. Further guidance on detailed dispersion modelling of road traffic sources can be provided by the LAQM Support Helpdesk²⁶.

Relationships between NO_x and NO₂

- 4.87 NO_x are predominantly emitted into the atmosphere in the form of nitric oxide (NO) which is then converted to nitrogen dioxide (NO₂) through chemical processes in the atmosphere. Under most atmospheric conditions, the dominant pathway for NO₂ formation is via the reaction of NO with ozone (O₃).
- 4.88 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 NO₂ concentrations have not declined as expected, particularly at roadside sites, and at some locations have actually increased in recent years.
- 4.89 A report from the Air Quality Expert Group⁴⁸ investigated these unexpected findings, and concluded that the most plausible explanation was an increased proportion of direct (or primary) NO₂ emission from road traffic, often referred to as “f-NO₂”⁴⁹. Increased primary NO₂ 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.
- 4.90 Defra developed a tool to allow the calculation of NO₂ from NO_x concentrations, taking account of the difference between fresh emissions of NO_x and background NO_x, the concentration of O₃, and the different proportions of primary NO₂ emission in different years.
- 4.91 This tool (NO_x to NO₂ calculator) is available on the LAQM Support website⁵⁰. This calculator allows the calculation of NO₂ from NO_x and vice versa.
- 4.92 Other approaches for NO_x to NO₂ 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-NO₂ and future year O₃ concentrations should be carefully considered and described. However, the “Derwent-Middleton” equation is no longer considered a suitable approach. Where a conversion method is incorporated within a dispersion model, care should be taken as models should generally be verified using NO_x and not NO₂.
- 4.93 Additional methodology to model NO₂ concentrations from NO_x stack emissions (taking into account background concentrations) used for specific studies investigating stack impacts alone

48 AQEG (2007), Trends in primary nitrogen dioxide in the UK. <http://uk-air.defra.gov.uk/assets/documents/reports/aqeg/primary-no-trends.pdf>

49 This is the fraction of NO_x emitted as NO₂

50 <http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOXNO2calc>

(likely to be more related to short-term impacts) can be provided by the LAQM Support Helpdesk. 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 NO_x to NO₂ calculator discussed above may be used for the conversion of total annual mean NO_x to annual average NO₂ concentrations.

Relationship between the Annual Mean and 1-hour NO₂ Objectives

- 4.94 Predicting exceedances of the NO₂ 1-hour objective is not straightforward, as these 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 (preferably a full calendar year) to ensure that the occurrence of occasional peaks is adequately captured. Dispersion models cannot predict short-term concentrations as reliably as annual mean concentrations. Moreover model verification is likely to be challenging.
- 4.95 Previous research carried out on behalf of Defra and the Devolved Administrations⁵¹ identified that exceedances of the NO₂ 1-hour mean are unlikely to occur where the annual mean is below 60µg/m³. This assumption is still considered valid; therefore local authorities should refer to it if NO₂ 1-hour mean monitoring data are not available (typically if monitoring NO₂ using passive diffusion tubes). It should be noted that this relationship is based upon observations made predominantly at roadside and kerbside monitoring sites where road traffic is the primary source of emissions; consequently, this relationship is not considered to be applicable in instances where industrial emissions impact on air quality, where the relationship with compliance on the hourly NO₂ objective is more appropriately considered through dispersion modelling and the plume chemistry of NO_x/NO₂ conversion.

Relationship between the Annual Mean and 24-hour Mean PM₁₀ Concentrations

- 4.96 As for NO₂, using a dispersion model to predict exceedances of the PM₁₀ short-term (24-hour mean) objective may be challenging. Therefore, to estimate potential exceedances of the PM₁₀ 24-hour mean objective, local authorities should use the following relationship, provided in previous Technical Guidance, which is still considered adequate:

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

- 4.97 Important issues regarding the monitoring of PM₁₀ concentrations are set out in section 2 (Air Quality Monitoring) of this chapter. It is possible that this relationship will change in the future, Defra and the Devolved Administrations will keep this under review, and will issue revised guidance to local authorities on the LAQM Support website as and when necessary.

51 Laxen D and Marnier B (2003). Analysis of the relationship between 1-hour and annual mean nitrogen dioxide at UK roadside and kerbside monitoring sites. Available at http://uk-air.defra.gov.uk/assets/documents/reports/cat06/1hr_NO2_rpt_Final_b.pdf

Source Apportionment

- 4.98 As discussed in Chapter 2, carrying out source apportionment to understand the contribution of all sources of emissions to exceedances of the air quality objectives within an AQMA is important to identify priorities whilst preparing an AQAP.
- 4.99 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 exceedances 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 exceedances. These will be the principal sources for the local authority to control within the Action Plan.
- 4.100 Since the AQAP will mainly 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. May be further 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 as road gradients that give rise to excess emissions if these are significant.
- 4.101 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 study. 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.
- 4.102 The definition of regional and local background is a straightforward exercise using the national maps, by considering the different sector contributions (see para 4.73).
- 4.103 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.
- 4.104 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 NO_x emissions may be calculated using the appropriate emission factors. The level of detail will be dependent upon the road traffic data that are available.
- 4.105 Local 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 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 AQAP. Without such evidence there is a risk that the AQAP will be disproportionate in addressing emissions.

4.106 Apportionment for NO₂ is not as straightforward, due to the non-linear relationship between the emissions of NO₂ and NO_x. This is additionally complicated by the different proportions of NO₂ in the NO_x emission for different sources, for example, petrol cars or diesel cars. The following advice therefore applies to NO₂ source apportionment:

- **Background contributions:** the national maps will give the total background NO₂ 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 NO₂ is the difference between the total (measured or modelled) NO₂ and the total background NO₂. 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.

4.107 An example of how to carry out apportionment for NO₂ is set out in Box 4.4.

Box 4.4 – Example of Source Apportionment for NO₂

The following provides an example of a source apportionment for NO₂ in a hot-spot near to a busy road. The highest annual mean NO₂ concentration [T-NO₂] at a relevant receptor, obtained from a verified model or monitoring is 46µg/m³.

Step 1: From the national maps of background annual mean concentrations obtain the total background NO₂ for the grid square within which the hot-spot is located [TB-NO₂] = 28µg/m³ also the total background NO_x [TB-NO_x] = 45µg/m³ and regional background NO_x [RB-NO_x] = 25µg/m³. From the total and regional background NO_x derive a local background NO_x:

$$[LB-NO_x] = [TB-NO_x] - [RB-NO_x] = 20\mu\text{g}/\text{m}^3$$

Step 2: Apportion the total background NO₂ into regional and local using the regional and local NO_x proportions:

- [RB-NO₂] = [TB-NO₂] × ([RB-NO_x] / [TB-NO_x]) = 15.6µg/m³
- [LB-NO₂] = [TB-NO₂] × ([LB-NO_x] / [TB-NO_x]) = 12.4µg/m³

Step 3: Calculate the local NO₂ contribution at the worst-case location [L-NO₂] from the total measured minus background:

$$[L-NO_2] = [T-NO_2] - [TB-NO_2] = 18\mu\text{g}/\text{m}^3$$

Step 4: Apportion the local contributions to total NO₂ concentration using the model concentrations or emission results for NO_x. 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.

- NO₂ vans and lorries = 44% × [L-NO₂] = 7.9µg/m³
- NO₂ buses = 22% × [L-NO₂] = 4.0µg/m³
- NO₂ cars = 34% × [L-NO₂] = 6.1µg/m³

The final source apportionment of the worst-case NO₂ 46µg/m³ is thus:

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

Calculation of the Required Reduction in Emissions for Action Plans

- 4.108 As discussed in Chapter 2, local authorities should identify the reduction in pollutant emissions required to attain the objectives within their AQMAs to determine the scale of effort required likely to be required.
- 4.109 In the case of NO_2 alongside roads, the required reduction should be stated as the concentration reduction in $\mu\text{g}/\text{m}^3$, for example, a $5\mu\text{g}/\text{m}^3$ reduction from $45\mu\text{g}/\text{m}^3$ to $40\mu\text{g}/\text{m}^3$. 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.
- 4.110 Calculation of the NO_x reduction requires the current 'road NO_x ' concentration (road NO_x -current) to be calculated, i.e. 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 $40\mu\text{g}/\text{m}^3$ (road NO_x -required). This can be done using the NO_2 from NO_x calculator (see para 4.90), by entering a total NO_2 concentration of $40\mu\text{g}/\text{m}^3$, 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 4.5. Help with these calculations can be obtained from the LAQM Support Helpdesk.

Box 4.5 – Example of Calculated Reduction in Road NO_x Emissions

The following is provided as an example of how to calculate the reduction in road NO_x emission required to meet the $40\mu\text{g}/\text{m}^3$ annual mean objective for NO_2 . The measured or modelled NO_2 at the worst-case relevant exposure location is $45\mu\text{g}/\text{m}^3$. 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 para 4.90) to obtain the NO_x concentration that equates to the $45\mu\text{g}/\text{m}^3$ NO_2 , which in this example is $99.0\mu\text{g}/\text{m}^3$.

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 $28.8\mu\text{g}/\text{m}^3$ respectively, from the background maps (see para 4.72).

Step 3: Calculate the current "road NO_x " concentration (road NO_x -current), i.e. the difference between total NO_x (calculated or measured) and local background NO_x . In this example road NO_x -current will be $59.2\mu\text{g}/\text{m}^3$ (99.0 minus $39.8\mu\text{g}/\text{m}^3$).

Step 4: Calculate the road NO_x concentration required to give a total NO_2 concentration of $40\mu\text{g}/\text{m}^3$, i.e. the annual mean objective (road NO_x -required). This can be done using the NO_2 from NO_x calculator by entering a total NO_2 concentration of $40\mu\text{g}/\text{m}^3$ along with the local background NO_2 concentrations. The calculator gives the road NO_x -required concentration which in this example is $44.3\mu\text{g}/\text{m}^3$.

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 is $14.9\mu\text{g}/\text{m}^3$ (59.2 minus $44.3\mu\text{g}/\text{m}^3$), which represents a 25.2% reduction in road NO_x ($14.9/59.2$ as a percentage).

Estimating $\text{PM}_{2.5}$ from PM_{10} Measurements

- 4.111 As a general simplification, $\text{PM}_{2.5}$ is regionally influenced with the secondary formation of nitrate and sulphate species being prevalent in the overall burden. However, primary emissions from

vehicle exhaust and industry arise. PM_{coarse} (the fraction of PM between $10\mu\text{m}$ and $2.5\mu\text{m}$, i.e. PM_{10} minus $PM_{2.5}$) is more often local in origin and can be attributed to activities such as construction, demolition, waste transfer operations, and tyre wear. Estimation of PM_{10} data from $PM_{2.5}$ data and vice versa should only be used to give an indication of PM fractions where only one of the two metrics is available, or where estimates on modelled $PM_{2.5}$ can be derived from modelled PM_{10} . London boroughs should clearly indicate where PM concentrations have been estimated based upon the below methods.

- 4.112 Where there are local sites measuring both PM_{10} and $PM_{2.5}$, then the ratio of $PM_{2.5}/PM_{10}$ can be calculated for this site. At local sites of the same site classification where there are only PM_{10} data, then the annual average $PM_{2.5}$ concentration can be estimated by multiplying the annual average PM_{10} concentration by this locally derived ratio. Similarly, at local sites of the same site classification where there are only $PM_{2.5}$ data, then the annual average PM_{10} concentration can be estimated by dividing the annual average $PM_{2.5}$ concentration by this locally derived ratio.
- 4.113 Where no appropriate local sites measuring both PM_{10} and $PM_{2.5}$ are available, then a nationally derived correction ratio of 0.7 can be used. This factor was calculated as the average of all ratios of $PM_{2.5}/PM_{10}$ found for years 2010 to 2014 for forty sites within the AURN where both PM_{10} and $PM_{2.5}$ are measured on an hourly basis. Specific analysis of $PM_{2.5}/PM_{10}$ ratios at AURN sites across Greater London has shown that the national correction ratio is also applicable in London. Therefore, London Boroughs should also use the national correction ratio to estimate $PM_{2.5}$ from PM_{10} monitoring data, if required. Further information on the derivation of this factor is provided in Annex A.
- 4.114 Box 4.6 provides some examples of estimating $PM_{2.5}$ concentrations from PM_{10} monitoring.
- 4.115 London boroughs may find it useful to use information gathered by any $PM_{2.5}$ monitoring to appraise the compliance with PM_{10} short-term objectives. For example, if the 24-hour mean $PM_{2.5}$ concentration exceeds $35\mu\text{g}/\text{m}^3$ (i.e. $50\mu\text{g}/\text{m}^3 \times 0.7$) on more than 35 occurrences a year, then there is a risk of exceedance of the 24-hour mean objective for PM_{10} , and London boroughs should consider installing a PM_{10} analyser in that location.

Box 4.6 - Estimating PM_{2.5} Concentrations from PM₁₀ monitoring

Example A – Estimate using Local PM₁₀ and PM_{2.5} Monitoring

The following provides an example of the estimation of PM_{2.5} where a local authority measures both PM₁₀ and PM_{2.5} at the same location using continuous monitoring instruments.

The recorded annual mean concentrations in 2015 were 30.1µg/m³ and 23.7µg/m³ for PM₁₀ and PM_{2.5} respectively at a reference roadside site. The authority also measured PM₁₀ at another roadside site; the 2015 annual mean concentration at this site was 27.8µg/m³. The PM_{2.5} concentration at this site can be estimated as follows:

Step 1: Calculate the ratio of PM_{2.5}/PM₁₀ at the reference site:

$$23.7 \div 30.1 = 0.79$$

Step 2: Multiply the PM₁₀ concentration recorded at the other site by the locally derived PM_{2.5}/PM₁₀ ratio:

$$27.8 \times 0.7 = 22.0$$

Step 3: Estimated annual mean PM_{2.5} = 22.0µg/m³

Example B – Estimate using National Factor

The following provides an example of the estimation of PM_{2.5} using the nationally derived correction factor.

The recorded annual mean concentration at a roadside site in 2015 was 30.1µg/m³. The PM_{2.5} concentration at this site can be estimated as follows:

Step 1: Multiply the annual mean PM₁₀ concentration by the nationally derived correction factor:

$$30.1 \times 0.7 = 21.1$$

Step 2: Estimated annual mean PM_{2.5} = 21.1µg/m³

2 – Air Quality Monitoring

Air Quality Monitoring Strategy for Review and Assessment

- 4.116 Most local authorities progressively adapted their monitoring strategy in accordance to the air quality issues specific to their administrative area. Over the years, many local authorities have relocated kerbside monitoring sites to roadside or other sites relevant of public exposure. Monitoring networks have also been progressively extended to identify all potential hot spots, whilst a number of sites have been moved elsewhere or closed in areas where data showed continued compliance.
- 4.117 Therefore, it is likely that the existing monitoring network for most local authorities is now adapted to respond to the requirements of the LAQM system. As a result, it is not expected that local authorities need extensive guidance in relation to air quality monitoring strategies, such as how to determine the best location, the number of monitoring sites required, etc. Therefore, only a brief summary of key aspects is provided below as a useful reminder:
- Local monitoring campaigns should be planned with due regard to the air quality objectives of concern and monitoring equipment installed at locations relevant for public exposure. This is to ensure that the data are fit for purpose, and results do not need to be corrected (such as adjustments to account for the distance to the nearest sensitive receptors);
 - The monitoring programme should be designed to assist the authority in defining the geographical extent of any exceedances;
 - Locations should be selected bearing in mind that results are likely to be used to help demonstrate the performance of dispersion. Therefore, care should be taken to ensure that the monitoring site is sufficiently close to the dominant pollution source (i.e. in the vast majority of cases, at roadside sites);
 - Screening assessments should provide useful 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;
 - Monitoring should also be undertaken at a number of background sites to obtain a representative background concentration for the area, supplementing the information provided by the national background maps (see para 4.72). Urban background monitoring is essential to monitor long-term trends, as such sites are less likely to be affected by variations in local sources, for example changes in traffic on a particular road;
 - To validate NO₂ diffusion tube data (bias adjustment), additional tubes should be exposed in triplicate at a suitable nearby automatic monitoring station, using the same monthly exposure periods as the other sites; and
 - Monitoring results, provided that they comply with QA/QC procedures and are located at suitable locations relevant of worst-case public exposure, should take precedence over modelling results. Therefore, if monitoring data do not indicate a likely exceedance of an air quality objective, there should be no need to declare an AQMA.
- 4.118 As a general rule, 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 4.7 lists some of the basic points to consider.
- 4.119 It is also important to note that local authorities should consult the GLA prior to altering their air quality monitoring network, as discussed in Chapter 3 (para 3.05).

Box 4.7 – Basic Considerations Before Proceeding with Air Quality Monitoring

The following points should be considered to determine a suitable air quality monitoring strategy:

- 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?

4.120 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 LAQM Support Helpdesk if they are uncertain about the best way to proceed.

Introduction to Monitoring

4.121 For local authorities, the majority of monitoring undertaken will focus on NO₂ and particulate matter (PM₁₀ and PM_{2.5}) as the concentrations of other pollutants have generally fallen below levels at which they are considered harmful. Monitoring of other pollutants are likely to only be required if there is a source for which an assessment may show a potential risk to compliance. One exception is where there is a national network monitor within the boundary of the local authority. In this case, then ratified data and statistics should be taken directly from the appropriate website (e.g. the UK-Air website⁵²). It is important to note that the data on the national websites are verified several months after the end of the calendar year, and as such the data available may be provisional and subject to further ratification. Local authorities should aim to use verified data, and specify in LAQM statutory reports whether verified or provisional data have been used.

4.122 For NO₂, SO₂ and CO, a series of reference method instruments have been approved for use by Defra and the Devolved Administrations. For NO₂, it is also permissible to use diffusion tubes. Instruments that employ alternative technologies such as electrochemical sensors, DOAS and cavity ringdown spectroscopy are not currently approved for NO₂, SO₂ or CO, as they have not yet been tested, though they may be suitable as supplementary monitoring to help local authorities Review and Assess air quality, or for local campaigns. Should alternative instruments be approved in the future, then this information will be disseminated to local authorities.

4.123 For PM₁₀ and PM_{2.5}, a large number of different technologies have been approved by Defra and the Devolved Administrations.

4.124 For lead, Defra and the Devolved Administrations have approved the use of a method that employs the subsequent analysis of sampled filters.

52 uk-air.defra.gov.uk/

- 4.125 For benzene and 1,3 butadiene, Defra and the Devolved Administrations have approved the use of chromatography based methods. A DOAS method has also been approved through the MCERTS certification scheme.
- 4.126 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, at an appropriate height and free from any obstruction.
- 4.127 This section discusses general siting requirements of the instruments used to monitor air pollution. The available instruments and reporting requirements are then discussed for each pollutant in turn.
- 4.128 Ideally, monitoring should be for a full calendar year. However, annualisation techniques can be used in order to estimate an annual average from a part year average. These are described in the following sections. Should monitoring be required for such as construction or demolition, then it is recommended that monitoring shall be undertaken for at least 3 month prior to site activity in order to ascertain background levels. It is also necessary to monitor throughout the construction or demolition phases of the work.
- 4.129 In order to ensure the correct functioning of the instruments, it is necessary to attend the site periodically in order to perform local site operator duties such as changing filters or cleaning the inlet.
- 4.130 It is also necessary to service the instruments every six months in order to limit instrument breakdowns.
- 4.131 In order to improve the reliability and validity of the data, it is recommended that the instruments should be periodically checked by an independent organisation accredited to perform QA/QC checks to ISO17025:2005. Ideally this should be performed every six months.

Site Classifications

- 4.132 The 2008 Air Quality Directive redefined site classifications. However, for LAQM reporting purposes, Councils should continue to use those previously used under the 2009 Technical Guidance, as presented in Table 4.7.

Table 4.7 - LAQM Site Type Classifications

Site Type	Description
Urban centre	An urban location representative of typical population exposure in towns or city centres, for example, pedestrian precincts and shopping areas.
Urban background	An urban location distanced from sources and therefore broadly representative of city-wide background conditions, e.g. 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 up to 15 m from the kerb in some cases).
Kerbside	A site sampling within one metre of the kerb of a busy road.

Site Type	Description
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.

4.133 UK-Air and other websites are now using the site classifications defined in the 2008 Directive. There are many possible permutations of site classifications allowed, but the UK uses just six of these to describe the National Network. These are summarised in Table 4.8. When obtaining data from UK-Air, Councils should use this table in order to work out how the site should be classified for LAQM reporting purposes. For example, a site classified in UK-Air as Urban Traffic would be either Roadside or Kerbside for LAQM reporting purposes.

Table 4.8 – Air Quality Monitoring Site Classification

New Classification	Old Classification	Description
Urban Traffic	Roadside or Kerbside	Sites in an urban area at least 25 metres from the edge of major junctions and no more than 10 metres from the kerbside. It is important to state the distance from the roadside when submitting LAQM reports.
Urban Background	Urban Background or Urban Centre	Sites in an urban area away from major roads that are representative of exposure of the general population. Urban background sites should not be dominated by single sources and should be representative of a wide area.
Suburban Background	Suburban	Sites in a suburban area away from major roads that are representative of exposure of the general population. A suburban area is defined as a location type situated in a residential area on the outskirts of a town or city. Suburban background sites should not be dominated by single sources and should be representative of a wide area.
Rural Background	Rural	Sites in a rural area away from roads that are representative of exposure of the general population. Rural background sites should not be influenced by agglomerations or industrial sources and should be representative of a wide area.
Urban Industrial	Industrial	Site in an urban residential area downwind of specific industrial source.
Suburban Industrial	Industrial	Site in a suburban area downwind of specific industrial source. A suburban area is defined as a location type situated in a residential area on the outskirts of a town or city.

Installing New Continuous Monitoring Sites

- 4.134 Continuous monitoring stations require a permanent power supply, and dependent upon the equipment installed, often require air conditioned enclosures. The power supply must be of sufficient rating to support the equipment to be installed. 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.
- 4.135 In order to aid potential future expansion of the UK monitoring network, Councils are encouraged to locate monitoring stations in one of the six classifications provided in Table 4.8. 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 NO₂ are highest at roadside locations, whereas SO₂ 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. Background monitoring is essential if there is a need to monitor long-term trends in pollutant concentration or population exposure. Background monitoring sites are less likely than roadside or kerbside sites to be affected by very local factors, for example changes in traffic on a particular road.
- 4.136 It is necessary to consider certain micro-scale siting requirements:
- Sites should be in as open a setting as possible in relation to surrounding buildings. Immediately above the site should be open to the sky, with no overhanging trees, structures or buildings. The flow around the inlet sampling probe shall be unrestricted without any obstructions affecting the airflow in the vicinity of the sampler (normally some metres away from buildings, balconies, trees and other obstacles and at least 0.5m from the nearest building in the case of sampling points representing air quality at the building line);
 - In general, the inlet sampling point shall be between 1.5m (the breathing zone) and 4m above the ground. For security reasons, the inlet should be greater than 2m, though it is recognised that lower sampling heights better reflect the ambient conditions encountered by members of the public;
 - The inlet probe shall not be positioned in the immediate vicinity of sources in order to avoid the direct intake of emissions unmixed with ambient air;
 - The sampler's exhaust outlet shall be positioned so that recirculation of exhaust air to the sampler inlet is avoided;
 - The site should not be close to local or point emissions sources, unless these have been specifically targeted for investigation. For industrial sites, where specific sources are being targeted, monitoring should be carried out within the zone of maximum impact as determined by modelling;
 - For urban background or suburban sites there should be no major sources of pollution (for example a large multi-storey car park) within 50m. There should be no medium sized emission sources (for example, petrol stations, boiler vents, or ventilation outlets to catering establishments) within 20m.
- 4.137 Regular review of site suitability is necessary as the micro-scale environment can change quickly. It is important to note that vegetation needs cutting back occasionally.

4.138 Other important considerations are:

- Interfering sources;
- Security;
- Access;
- Availability of electrical power and telephone communications;
- Visibility of the site in relation to its surroundings;
- Safety of the public and operators. Examples include: Sloping roofs, ladder restraints, fencing around roof, direction in which door through fencing opens, safety of steps and handrails;
- The desirability of co-locating sampling points for different pollutants;
- Planning requirements.

4.139 Generally, there is a large amount of time involved in the coordination of the planning authorities, the highways agency, traffic management services, instrument suppliers, enclosure suppliers, delivery companies, air conditioning engineers, electricity suppliers, site electricians, the company that builds the plinth and the telecommunications suppliers. As such, local authorities are advised to procure the services of the equipment supplier or a consultancy company in order to assist in the process.

4.140 It is generally advised that all data are collected, stored and analysed in GMT irrespective of the season. However this means that anyone carrying out analysis of the data needs to be aware that, for example, the rush hour peak is, 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. When both reporting data and using data from other sources, it is imperative to make it clear whether the date and time stamp assigned to the data corresponds to the beginning or the end of the monitoring period.

Identifying Erroneous Data

4.141 Different instruments require data to be processed in different ways. This is discussed later in the individual sections on each pollutant. However, in all cases, the local authority should identify and delete erroneous data, and there are various common themes irrespective of pollutant or instrument.

- *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). For example, CO, NO_x and PM₁₀ are all 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.
- *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.

Particulate Matter Monitoring (PM₁₀ and PM_{2.5})

4.142 Defra and the Devolved Administrations have approved a number of different monitoring technologies to be equivalent to the reference method. In some cases the data have to be corrected before they can be used. A summary of technologies approved to date is as follows. As more instruments are approved, they will be listed under the 'Deemed equivalent by Defra' column on the UK-Air website⁵³.

Gravimetric Measurements of Particulate Matter

- 4.143 Instruments are available which pass air through a filter which is weighed before and after sampling. The concentration of PM₁₀ or PM_{2.5} can then be calculated as the increase in mass of the filter divided by the volume of the sample expressed to ambient conditions. It is recommended that local authorities use Emfab filters for PM₁₀ or PM_{2.5} measurements. If the filters are required for subsequent analysis for component pollutants, then other filter materials may be more suitable. Due to the very tight controls that should be applied to the filter weighing and conditioning procedures, local authorities are advised to use an independent filter weighing service. The service should be UKAS accredited to CEN standard EN12341.
- 4.144 The reference method (CEN Standard EN12341:2014) can by definition be used without the need for correction for slope and/or intercept. Several manufacturers make versions of the reference method. It is recommended that local authorities use an instrument that automatically changes filters.
- 4.145 The PM₁₀ Partisol 2025 and PM_{2.5} Partisol 2025 have both been declared equivalent to the reference method. Local authorities can use these without the need for correction for slope and/or intercept.
- 4.146 In any gravimetric particulate monitoring programme, field blanks should be included as a matter of course and in a systematic way. Field blanks provide for a QA/QC check to ensure that no significant contamination has been introduced during the sample handling process. At all stages, field blank filters are subject to handling in the same way as an actual sample filter. Field blank filters are transported to the sampling site in the same manner as filters intended for sampling, installed in the sampler, removed from the sampler without sampling, then stored in their protective containers inside the sampler's case at the sampling site until the corresponding exposed

⁵³ uk-air.defra.gov.uk/networks/monitoring-methods?view=mcerts-scheme

filter(s) is (are) retrieved and returned for post-sampling weighing in the laboratory. Ideally the mass gained during filter handling should be equal to or close to zero, with the field blank mass subsequently subtracted from the exposed filter sample masses, for all filters in the same batch. Should the mass gained during filter handling be considered unacceptable, any associated sample measurements should be either treated with caution or discarded

Tapered Element Oscillating Microbalances (TEOMs)

- 4.147 TEOMs collect particles on a small oscillating filter. The change in oscillation frequency of the filter is proportional to the change in PM_{10} and $PM_{2.5}$ concentrations. TEOMs are operated at 50°C and as such lose volatile components of the PM_{10} and $PM_{2.5}$.
- 4.148 The PM_{10} TEOM1400AB can be used by local authorities after correction by the volatile correction model. This method adds the 1.87 times the volatile fraction as measured by remote FDMSs (see below) to the TEOM data in order to correct for the underestimation of PM concentrations by the TEOM. Tools to process TEOM data are available at the Volatile Correction Model website⁵⁴;
- 4.149 The $PM_{2.5}$ TEOM1400AB, PM_{10} TEOM1405 and $PM_{2.5}$ TEOM1405 have not been tested for equivalence and should not be used by local authorities.

TEOM - Filter Dynamics Measurement System (TEOM-FDMS)

- 4.150 The Tapered Element Oscillating Microbalance Filter Dynamics Measurement system (TEOM-FDMS) is a modification of the TEOM. The instrument operates at 30 °C rather than 50°C; removes water from the sample stream with a nafion drier; and alternates between taking ambient air samples and blank samples on a 6 minute frequency.
- 4.151 The PM_{10} FDMS 8500, $PM_{2.5}$ FDMS 8500, PM_{10} FDMS 1405F, $PM_{2.5}$ FDMS 1405F and the FDMS1405DF (which measures both PM_{10} and $PM_{2.5}$ at the same time) have all been declared equivalent to the reference method. Local authorities can use any of these FDMS variants without the need for correction for slope and/or intercept.

Beta Attenuation Monitors (BAMs)

- 4.152 Beta Attenuation Monitors (BAMs) pass air through a filter material and monitor the increase in mass by the attenuation of beta radiation. BAM instruments are made by multiple manufacturers.
- 4.153 The Met One PM_{10} Smart Heated BAM 1020 can be used by local authorities after correction for slope by dividing the data by 1.035;
- 4.154 The Met One $PM_{2.5}$ Smart Heated BAM 1020 can be used by local authorities without the need for correction for slope and/or intercept;

54 www.volatile-correction-model.info

- 4.155 The Met One PM₁₀ Unheated BAM 1020 can be used by local authorities after correction for slope by dividing the data by 1.2. Rather than dividing by 1.2, data on UK Air are multiplied by 0.833. Both methods are permissible. The instrument should be set up to report the data to US standard conditions (25°C, 1 atmosphere) in order to mimic the set-up of the instrument during the original equivalence tests;
- 4.156 The Met One PM_{2.5} Unheated BAM 1020 has not been tested for equivalence and should not be used by local authorities;
- 4.157 FAI produce many variants of their SWAM BAM instrument (PM₁₀ SWAM 5a 24 Hour, PM_{2.5} SWAM 5a 24 Hour, SWAM 5a DC 24 Hour (which measures both PM₁₀ and PM_{2.5} at the same time), and the SWAM 5a DC Hourly (which measures both PM₁₀ and PM_{2.5} at the same time)). All of these have been declared equivalent to the reference method. Local authorities can use any of these BAM variants without the need for correction for slope and/or intercept. The instruments should be operated with GF10 glass fibre filters;
- 4.158 The PM₁₀ Opsis SM200 should be operated with stretched Teflon membrane filters that are provided by the manufacturer. When used to calculate concentrations using Beta radiation, local authorities can use the PM₁₀ Opsis SM200 without the need for correction for slope and/or intercept. However, if the filters are to be weighed before and after sampling, then local authorities should correct for slope and intercept by first subtracting 1.286, then dividing by 0.819;
- 4.159 The PM_{2.5} Opsis SM200 has not been tested for equivalence and should not be used by local authorities.

Light-Scattering Monitors

- 4.160 A light-scattering monitor measures pulses from light scattered in a particular direction and outputs a signal determined by the size and the concentration of airborne particles in the sample stream. The PM₁₀ and PM_{2.5} are calculated by conversion of particle numbers measured per unit time into mass per unit volume using dedicated multi-regression analysis or with pre-set particle densities.
- 4.161 The Palas Fidas 200 measures both PM₁₀ and PM_{2.5} at the same time. Data are processed by an inbuilt algorithm, and the algorithm known as Method 11 has been certified in the UK. The Method 11 PM₁₀ data can be used by local authorities without the need for correction for slope and/or intercept. The Method 11 PM_{2.5} data can be used by local authorities after correction for slope by dividing by 1.06. Data processed by algorithms other than Method 11 may in the future be proven equivalent to the reference methods. Details of the correction factors to be used will be disseminated via the UK-Air website⁵⁵.
- 4.162 Many other optical instruments are available, and have been certified using the Environment

55 uk-air.defra.gov.uk/networks/monitoring-methods?view=mcerts-scheme

Agency's Indicative instrument certification scheme⁵⁶. These instruments are not suitable for measuring the annual PM₁₀ or PM_{2.5} or the number of exceedances as they are not accurate enough to meet the expanded uncertainty requirements of equivalent instruments. These instruments are however useful for identifying short-term pollution events at construction, demolition or waste transfer sites⁵⁷ and are suitable for short, local campaigns.

Other Instruments

4.163 In addition, a number of instruments exist that have not been approved by Defra, but have approval in other European countries, namely the: Sharp 5030i; 5014i; Sharp 5030, Grimm EDM180; PM_{2.5} Opsi SM200; the Horiba APDA-371 BAM; and the Horiba APDA-372. If local authorities operate any of these instruments, then they should contact the LAQM Support Helpdesk²⁶ for advice on how best to process the data that they produce.

General Considerations

4.164 Regardless of the instrument used:

- Local authority personnel should attend the site at frequent intervals and follow procedures as set out by the manufacturers in the instrument operating manuals. While the procedures differ by instrument, common procedures include: changing filters; cleaning the inlet; leak checks; flow checks and zero checks.
- In order to improve the reliability and validity of the data, it is recommended that instruments should be periodically checked by an independent organisation accredited to perform QA/QC checks to ISO17025:2005. Ideally this should be performed every six months.
- Instruments should be periodically serviced by the manufacturer or an approved service unit. Ideally this should be performed every six months and within three weeks of the independent QA/QC audit. 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.

4.165 All erroneous data should be disregarded before any averaging or data interpretation is undertaken. The approved instruments produce a data record every 15 minutes, 1 hour or 24 hours. In order to calculate the 24 hour average data:

- Where data are produced on a 15 minute basis, it is required to calculate the 24 hour average data by averaging 96 records. The 24 hour average will only be valid if there was at least 75% data capture, i.e. 72 valid 15 minute averages.
- Where data are produced on a 1 hour basis, it is required to calculate the 24 hour average data by averaging 24 records. The 24 hour average will only be valid if there was at least 75% data capture, i.e. 18 valid 1 hour averages.

56 www.csagroupuk.org/wp-content/uploads/2015/08/MCERTSCertifiedProductsIndicativeCAMS.pdf

57 www.iaqm.co.uk/wp-content/uploads/guidance/monitoring_construction_sites_2012.pdf

- Where data are produced on a 24 hour basis, there is no requirement to average the data further.
- 4.166 PM₁₀ and PM_{2.5} data capture can be calculated as the number of valid 24 hour averages divided by the number of days in the year, and this is expressed as a percentage by multiplying by 100. For example, if there were 300 valid days of PM₁₀ data in a non-leap year, then the data capture is $(100 \times 300) / 365$, which is 82.2%.
- 4.167 For both PM₁₀ and PM_{2.5}, the annual average can be calculated by averaging all of the valid 24 hour average data for the calendar year.
- 4.168 For PM₁₀ it is required to report the number of days where there was greater than 50µg/m³ over a calendar year. No more than 35 exceedances per calendar year are allowed for local authorities in England. The number of exceedances should only be reported where data capture is more than 85% of a full year. If data capture is less than 85% or monitoring is for less than a full year, then local authorities should instead report the 90.4th percentile for 24 hour PM₁₀. For example, if the available 24 hour average data are in Column A in an Excel spreadsheet, then the Excel formula would be =PERCENTILE(A:A,0.9). If the 90.4th percentile is greater than 50µg/m³, then this means that if there had been 100% data capture, then there have been greater than 35 exceedances of 50µg/m³ per calendar year.

Box 4.8 – Example: Annualising Continuous Monitoring Data

It has only been possible to carry out a monitoring survey at site for six months between July and December 2015. The measured mean concentration M for this period is $30.2\mu\text{g}/\text{m}^3$. How can this be used to estimate the annual mean for this location?

- Identify two to four nearby, long-term, continuous monitoring sites, ideally those forming part of the national network. The data capture for each of these sites should ideally be at least 85%. These sites should be background (Urban Background, Suburban or Rural) sites to avoid any very local effects that may occur at Urban Centre, Roadside or Kerbside sites, and should, wherever possible lie within a radius of about 50 miles. If no background sites are available, and the site to be annualised is itself a Urban Centre, Roadside or Kerbside site, then it is permissible to annualise using roadside or kerbside sites rather than background sites, though this should be clearly stated in the annual report.
- Obtain the annual means, A_m , for the calendar year for these sites.
- Work out the period means, P_m , for the period of interest, in this case July to December 2015.
- Calculate the ratio, R , of the annual mean to the period mean (A_m/P_m) for each of the sites.
- Calculate the average of these ratios, R_a . This is then the annualisation factor.
- Multiply the measured period mean concentration M by this annualisation factor R_a to give the estimate of the annual mean for 2015.

For this example the best estimate of the annual mean for site S in 2015 will be $M \times R_a = 30.2 \times 0.944 = 28.5\mu\text{g}/\text{m}^3$.

Background Site	Annual mean 2015 (A_m)	Period Mean 2015 (P_m)	Ratio (A_m/P_m)
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

If the short-term period covers, for instance, February to June 2016, and the work is being carried out in August 2016, then an annual mean for 2016 will not be available. The calculation can then be carried out using the ratio to the 2015 annual mean, but the result is then an estimate of the 2015 annual mean at the short-term site. The 2016 bias correction factor would also not be available, and so it would be necessary to use the 2015 factor instead.

NO_x and NO₂ Monitoring

NO₂, NO and NO_x by Chemiluminescence

4.169 The reference method for NO₂ monitoring is chemiluminescence. A number of instruments have been approved under the MCERTS scheme⁵⁸.

4.170 This technique alternates between two modes:

- Measuring NO by reacting NO with ozone which forms a photon of light which is measured and is proportional to the NO mixing ratio in parts per billion by volume (ppbV);
- Catalysing the NO₂ in the air over a molybdenum convertor which converts the NO₂ to NO. The air is then reacted with ozone. This gives the mixing ratios of both NO and NO₂ together,

⁵⁸ www.csagroupuk.org/wp-content/uploads/2015/05/MCERTSCertifiedProductsCAMS.pdf

which is known as oxides of nitrogen (NO_x).

- 4.171 NO_2 is then calculated as NO_x minus NO . All are given in mixing ratios of ppbV, and it is necessary to convert them to concentrations in $\mu\text{g}/\text{m}^3$ (see para 4.175).
- 4.172 Ideally, local authority personnel should attend the site every two weeks for sites in roadside or kerbside locations or at urban centre locations with particularly high concentrations. Local authority personnel should attend the site four weeks for sites at other locations. At this time, the filter should be changed and the instrument's calibration should be checked. This is done by introducing nominally 450 ppbV NO in nitrogen to the system and then noting the values of NO_2 , NO and NO_x from the front panel of the instrument after the readings have stabilised. 450 ppbV is chosen as this is 90% of the 500 ppbV full span of the instrument. The zero of the instrument is then checked by passing synthetic air or ambient air that has been purified. Again, the values of NO_2 , NO and NO_x are noted from the front panel of the instrument. If one is available, then additionally, the process may be repeated with a 450 ppbV cylinder of NO_2 in synthetic air. This is used to check the efficiency of the molybdenum convertor, and the results are not used to calibrate the data. The 450 ppbV NO in nitrogen cylinder should be traceable to a national or international reference cylinder so that the concentration is accurately known.
- 4.173 In order to improve the reliability and validity of the data, it is recommended that instruments should be periodically checked by an independent organisation accredited to perform QA/QC checks to ISO17025:2005. Ideally this should be performed every six months. It is important that the QA/QC process checks the calibration using both NO in nitrogen and NO_2 in synthetic air.
- 4.174 Instruments should be periodically serviced by the manufacturer or an approved service unit. Ideally this should be performed every six months and within three weeks of the independent QA/QC audit. It is expected that the response of the instrument to NO in nitrogen will increase following the service as the optical components within the instrument are cleaned. 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.
- 4.175 In order to correct for the drift in instrument calibration and then to convert from ppbV to $\mu\text{g}/\text{m}^3$, it is necessary to follow the below procedure:
- Erroneous calibrations should be identified by observing the trend in the ppbV readings of NO_x and NO from the front of the instrument when the nominally 450 ppbV NO in nitrogen and zero gases were introduced. Readings which do not follow anticipated trends should be ignored;
 - For each day that the calibration was checked on the instrument, the NO zero is taken to be the ppbV mixing ratio of NO that was displayed on the front of the instrument when the zero gas was introduced. It is possible for the NO zero to be incorrect, and instead the correct zero may be identified by observing trends in the lowest concentration of the ambient NO data;
 - For each day that the calibration was checked on the instrument, the NO span is taken to be the ppbV mixing ratio of NO that was displayed on the front of the instrument when the 450 ppbV NO in nitrogen gas was introduced;
 - For each day that the calibration was checked on the instrument, the NO range is calculated as NO span minus NO zero;
 - For each day that the calibration was checked on the instrument, the NO calibration factor is calculated by taking the exact known NO ppbV mixing ratio of the NO in nitrogen cylinder

and dividing this by the NO range;

- For each day that the calibration was checked on the instrument, the NO_x zero is taken to be the ppbV mixing ratio of NO_x that was displayed on the front of the instrument when the zero gas was introduced. It is possible for the NO_x zero to be incorrect, and instead the correct zero may be identified by observing trends in the lowest concentration of the ambient NO_x data;
- For each day that the calibration was checked on the instrument, the NO_x span is taken to be the ppbV mixing ratio of NO_x that was displayed on the front of the instrument when the 450 ppbV NO in nitrogen gas was introduced;
- For each day that the calibration was checked on the instrument, the NO_x range is calculated as NO_x span minus NO_x zero;
- For each day that the calibration was checked on the instrument, the NO_x calibration factor is calculated by taking the exact known NO_x ppbV mixing ratio of the NO in nitrogen cylinder and dividing this by the NO_x range;
- The NO calibration factor, NO_x calibration factor, NO zero and NO_x zero should be defined for every 15 minute monitoring period that monitoring was undertaken. It is important that a step change in calibration factors is accounted for whenever the instrument was serviced or repaired. It is considered sufficient to take the NO calibration factor, NO_x calibration factor, NO zero and NO_x zero to be the same for every record following each calibration check prior to the following calibration check. It is however more accurate to linearly interpolate the NO calibration factor, NO_x calibration factor, NO zero and NO_x zero between calibration checks;
- The 15 minute NO ppbV readings from the instrument are zero corrected by subtracting the NO zero assigned to that 15 minute record;
- The 15 minute zero corrected NO ppbV readings are span corrected by multiplying by the NO calibration factor assigned to that 15 minute record;
- The 15 minute NO_x ppbV readings from the instrument are zero corrected by subtracting the NO_x zero assigned to that 15 minute record;
- The 15 minute zero corrected NO_x ppbV readings are span corrected by multiplying by the NO_x calibration factor assigned to that 15 minute record;
- The 15 minute NO₂ ppbV mixing ratio is calculated by subtracting the zero and span corrected NO mixing ratio from the zero and span corrected NO_x mixing ratio;
- NO₂ ppbV is converted in to µg/m³ by multiplying by 1.91;
- NO ppbV is converted in to µg/m³ by multiplying by 1.25;
- NO_x ppbV is converted in to µg/m³ by multiplying by 1.91. This is because NO_x is expressed as if all of the molecules were NO₂, and is commonly referred to as "NO_x as NO₂".

4.176 All erroneous data should be disregarded before any averaging or data interpretation is undertaken. Chemiluminescent monitors produce a data record every 15 minutes, whereas the objectives for NO₂ relate to hourly and annual µg/m³ averages. In order to calculate the 1 hour average data, four 15 minute µg/m³ records are averaged. The 1 hour average will only be valid if there was at least 75% data capture, i.e. 3 valid 15 minute averages. The annual average is calculated as the average of all valid 1 hour averages in the year.

4.177 1 hour data capture can be calculated as the number of valid 1 hour averages divided by the number of hours in the year, and this is expressed as a percentage by multiplying by 100. For

example, if there were 8560 valid 1 hour averages of NO₂ data in a non-leap year, then the data capture is $(100 \times 8560) / 8760$, which is 97.7%.

- 4.178 It is required to report the number of hours where there was greater than 200µg/m³ over a calendar year. There are allowed to be no more than 18 exceedances per calendar year. The number of exceedances should only be reported where data capture is more than 85% of a full year. If data capture is less than 85% or monitoring is for less than a full year, then local authorities should instead report the 99.8th percentile for 1 hour NO₂. For example, if the available 1 hour average data are in Column A in an Excel spreadsheet, then the Excel formula would be =PERCENTILE(A:A,0.998). If the 99.8th percentile is greater than 200µg/m³, then this means that if there had been 100% data capture, then there have been greater than 18 exceedances of 200µg/m³ per calendar year.
- 4.179 The annual NO₂ average should be below 40µg/m³. If the data capture was below 75%, then it is necessary to annualise the data as per the example in Box 4.8. The reason for annualisation is that the concentration varies throughout the year, and the instrument may have been operational for a period of above or below average concentrations.

NO₂ by Diffusion Tubes

- 4.180 Diffusion tubes take samples over an approximately 1 month period. As such they are useful for assessing the annual objective of 40µg/m³, but cannot be used to assess the number of hours greater than 200µg/m³. As they are not the reference method, and passive diffusion typically results in a low accuracy, it is necessary to bias correct the results based upon local or national collocation studies with chemiluminescent analysers. It is also necessary to calculate the data capture, and if this is less than 75%, the results must be annualised.
- 4.181 Diffusion tubes are inexpensive and many can be installed over a geographical area. The low cost per tube permits sampling at a number of points in the area of interest; which 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. They are useful both for annual monitoring as well as short term monitoring projects. They can be placed in many different locations, though are typically placed on building facades in heavily trafficked areas, and in urban background locations. If there are any continuous NO₂ chemiluminescent monitors within the local authority area, then three diffusion tubes must be collocated as close as possible to the chemiluminescent sampler’s inlet, but certainly within 1m.
- 4.182 The site should be open to the sky, with no overhanging vegetation or buildings. It is important to place diffusion tubes where there is free circulation of air around the tube, but the opposite extreme should also be avoided, i.e. 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, sinks of NO₂, or disturbances to the airflow. For example, tubes must be mounted greater than 10m from the following:
- 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.
- 4.183 Many different types of diffusion tube are available. These differ in three ways:
- the analytical laboratory;
 - whether the solvent used to prepare them was water or acetone, and
 - the percentage of Triethanolamine (TEA) used in the preparation of the tubes.
- 4.184 When selecting an appropriate laboratory and type of tube to use, local authorities should research the spread in the bias correction factors and the precision of tubes analysed in previous years – this information is made available on the LAQM Support website. Additional information on the QA/QC framework that is used to evaluate the performance of analytical laboratories that supply and analyse the diffusion tubes, namely the AIR-PT scheme (previously the Workplace Analysis Scheme for Proficiency - WASP), may also be considered. This information is available on the LAQM Support website⁵⁹.
- 4.185 Tubes should be put out in accordance to the Diffusion Tube Calendar. This will be disseminated to local authorities towards the end of the previous calendar year. The calendar splits the year in to 4 and 5 week blocks and suggests that tubes are changed on a Wednesday. It is preferable to change the tubes on the Wednesday, but Tuesday and Thursday are also acceptable. Monday and Friday are acceptable under exceptional circumstances. The first date of the calendar is generally around the 8th of January. This is in order to avoid the requirement to change tubes over the Christmas and New Year period. As such, the annual average is not identical to the calendar year, but is offset by about a week. If diffusion tubes are left out for significantly longer or shorter periods than the 4 and 5 weeks recommended, then the data may not be reliable as the diffusion rate may not have been accurately defined. Local authorities should discuss this with their diffusion tube supplier.
- 4.186 The end of the tube that should be removed prior to mounting them is typically clear or white, but will be specifically dictated by the laboratory that supplied them. 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, and the fittings should be mounted so that the tubes can be changed easily. Tubes must not be fixed directly to walls or similar surfaces, 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. The specific spacer technique used to mount the tubes will depend upon the specific equipment supplied by laboratory which prepared them.
- 4.187 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 label 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;

⁵⁹ <http://laqm.defra.gov.uk/diffusion-tubes/qa-qc-framework.html>

- 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 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.

4.188 It is recommended that travel blanks are routinely deployed. Travel blanks are used 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).

4.189 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? 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 ($3\mu\text{g}/\text{m}^3$ or less) are rare at urban 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. 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;
- 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.

- 4.190 Once erroneous data have been deleted, it is necessary to calculate the annual average. The data need to be annualised, and then bias corrected. In order to do this, firstly the annual average is calculated for all sites. So long as the diffusion tube calendar is adhered to, then even though the periods that the tubes are out varies, it is acceptable to do a simple average. If the periods that the tubes were out varied beyond the 4 to 5 week recommendation, then it may be necessary to do a time weighted average. In order to do this, each concentration is multiplied by the number of days that the tube was out. These results are then added together for every period of the year. Finally, this is divided by the total number of days that all the tubes were out. For example, if Tube 1 was out for 32 days and had a $45\mu\text{g}/\text{m}^3$ average, and Tube 2 was out for 46 days and had a $25\mu\text{g}/\text{m}^3$ average, the simple average is $(45+25)/2 = 35\mu\text{g}/\text{m}^3$; whereas the time weighted average = $((45\times 32)+(25\times 46))/(32+46) = 33.2\mu\text{g}/\text{m}^3$.
- 4.191 For those sites with fewer than 9 months' worth of data, it is necessary to perform annualisation. This can be undertaken using the technique discussed in Box 4.8, but if there are many sites to be corrected then local authorities are advised to use the technique described in Box 4.9.

Box 4.9 – Example: Annualising NO₂ Diffusion Tube Monitoring Data

A diffusion tube site (D1) has 8 months' worth of data and so it is necessary to annualise. A continuous background site (B1) has greater than 85% data capture for the year. The tubes were set out in accordance with the recommended calendar for 2015. If there are many locations to be annualised then it can be quicker to average the background site data to the same calendar as the diffusion tubes. The results are given in the below table. In addition, the results are given for the background site for those months that D1 data are available (Column B1 when D1 is available).

Start Date	End Date	B1	D1	B1 when D1 is available
7 January 2015	4 February 2015	15.6	38.4	15.6
4 February 2015	4 March 2015	38.3		
4 March 2015	1 April 2015	22.7	43.1	22.7
1 April 2015	29 April 2015	22.2		
29 April 2015	27 May 2015	24.9	51.3	24.9
27 May 2015	1 July 2015	20.8		
1 July 2015	29 July 2015	18.1	31.3	18.1
29 July 2015	26 August 2015	16.1	26.8	16.1
26 August 2015	30 September 2015	25.5	41.0	25.5
30 September 2015	28 October 2015	21.1		
28 October 2015	2 December 2015	28.1	29.8	28.1
2 December 2015	6 January 2016	32.0	39.8	32.0
Average		23.8	37.7	22.9

The annual mean (A_m) of B1 is $23.8\mu\text{g}/\text{m}^3$. The period mean (P_m), of B1 is $22.9\mu\text{g}/\text{m}^3$. The ratio R of the annual mean to the period mean (A_m/P_m) is 1.04. This process should be repeated for all continuous background sites. If no continuous monitoring sites are available, then diffusion tube sites from background locations with 12 months' data may be used. In either case, the more background sites that can be identified the better. Calculate the average of these ratios R_a . This is then the annualisation factor.

The measured period mean concentration M is $37.7\mu\text{g}/\text{m}^3$. Multiply by this annualisation factor R_a to give the estimate of the annual mean for 2015. Assuming that all other background sites yielded an annualisation factor of 1.04, then R_a in this example is 1.04; and the annualised average of $D1 = M \times R_a = 37.7 \times 1.04 = 39.2\mu\text{g}/\text{m}^3$.

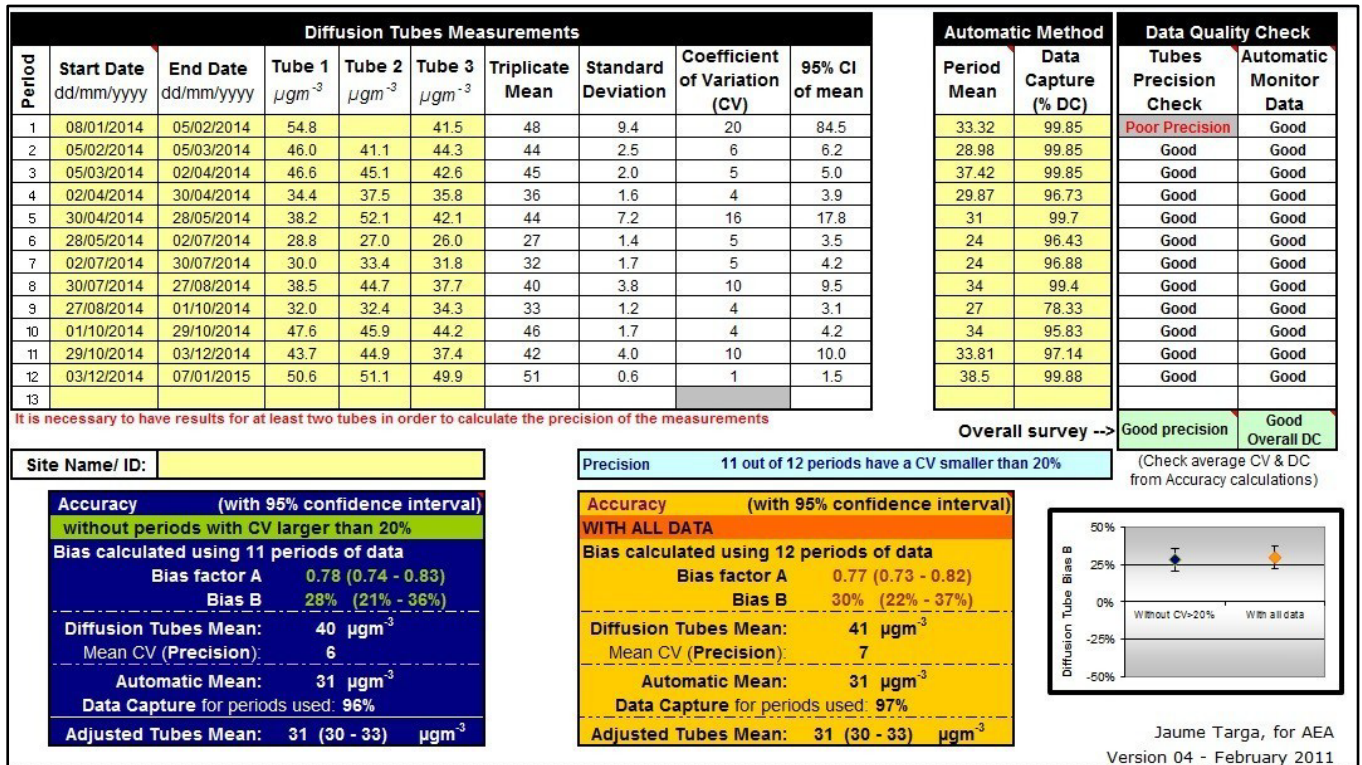
If the periods that the tubes were out varied beyond the 4 to 5 week recommendation, then it may be necessary to do a time weighted average rather than simple average in order to calculate M , A_m and P_m .

- 4.192 After annualisation, the tubes should be corrected for bias. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser. This should not be confused with precision, which is an indication of how similar the results of duplicate or triplicate tubes are to each other. While it is possible to adjust diffusion tube results to account for bias, but it is not possible to correct for poor precision. A spreadsheet-based tool⁶⁰ has been developed that allows local authorities to easily calculate the bias and precision of their tubes.

60 http://laqm.defra.gov.uk/documents/AEA_DifTPAB_v04.xls

An example of the output is illustrated in Figure 4.1.

Figure 4.1 – Local Bias Adjustment Factor Tool



- 4.193 The yellow cells are those to be completed by the local authority. Precision is calculated based on the diffusion tube data only. Tube precision is categorised as good or poor. 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%. Bias is calculated only if the period mean and data capture from a collocated chemiluminescence analyser are included on the spreadsheet. Two boxes are output by the spreadsheet, a blue one and an orange one. Local authorities should use the blue box, in which the spreadsheet automatically disregards the diffusion tubes where there is poor precision. Having calculated the accuracy of your local co-location study, the Single Tube and Multiple Tubes Adjustment sheets may be useful for assisting in bias adjusting tubes.
- 4.194 Two bias factors are output, A and B, and in this example they are 0.78 and 28% respectively. The Bias factor A is the local bias correction factor. If there is more than one local collocation study, then the A factors should not be averaged. Instead, a reasonable approximation can be derived by averaging the B values. For example, if there were 2 studies of 22% and 28%, then the average would be 25%. This is then expressed as a factor, e.g. 25% is 0.25. Next add 1 to this value, e.g. $0.25 + 1.00 = 1.25$. Finally, take the inverse to give the bias adjustment factor, e.g. $1/1.25 = 0.80$.
- 4.195 Where local authorities have conducted a collocation study, then the results of the studies must be sent to the LAQM Support Helpdesk. This information is used to formulate a national bias adjustment factor for each type of tube. Figure 4.2 shows an example output from the National

Diffusion Tube Bias Adjustment Factor Spreadsheet. In this example, there were five different studies throughout the UK, and the average bias factor was 0.79.

- 4.196 Local authorities should compare the results of correcting data by the locally derived factor (in this example 0.80); to that of the nationally derived factor (in this example 0.79). It is important to stress that correction should not be done by both the local and national factors at the same time. If the factors are significantly different from each other, and/or if it makes a difference as to which sites are greater or less than $40\mu\text{g}/\text{m}^3$, then this should be clearly discussed in the LAQM report. The nationally derived factor will also include any locally derived factors as the collocation data must be sent to NPL. As such, the national factor is likely to be the more reliable.
- 4.197 However, the choice of whether to apply the local or national factor is not always straightforward. Guidance on the most suitable approach is given in Box 4.10.
- 4.198 The value of a local co-location study (and the subsequent bias adjustment) will be improved if the concentrations being measured are similar to those in the wider survey. Broadly, this equates to carrying out a co-location study at roadside locations in order to derive a bias adjustment factor to be applied to a survey of roadside concentrations.
- 4.199 Care should be taken to avoid applying a bias adjustment factor derived from a local co-location study carried out for concentrations that are very different to those being measured in the wider survey. In other words, co-location results from a low concentration site (typically a background site) should not be used to derive a bias adjustment factor for survey results from high concentration sites (typically roadside sites) and vice versa. There may be circumstances where this is not possible, and this will increase the uncertainty of the results.

Box 4.10 - Choice of NO₂ Bias Adjustment Factor

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, e.g. October 2014 to September 2015 – 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, i.e. 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, e.g. 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 LAQM Support Helpdesk website.

Figure 4.2 – National Bias Adjustment Factor Spreadsheet

National Diffusion Tube Bias Adjustment Factor Spreadsheet							Spreadsheet Version Number: 06/15			
Follow the steps below in the correct order to show the results of relevant co-location studies							This spreadsheet will be updated at the end of September 2015			
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods							LAQM Helpdesk Website			
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet							Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.			
This spreadsheet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.										
The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.										
Step 1:	Step 2:	Step 3:	Step 4:							
Select the Laboratory that Analyses Your Tubes from the Drop-Down List	Select a Preparation Method from the Drop-Down List	Select a Year from the Drop-Down List	Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor ³ shown in blue at the foot of the final column.							
If a laboratory is not shown, we have no data for this laboratory.	If a preparation method is not shown, we have no data for this method at this laboratory.	If a year is not shown, we have no data ²	If you have your own co-location study then see footnote ¹ . If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@uk.bureauveritas.com or 0800 0327953							
Analysed By ¹	Method	Year ²	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m ³)	Automatic Monitor Mean Conc. (Cm) (µg/m ³)	Bias (B)	Tube Precision ³	Bias Adjustment Factor (A) (Cm/Dm)
ESG Didcot	20% TEA in water	2014	KS	Marylebone Road Intercomparison	12	114	80	42.6%	G	0.70
ESG Didcot	20% TEA in water	2014	R	Rhondda Cynon Taf CBC	11	34	30	10.5%	G	0.90
ESG Didcot	20% TEA in water	2014	KS	South Lakeland District Council	9	41	32	29.2%	G	0.77
ESG Didcot	20% TEA in water	2014	UB	Wigan Council	13	28	22	27.5%	P	0.78
ESG Didcot	20% TEA in water	2014		Overall Factor³ (4 studies)				Use		0.79

4.200 Consideration may also be given to whether additional adjustment of diffusion tube monitoring results is required to account for tube chemistry. Whilst it is not recommended that this adjustment is applied routinely, in certain circumstances this may help to reduce the uncertainty of the diffusion tube results further. See Box 4.11 for more information.

Box 4.11 - Diffusion Tube Chemistry and Adjustment

Results of a nationwide survey of nitrogen dioxide diffusion tube co-location studies have been used to improve current understanding of diffusion tube bias. Data suggests that tubes close to a road are more likely to underestimate concentrations, once they have been adjusted for laboratory bias, and conversely tubes further away from roads are more likely to overestimate concentrations.

Careful analysis of the results suggests that it is not the distance from the road that matters, but the different concentrations of nitric oxide, nitrogen dioxide and ozone that this reflects. These different concentrations influence the chemistry taking place within the diffusion tube, in particular the formation of additional nitrogen dioxide from a reaction of ozone with nitric oxide.

A relationship has been identified between diffusion tube bias and the measured annual mean nitrogen dioxide concentration that can be used to adjust the diffusion tube result. The effect of this 'tube-chemistry' adjustment depends on the measured concentration: thus a laboratory bias adjusted result of 20µg/m³ would become 18.1µg/m³ after adjustment for bias due to tube chemistry. A value of 40µg/m³ would remain at 40µg/m³ and 60µg/m³ would become 65.1µg/m³. The effect of this adjustment is minimal at concentrations close to the objective of 40µg/m³, thus it will not have a material effect on exceedances of the objective identified using diffusion tubes.

Adjusting for tube chemistry reduces the uncertainty of diffusion tube results. It is not recommended, however, that this adjustment is applied routinely. There may be occasions though when it is appropriate to apply the tube-chemistry bias adjustment, e.g. it may improve the reliability of the diffusion tube data for use in model verification at both roadside and background sites. The LAQM Support Helpdesk should be contacted for further advice if you are unsure as to whether this is relevant to your particular circumstances.

SO₂ Monitoring

- 4.201 The reference method for SO₂ monitoring is ultraviolet fluorescence. A number of instruments have⁵⁶ been approved under the MCERTS scheme.
- 4.202 This technique is based on the emission of light by SO₂ molecules excited by UV radiation and is proportional to the SO₂ mixing ratio in parts per billion by volume (ppbV). It is necessary to convert the ppbV mixing ratios to concentrations in µg/m³ (See below).
- 4.203 Ideally, local authority personnel should attend sites with particularly high concentrations every two weeks, e.g. urban centre locations or industrial sites with localised point sources. Local authority personnel should attend the site every four weeks for sites at all other locations. At this time, the filter should be changed and the instrument's calibration should be checked. This is done by introducing nominally 450 ppbV SO₂ in synthetic air to the system and then noting the value of SO₂ from the front panel of the instrument after the reading has stabilised. 450 ppbV is chosen as this is 90% of the 500 ppbV full span of the instrument. The zero of the instrument is then checked by passing synthetic air or ambient air that has been purified. Again, the value of SO₂ is noted from the front panel of the instrument. The 450 ppbV SO₂ in synthetic air cylinder should be traceable to a national or international reference cylinder so that the concentration is accurately known.
- 4.204 Instruments should be periodically checked by an independent organisation accredited to perform QA/QC checks to ISO17025:2005. Ideally this should be performed every six months. It is essential that the QA/QC process checks the calibration using SO₂ in synthetic air.
- 4.205 In order to improve the reliability and validity of the data, it is recommended that instruments should be periodically serviced by the manufacturer or an approved service unit. Ideally this should be performed every six months and within three weeks of the independent QA/QC audit. 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.
- 4.206 In order to correct for the drift in instrument calibration and then to convert from ppbV to µg/m³, it is necessary to follow the below procedure:
- Erroneous calibrations should be identified by observing the trend in the ppbV readings of SO₂ from the front of the instrument when the nominally 450 ppbV SO₂ in synthetic air and zero gases were introduced. Readings which do not follow anticipated trends should be ignored;
 - For each day that the calibration was checked on the instrument, the SO₂ zero is taken to be the ppbV mixing ratio of SO₂ that was displayed on the front of the instrument when the zero gas was introduced. It is possible for the SO₂ zero to be incorrect, and instead the correct zero may be identified by observing trends in the lowest concentration of the ambient SO₂ data;
 - For each day that the calibration was checked on the instrument, the SO₂ span is taken to be the ppbV mixing ratio of SO₂ that was displayed on the front of the instrument when the 450 ppbV SO₂ in synthetic air gas was introduced;
 - For each day that the calibration was checked on the instrument, the SO₂ range is calculated as SO₂ span minus SO₂ zero;

- For each day that the calibration was checked on the instrument, the SO₂ calibration factor is calculated by taking the exact known SO₂ ppbV mixing ratio of the SO₂ in synthetic air cylinder and dividing this by the SO₂ range;
- For each day that the calibration was checked on the instrument, the SO₂ calibration factor is calculated by taking the exact known SO₂ ppbV mixing ratio of the SO₂ in synthetic cylinder and dividing this by the SO₂ range;
- The SO₂ calibration factor and SO₂ zero should be defined for every 15 minute monitoring period that monitoring was undertaken. It is important that a step change in calibration factors is accounted for whenever the instrument was serviced or repaired. It is considered sufficient to take the SO₂ calibration factor and SO₂ zero to be the same for every record following each calibration check prior to the following calibration check. It is however more accurate to linearly interpolate the SO₂ calibration factor and SO₂ zero between calibration checks;
- The 15 minute SO₂ ppbV readings from the instrument are zero corrected by subtracting the SO₂ zero assigned to that 15 minute record;
- The 15 minute zero corrected SO₂ ppbV readings are span corrected by multiplying by the SO₂ calibration factor assigned to that 15 minute record;
- SO₂ ppbV is converted in to µg/m³ by multiplying by 2.66.
- All erroneous data should be disregarded before any averaging or data interpretation is undertaken. Ultraviolet fluorescence monitors produce a data record every 15 minutes. The objectives for SO₂ relate to 15 minute, hourly and 24 hour µg/m³ averages. In order to calculate the 1 hour average data, four 15 minute µg/m³ records are averaged. The 1 hour average will only be valid if there was at least 75% data capture, i.e. 3 valid 15 minute averages. The 24 average is calculated as the average of all valid 1 hour averages in the day. The 24 hour average will only be valid if there was at least 75% data capture, i.e. 18 valid 1 hour averages.
- As the objectives for SO₂ relate to 15 minute, hourly and 24 hour averages, three different data capture rates should be calculated based upon the number of valid 15 minute, 1 hour and 24 hour average in the year. For example, if there were 30720 valid days of 15 minute SO₂ data in a leap year, then the data capture is $(100 \times 30720) / 35136$, which is 87.4%.
- It is required to report the number of 15 minute periods where there was greater than 266µg/m³ over a calendar year. There are allowed to be no more than 35 exceedances per calendar year. The number of exceedances should only be reported where data capture is more than 85% of a full year. If data capture is less than 85% or monitoring is for less than a full year, then local authorities should instead report the 99.9th percentile for 15 minute SO₂. For example, if the available 15 minute average data are in Column A in an Excel spreadsheet, then the Excel formula would be =PERCENTILE(A:A,0.999). If the 99.9th percentile is greater than 266µg/m³, then this means that if there had been 100% data capture, then there have been greater than 35 exceedances of 266µg/m³ per calendar year.
- It is required to report the number of 1 hour periods where there was greater than 350µg/m³ over a calendar year. There are allowed to be no more than 24 exceedances per calendar year. The number of exceedances should only be reported where data capture is more than 85% of a full year. If data capture is less than 85% or monitoring is for less than a full year, then local authorities should instead report the 99.7th percentile for 1 hour SO₂.
- It is required to report the number of 24 hour periods where there was greater than 125µg/m³ over a calendar year. There are allowed to be no more than 3 exceedances per

calendar year. The number of exceedances should only be reported where data capture is more than 85% of a full year. If data capture is less than 85% or monitoring is for less than a full year, then local authorities should instead report the 99.2nd percentile for 24 hour SO₂.

Carbon Monoxide Monitoring

- 4.207 The reference method for CO monitoring is non-dispersive infrared spectroscopy. A number of instruments have been approved under the MCERTS scheme⁵⁶.
- 4.208 This technique is based on the attenuation of infrared light passing through a sample cell which is proportional to the CO mixing ratio in parts per million by volume (ppmV). It is necessary to convert the ppmV mixing ratios to concentrations in mg/m³ (See below).
- 4.209 Ideally, local authority personnel should attend the site every two weeks for sites in roadside or kerbside locations or at urban centre locations with particularly high concentrations. Local authority personnel should attend the site every four weeks for sites at other locations. At this time, the filter should be changed and the instrument's calibration should be checked. This is done by introducing nominally 20 ppmV CO in synthetic air to the system and then noting the value of CO from the front panel of the instrument after the reading has stabilised. The zero of the instrument is then checked by passing synthetic air or ambient air that has been purified. Again, the value of CO is noted from the front panel of the instrument. The 20 ppmV CO in synthetic air cylinder should be traceable to a national or international reference cylinder so that the concentration is accurately known.
- 4.210 In order to improve the reliability and validity of the data, it is recommended that instruments should be periodically checked by an independent organisation accredited to perform QA/QC checks to ISO17025:2005. Ideally this should be performed every six months. It is essential that the QA/QC process checks the calibration using CO in synthetic air.
- 4.211 Instruments should be periodically serviced by the manufacturer or an approved service unit. Ideally this should be performed every six months and within three weeks of the independent QA/QC audit. 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.
- 4.212 In order to correct for the drift in instrument calibration and then to convert from ppmV to mg/m³, it is necessary to follow the below procedure:
- Erroneous calibrations should be identified by observing the trend in the ppmV readings of CO from the front of the instrument when the nominally 20 ppmV CO in synthetic air and zero gases were introduced. Readings which do not follow anticipated trends should be ignored;
 - For each day that the calibration was checked on the instrument, the CO zero is taken to be the ppmV mixing ratio of CO that was displayed on the front of the instrument when the zero gas was introduced. It is possible for the CO zero to be incorrect, and instead the correct zero may be identified by observing trends in the lowest concentration of the ambient CO data;
 - For each day that the calibration was checked on the instrument, the CO span is taken to be the ppmV mixing ratio of CO that was displayed on the front of the instrument when the 20

ppmV CO in synthetic air gas was introduced;

- For each day that the calibration was checked on the instrument, the CO range is calculated as CO span minus CO zero;
- For each day that the calibration was checked on the instrument, the CO calibration factor is calculated by taking the exact known CO ppmV mixing ratio of the CO in synthetic air cylinder and dividing this by the CO range;
- For each day that the calibration was checked on the instrument, the CO calibration factor is calculated by taking the exact known CO ppmV mixing ratio of the CO in synthetic cylinder and dividing this by the CO range;
- The CO calibration factor and CO zero should be defined for every 15 minute monitoring period that monitoring was undertaken. It is important that a step change in calibration factors is accounted for whenever the instrument was serviced or repaired. It is considered sufficient to take the CO calibration factor and CO zero to be the same for every record following each calibration check prior to the following calibration check. It is however more accurate to linearly interpolate the CO calibration factor and CO zero between calibration checks;
- The 15 minute CO ppmV readings from the instrument are zero corrected by subtracting the CO zero assigned to that 15 minute record;
- The 15 minute zero corrected CO ppmV readings are span corrected by multiplying by the CO calibration factor assigned to that 15 minute record;
- CO ppmV is converted in to mg/m^3 by multiplying by 1.16.

4.213 All erroneous data should be disregarded before any averaging or data interpretation is undertaken. Non-dispersive infrared spectroscopy monitors produce a data record every 15 minutes. The objectives for CO relate to a running 8 hour mg/m^3 average. This is an 8 hour average that is updated once every hour – i.e. there are 8760 running 8 hour averages beginning in a non-leap year, though only 8752 of these will lie entirely within the year. It is first necessary to calculate the 1 hour average data, to do this; four 15 minute mg/m^3 records are averaged. The 1 hour average will only be valid if there was at least 75% data capture, i.e. 3 valid 15 minute averages. Eight 1 hour averages are then averaged for every 8 hour period. The 8 hour average will only be valid if there was at least 75% data capture, i.e. 6 valid 1 hour averages. The running 8 hour average is not allowed to exceed $10\text{mg}/\text{m}^3$ on any single occasion during the year.

4.214 Rolling 8 hour data capture can be calculated as the number of rolling 8 hour averages divided by the number of hours in the year, and this is expressed as a percentage by multiplying by 100. For example, if there were 7852 valid rolling 8 hour averages of CO data in a non-leap year, then the data capture is $(100 \times 7852) / 8760$, which is 89.6%.

Lead Monitoring

4.215 Defra and the Devolved Administrations have approved a number of similar methods for the analysis of lead in air. It is first necessary to take PM_{10} sample filters using an approved method PM_{10} sampling method that utilises filters, i.e. the reference method, Partisol, Opsis SM200 or FAI SWAM (see para 4.157). It is possible to analyse multiple one day filters together, or to take a single filter sample over multiple days. When taking a multiple day sample, it is important that the

sample flow does not drop below 10% of the nominal value, and that the total volume is accurately measured. The filters can be any of quartz, cellulose nitrate or cellulose acetate membrane, so long as the filter lead content can be demonstrated to be low and constant. The analysis can be any either Graphite Furnace Atomic Absorption Spectrometry (GFAAS), or Inductively Coupled Plasma – Mass Spectrometry (ICP-MS), so long as the detection limit can be demonstrated to be sufficient for the lead concentrations to be monitored for: The concentration in $\mu\text{g}/\text{m}^3$ of each sample is taken as the mass of lead in μg divided by the sample volume in m^3 . The PM sampler and the instrument used to quantify the metals content should be subjected to six monthly QA/QC and servicing schedules.

- 4.216 The annual mean should be below $0.25\mu\text{g}/\text{m}^3$. This can be calculated as the average of all the samples taken during the year. If the time of each sample was not constant, then it is necessary to calculate a time weighted average. First multiply each sample concentration by the number of days over which that sample was taken. These values are then added up. Finally, this value is divided by total number of days over which the samples were taken.

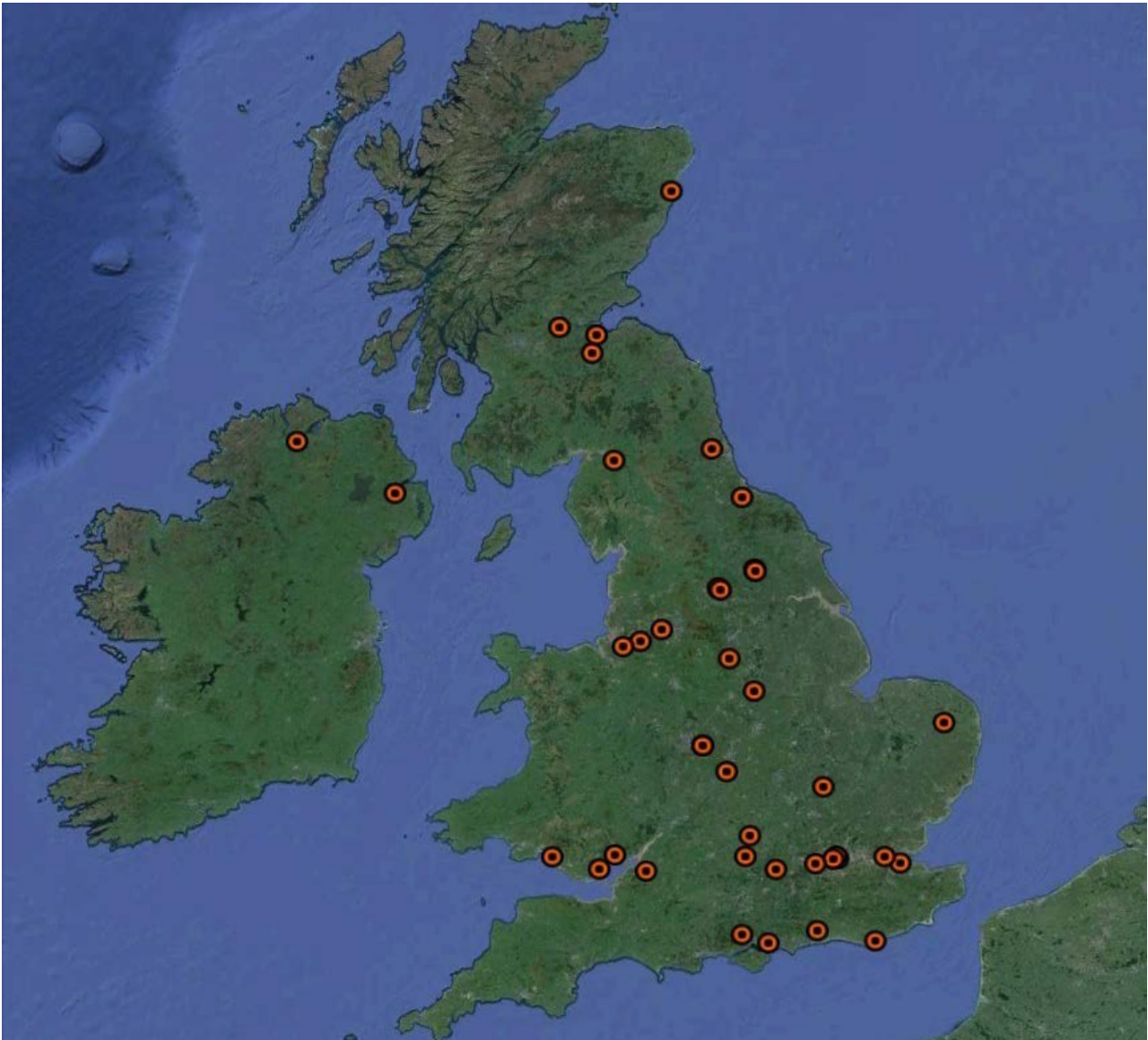
Benzene and 1,3-Butadiene Monitoring

- 4.217 Benzene and 1,3-butadiene are monitored by collecting a sample on to an adsorbent material and then subsequently analysing this by gas chromatography. One of three methods can be used for this:
- Taking hourly or multi-hour samples by sucking air through the adsorbent, and then automatically analysing these on-site. The resultant chromatographs may be analysed automatically on-site or analysed off-site at a later date. This method is expensive, but is both highly accurate and allows for highly time resolved data;
 - Taking longer samples by sucking air through the adsorbent, and then sending these to a laboratory for analysis. The Defra pumped benzene network takes two week samples using this method. This method is moderately affordable and the data are accurate, but it only allows for infrequently time resolved data;
 - Leaving tubes containing the adsorbent outside in order for the benzene or 1,3 butadiene to diffuse on to the adsorbent, then sending these to a laboratory for analysis. This method is affordable, but passive diffusion is less accurate than active sampling, and it only allows for infrequently time resolved data.
 - Continuous methods should be subjected to six monthly QA/QC and servicing schedules.
 - 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. The use of solvent based marker pens should also be avoided.
 - In addition, a DOAS based benzene sampler has been approved under the MCERTS scheme⁵⁶.
 - For Benzene (in England and Wales), the annual mean should be below $5\mu\text{g}/\text{m}^3$. This can be calculated as the average of all the samples taken during the year. If the time of each sample was not constant, then it is first necessary to multiply each sample concentration by the number of days over which that sample was taken. These values are then added up. Finally, this value is divided by total number of days over which the samples were taken.
 - For 1,3-Butadiene throughout the UK, the running annual average should be below $2.25\mu\text{g}/\text{m}^3$.

Annex A. Derivation of $PM_{2.5}$ to PM_{10} Ratio

A.01. Local authorities may wish to estimate $PM_{2.5}$ data from PM_{10} data and vice versa. In order to investigate potential estimation methods, forty sites were identified within the AURN for where there are collocated PM_{10} and $PM_{2.5}$ FDMSs. The location of these sites is shown in Figure A.1.

Figure A.1 - Location of the PM_{10} and $PM_{2.5}$ Monitoring Sites utilised in this Study



A.02. It is noted that there are large regions of the UK where there are no nearby monitoring sites with collocated hourly PM_{10} and $PM_{2.5}$ measurements in the AURN. However, there may be suitable instruments in other networks.

A.03. The hourly ratified data were downloaded for each site for each year from 2010 to 2014. Two methods were investigated, one utilising the ratio of $PM_{2.5}/PM_{10}$, and another the

concentration of PM_{Coarse} in $\mu g/m^3$ was calculated as $PM_{10} - PM_{2.5}$.

A.04. OpenAir was used to plot time-variation plots of the hourly, daily and monthly variations. Two examples of these plots are shown in Figure A.2 and Figure A.3.

Figure A.2 - The Hourly Variation of the Ratio of $PM_{2.5}/PM_{10}$ for each Site

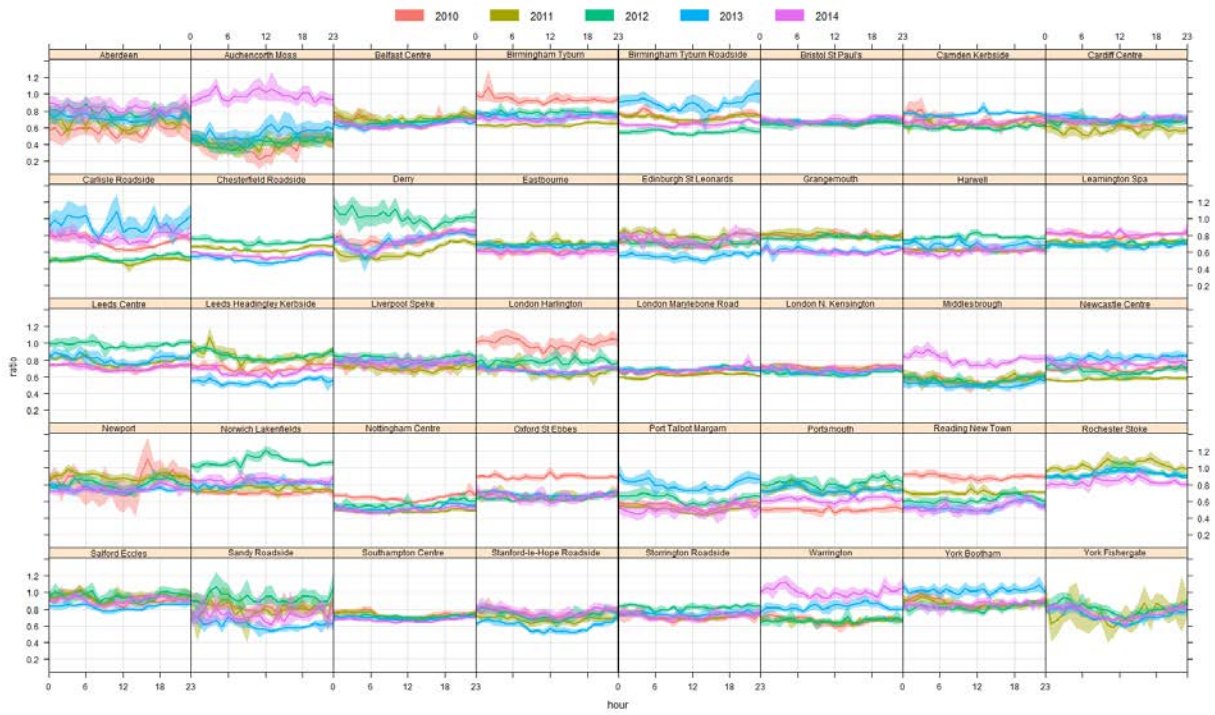
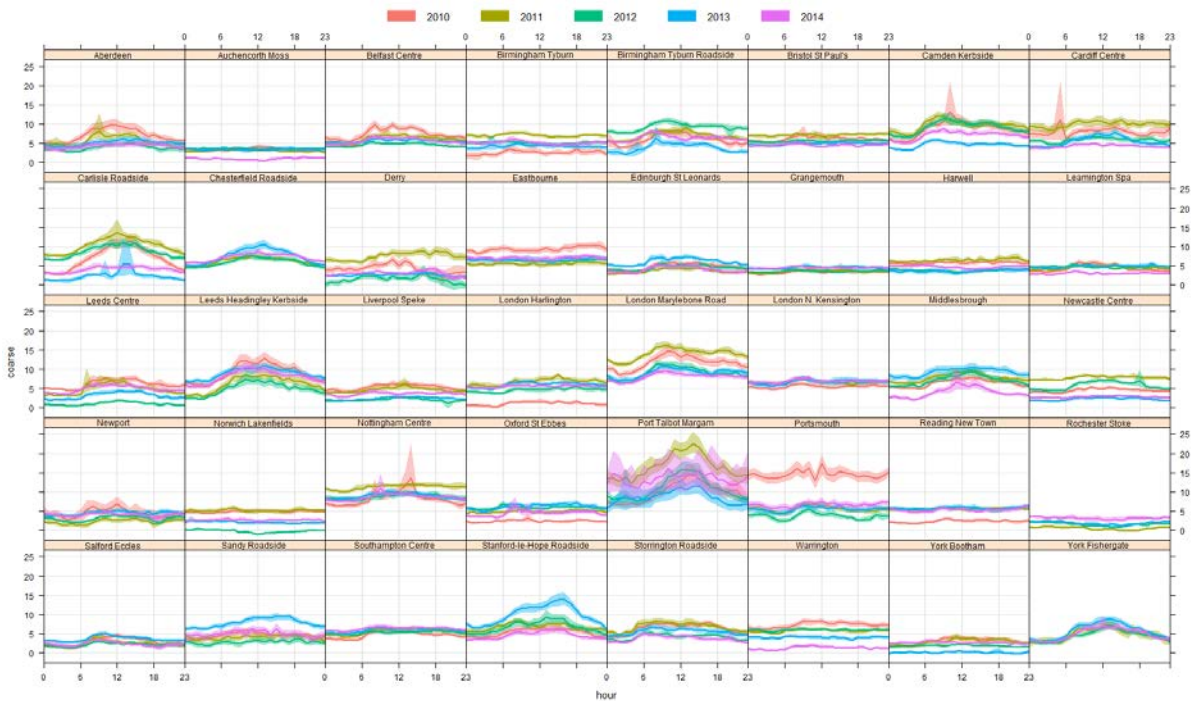


Figure A.3 - The Hourly Variation of PM_{Coarse} $\mu g/m^3$ for each Site



A.05. It is noted that there is a large variation in ratios between sites, and in some cases, between different years at a single site.

A.06. In addition, box and whisker plots were plotted, and four examples are shown below.

Figure A.4 - A Box and Whisker Plot showing the Spread in the Annual Average PM_{Coarse} $\mu g/m^3$ as a Function of Site Classification for All Years

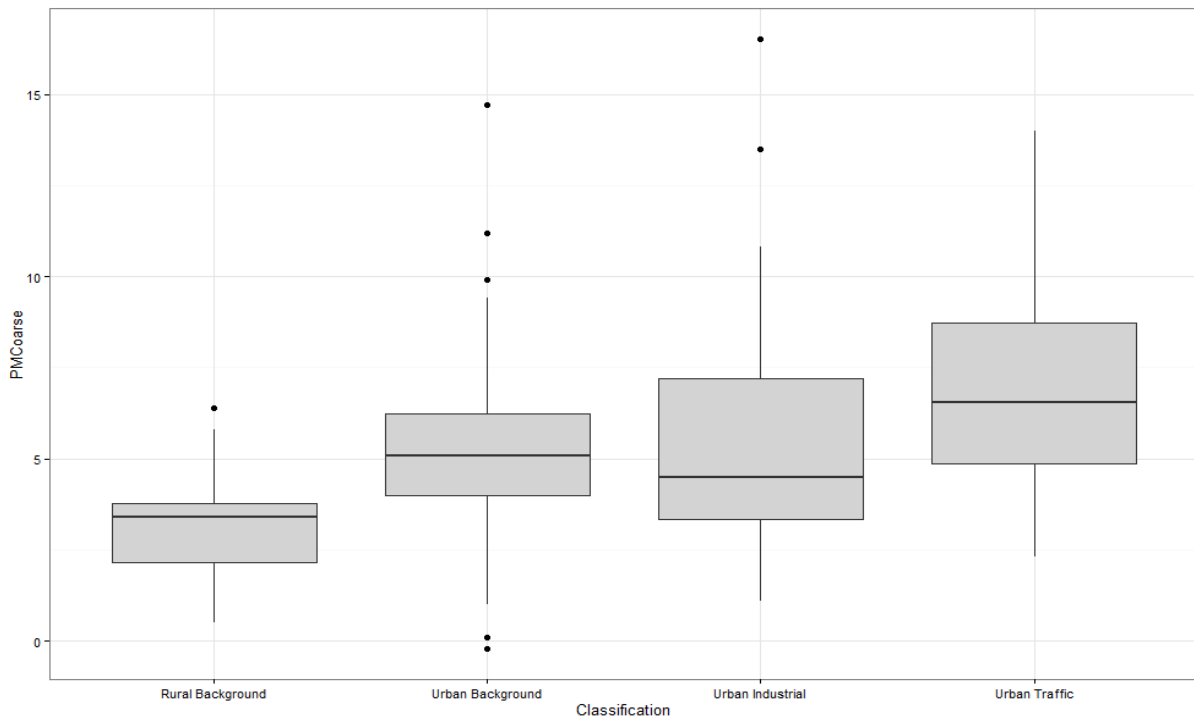


Figure A.5 - A Box and Whisker Plot showing the Spread in the Annual Average PM_{Coarse} $\mu g/m^3$ as a Function of Region for All Years

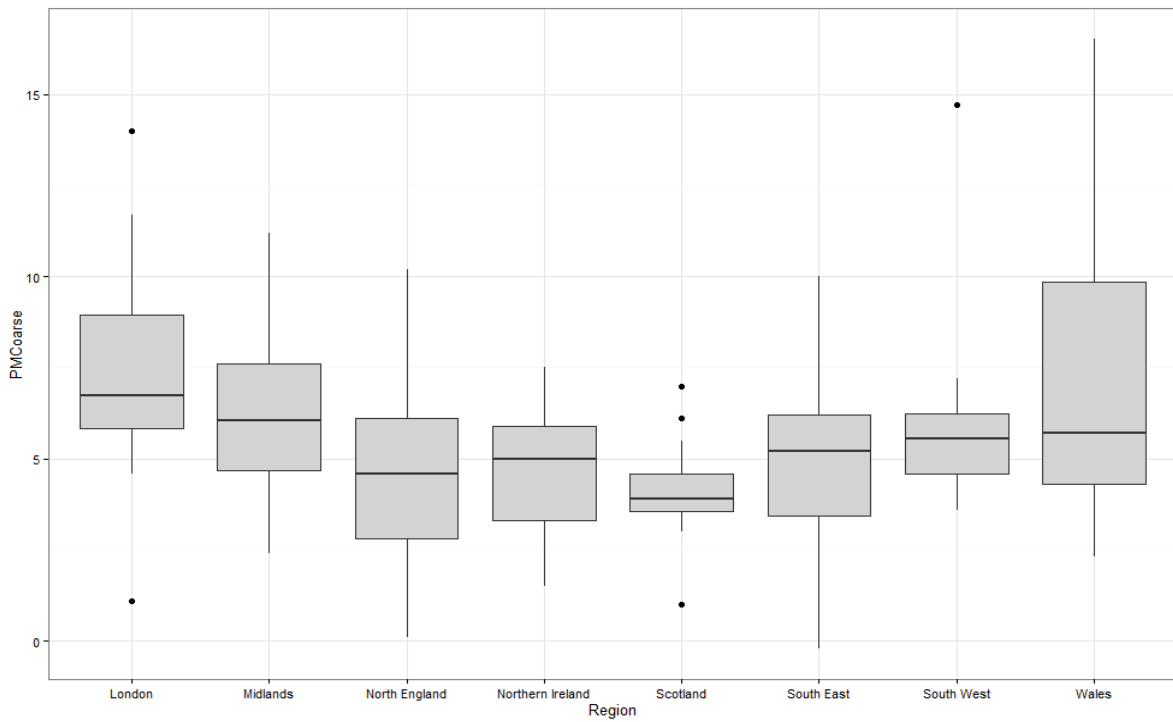


Figure A.6 - A Box and Whisker plot showing the Spread in the Annual Average Ratio of $PM_{2.5}/PM_{10}$ as a Function of Site Classification for All Years

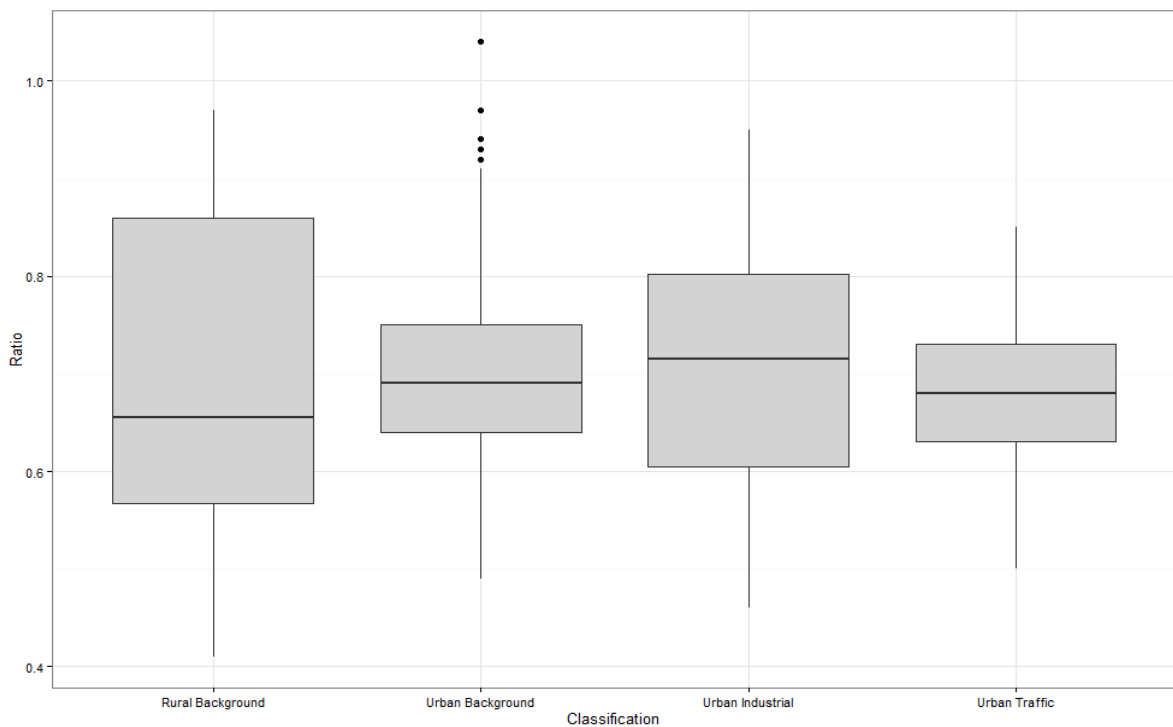
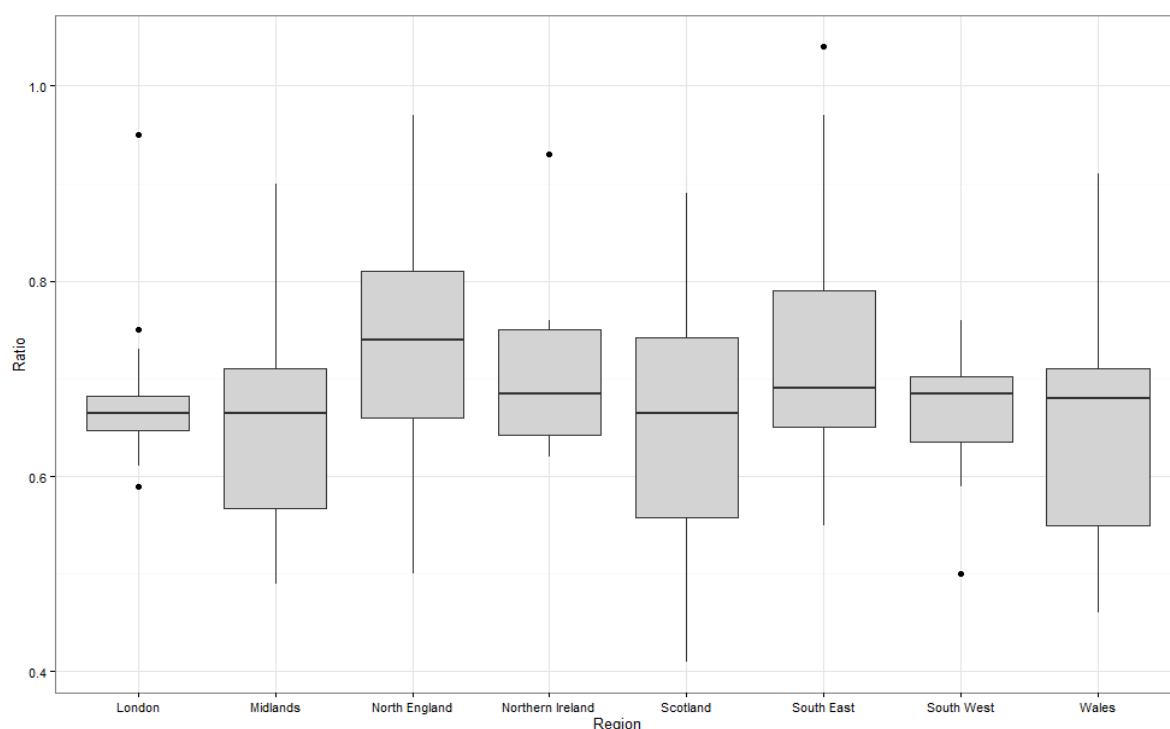


Figure A.7 - A Box and Whisker Plot showing the Spread in the Annual Average Ratio of $PM_{2.5}/PM_{10}$ as a Function of Region for All Years



- A.07. Sites in Scotland and Rural Background sites both stand out as have significantly lower PM_{Coarse} concentrations than other sites in the UK. Conversely, sites in London and Urban Traffic sites both stand out as having significantly higher PM_{Coarse} concentrations than other sites in the UK. The ratio of $PM_{2.5}/PM_{10}$ shows much less of a variation as a function of Site Classification or Region. Previous research highlighted in the AQEG report on $PM_{2.5}$ ¹³ stated that the ratio of $PM_{2.5}/PM_{10}$ varied with distance from Dover. Such a degree of variation is not evident in this analysis.
- A.08. The daily averages were calculated for PM_{10} and $PM_{2.5}$ for those days with greater than 90% data capture. PM_{Coarse} and the ratio of $PM_{2.5}/PM_{10}$ were calculated based upon these daily averaged concentrations. Annual averages were then calculated from the daily averaged data. Statistics summarising the distribution of data were calculated for different levels of annual Data Capture (DC) are given in Table A.1.

Table A.1 - Maximum, Minimum, Mean and Standard Deviation of the $PM_{2.5}/PM_{10}$ Ratio for All Sites for Years 2010 to 2014 and for Three Different Data Capture Limits

Statistic	Data Capture	Ratio	PM_{Coarse} ($\mu g/m^3$)
Count	No DC Limit	197	197
Maximum	No DC Limit	1.04	16.5
Minimum	No DC Limit	0.41	-0.2

Statistic	Data Capture	Ratio	PM _{Coarse} (µg/m ³)
Mean	No DC Limit	0.69	5.5
Standard Deviation	No DC Limit	0.11	2.6
Count	75% DC	109	109
Maximum	75% DC	1.04	16.5
Minimum	75% DC	0.41	-0.2
Mean	75% DC	0.70	5.2
Standard Deviation	75% DC	0.11	2.6
Count	90% DC	44	44
Maximum	90% DC	0.86	16.5
Minimum	90% DC	0.46	1.8
Mean	90% DC	0.70	5.2
Standard Deviation	90% DC	0.09	2.5

A.09. Considering the scenario where no annual averages have been deleted due to low data capture, there is a large spread in the ratio of PM_{2.5}/PM₁₀ from 0.41 to 1.04. A ratio of greater than 1 may indicate a problem with the data for that site. It may also indicate that the PM₁₀ and PM_{2.5} concentrations were similar, but both within the prescribed 25% expanded uncertainty allowed by the Air Quality Directive 2008/50/EC. The mean ratio of PM_{2.5}/PM₁₀ was 0.69 ± 0.11 for where no data have been deleted due to low data capture; 0.70 ± 0.11 for where data have been deleted as below 75% data capture; and 0.70 ± 0.09 for where data have been deleted as below 90% data capture. The mean concentration of PM_{Coarse} was 5.5 ± 2.6 µg/m³ for where no data have been deleted due to low data capture; 5.2 ± 2.6 µg/m³ for where data have been deleted due to below 75% data capture; 5.2 ± 2.5 µg/m³ for where data have been deleted due to below 90% data capture. This would suggest that outliers are having little effect upon the mean and standard deviation of annual average PM_{Coarse} and the ratio of PM_{2.5}/PM₁₀.

A.10. Two correction methodologies were tested:

- **Method 1.** Subtracting the average annual average PM_{Coarse} of nearby sites from the annual average PM₁₀ concentration of the site to be corrected; and
- **Method 2.** Multiplying the annual average PM₁₀ concentration of the site to be corrected by the average ratio of PM_{2.5}/PM₁₀ of 0.7.

A.11. Six scenarios were investigated:

- All Urban Background sites in the North of England for years 2010 to 2014 (6 sites);
- All sites in Scotland for years 2010 to 2014 (4 sites);
- All sites in Wales for years 2010 to 2014 (3 sites);

- All sites in Northern Ireland for years 2010 to 2014 (2 sites);
- Traffic sites in London for years 2010 to 2014 (2 sites); and
- All Urban Industrial Sites in the UK for years 2010 to 2014 (4 sites).

A.12 Two parameters were calculated:

- Method 1 Difference: Method 1 predicted $PM_{2.5}$ minus Measured $PM_{2.5}$; and
- Method 2 Difference: Method 2 predicted $PM_{2.5}$ minus Measured $PM_{2.5}$.

A.13 The results are summarised in Table A.2.

Table A.2 - Variation of Maximum, Minimum and Spread of the ‘Method 1 Difference’ and ‘Method 2 Difference’

	North Urban Background		Scotland		Wales		Northern Ireland		London Traffic		UK Industrial	
	Method		Method		Method		Method		Method		Method	
	1	2	1	2	1	2	1	2	1	2	1	2
	1	2	1	2	1	2	1	2	1	2	1	2
Maximum	6.4	3.0	2.3	2.2	10.4	7.7	4.1	1.8	4.4	2.9	12.2	7.7
Minimum	-4.6	-4.0	-3.2	-1.3	-12.3	-4.4	-4.3	-3.6	-4.4	-1.3	-6.4	-3.4
Spread	11.0	6.9	5.5	3.5	22.6	12.1	8.3	5.4	8.8	4.2	18.6	11.1

A.12. In all of the six scenarios, the spread in the range of concentrations calculated by Method 2 is always lower than that calculated by Method 1. This analysis would suggest that Method 2 is the better of the two methods.

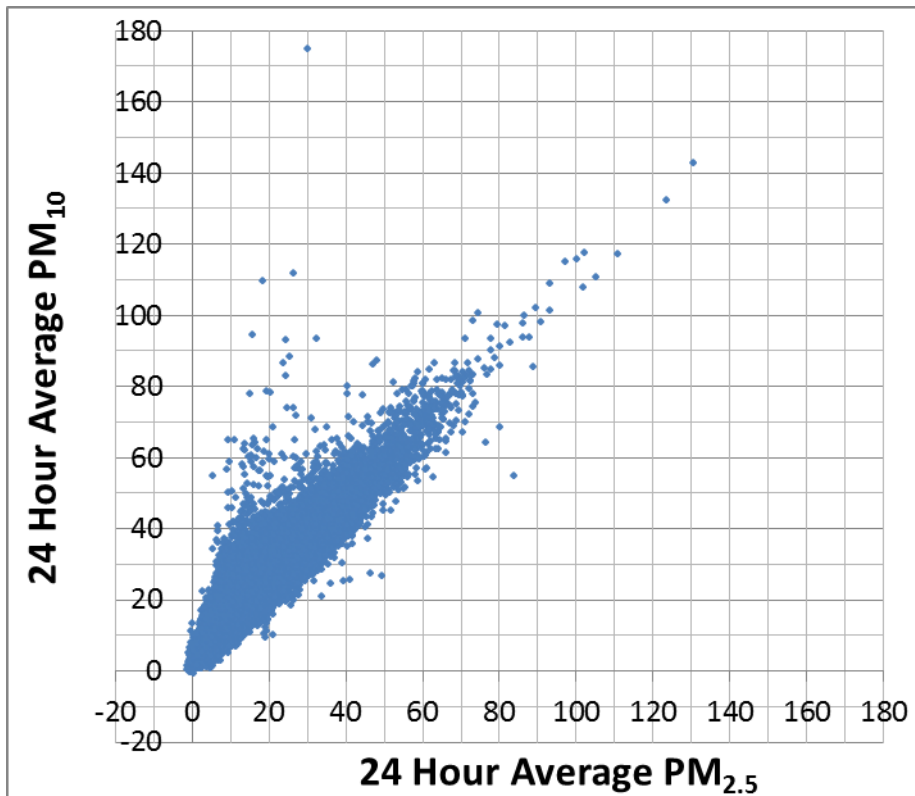
A.13. It is also important to consider that:

- Method 2 is easier for local authorities to undertake; and
- When using Method 1, it may be difficult to find enough suitable nearby sites of the same site classification that measure both PM_{10} and $PM_{2.5}$.

A.14. It is recommended that Method 2 is utilised, i.e. multiplying the annual average PM_{10} concentration of the site to be corrected by the ratio of $PM_{2.5}/PM_{10}$. Where suitable sites of the same site classification are available nearby, then a locally derived ratio may be used. If no sites are available, then local authorities should use the UK average ratio of 0.7.

A.15. Figure A.8 shows the 24-hour mean $PM_{2.5}$ concentration (x-axis) plotted against the 24-hour mean PM_{10} concentration (y-axis). There are 53,294 points on the graph.

Figure A.8 - Scatter Graph comparing 24-hour mean PM₁₀ and PM_{2.5} Concentrations

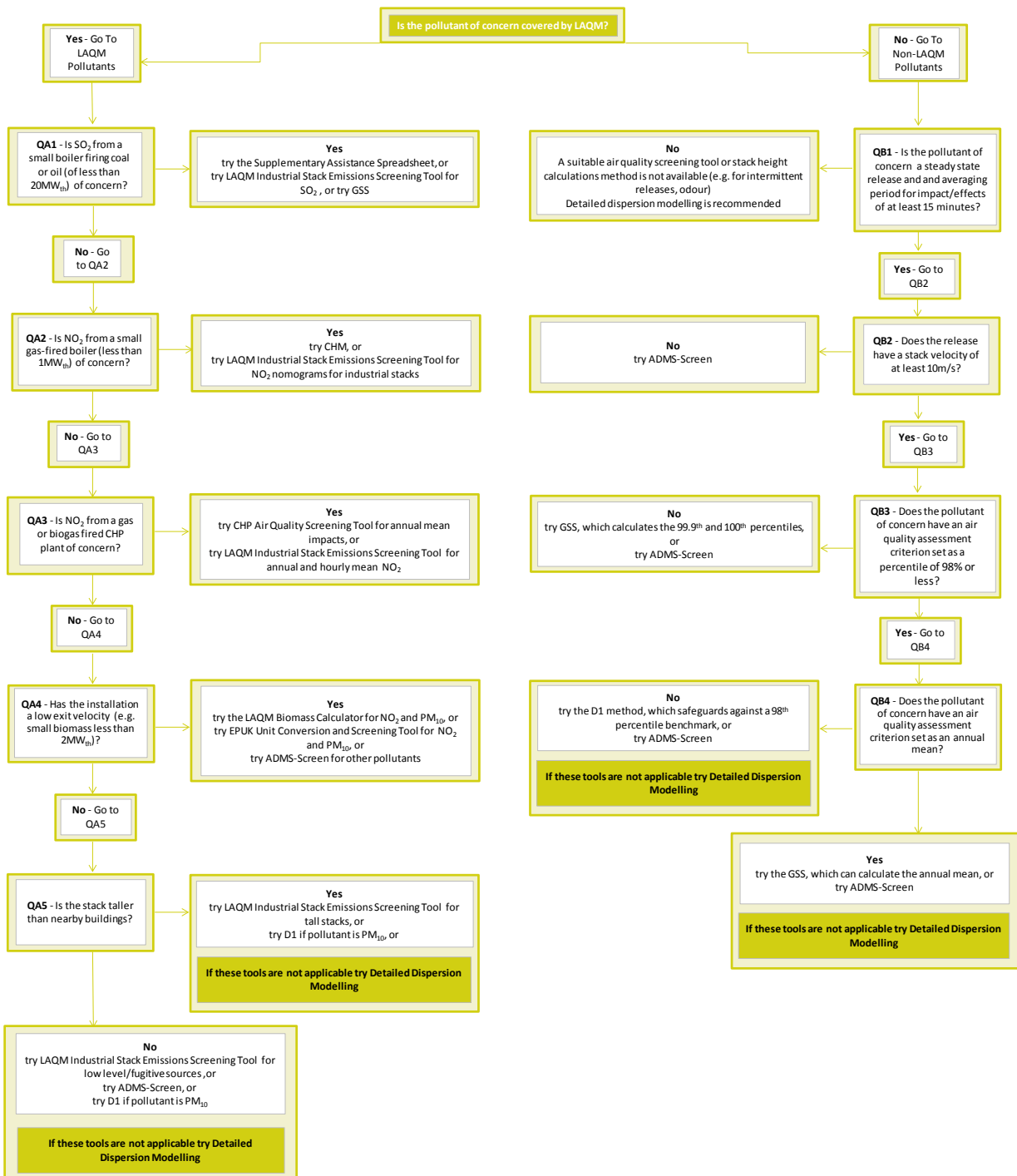


- A.16. Taking a transect of PM_{2.5} concentrations where PM₁₀ = 50µg/m³, the majority of points lie within the range 30 to 50 µg/m³ for PM_{2.5}. This would suggest that if the 24-hour mean PM_{2.5} concentration exceeds 30µg/m³ on more than 7 (Scotland) or 35 (Rest of the UK) occurrences a year, then the local authority should consider installing PM₁₀ analyser in that location. Next, taking a transect of PM₁₀ concentrations where PM_{2.5} = 30µg/m³, the majority of points lie within the range 25 to 55 µg/m³ for PM₁₀. This would suggest that setting a threshold of 30µg/m³ for the 24-hour mean PM_{2.5} concentration would be erring on the side of extreme caution, and would identify more sites for PM₁₀ monitoring than are probably necessary. It is therefore recommended to recommend a threshold of 35µg/m³ for the 24-hour mean PM_{2.5} concentration, as in addition to being less cautious, is also consistent with the proposed ratio of PM_{2.5}/PM₁₀ of 0.7.

Annex B. Stack Screening Method Selection Tool

- B.01 The flow chart provided below is intended to assist local authorities in selecting the most appropriate screening method to assess the impact of stack emissions on local air quality, either for planning or LAQM purposes.
- B.02 It is relevant to the smaller industrial processes, which come under local authority control, and is based upon the applicability and limitations of the various air quality screening tools and stack height calculation methods that are available, as discussed in Chapter 4 Part 1 – Screening Tools and Methodology.

Figure B.1 – Choosing the Most Appropriate Stack Emissions Screening Method



CHM – Department of Environment (DoE) Chimney Height Memorandum (CHM) 3rd Edition GSS – Environment Agency (EA) Guidance on Stationary Sources (GSS)