Stanger

Assistance with the review and assessment of PM_{10} concentrations in relation to the proposed EU Stage 1 Limit Values

A report produced for the Department of the Environment, Transport and the Regions, the Welsh Office and the Scottish Office

Prepared by

Stanger Science and Environment
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National Environmental Technology Centre

AQC Air Quality Consultants

NETCEN National Environmental Technology Centre

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Overview

Introduction

1. This document has been prepared by Stanger Science & Environment (SSE), in association with Air Quality Consultants (AQC) and the National Environmental Technology Centre (NETCEN), on behalf of the Department of the Environment, Transport and the Regions (DETR), the Welsh Office and the Scottish Office. It's aim is to provide informal assistance to those local authorities who may wish to assess the likelihood of areas within their locality exceeding the proposed EU Stage 1 Limit Values for PM_{10}.

2. The Government has recently published its proposals for review of the National Air Quality Strategy (NAQS)[1], and in particular its proposals for revised and additional objectives for the pollutants. During the review process, as a result of the work of the Airborne Particles Expert Group (APEG), it became apparent that the original PM_{10} objective was unrealistic. The APEG report[2] also highlighted the importance of European sources and the limit to which local authority action could control levels of PM_{10}. The Government has therefore proposed replacing the objective in regulation with the proposed EC Air Quality Daughter Directive Stage 1 Limit Values (see Box 1).

BOX 1: Summary of the existing and proposed objectives

Existing Objective	Proposed Objectives
50 µg/m^3, measured as the 99th percentile of the daily maximum running 24 hour mean (equivalent to 4 exceedances per year), to be achieved by 31.12.2005	40 µg/m^3 as the annual mean, and 50 µg/m^3 as a fixed 24 hour mean, maximum of 35 exceedances per year (approximately equivalent to the 90th percentile) to be achieved by 31.12.2004
Objective is based on measurements carried out using the TEOM analyser, or equivalent	Objectives are based on the European gravimetric transfer reference sampler or equivalent

3. Following consultation, the Government may conclude that the national objective for PM_{10} should be replaced in regulation by the EC Stage 1 Limit Values. Such a change would clearly have significant implications for the scale of work local authorities undertake on the review and assessment of PM_{10} and the conclusions they reach.

4. This note suggests a methodology which may be used by local authorities to assess PM_{10} levels against the proposed new objectives. The methods described within this note follow the phased approach to review and assessment previously described within the LAQM Technical Guidance Note series (LAQM.TG1 to LAQM.TG4)[3,4,5,6]. The intention of that guidance is that local authorities should only undertake as much work as necessary, commensurate with the extent of air quality problems in their area, and the likelihood of a prescribed objective being exceeded.

5. The First Stage review and assessment is intended to assist the local authority undertake an initial screening of industrial, transport and other PM_{10} sources which may have a significant impact within, or close to their boundary. If this initial screening suggests that an exceedance of the proposed new objectives is likely, then the authority may proceed to the Second Stage review and assessment, which is likely to involve the use of simple screening models. In certain circumstances, the authority may choose to proceed directly to the Third Stage review and assessment, ignoring the suggested Second Stage. However, the simple methodologies

suggested for the Second Stage may form a useful next step in preparing for the more detailed Third Stage work.

6. The aim of the Second Stage review and assessment is to provide a further screening of PM_{10} concentrations within local authority areas. It is not intended that it should provide an accurate prediction of current or future air quality across the whole of the authority's area, nor does it require an authority to estimate every potential area of exceedance. Authorities are advised to focus upon locations where the highest PM_{10} concentrations are likely to occur (highlighted by the First Stage), and to determine whether there is a significant risk of the proposed objectives being exceeded by the end of 2004.

7. Where the Second Stage review and assessment indicates that the proposed objectives will not be achieved by the end of 2004, or where there are significant uncharacterised PM_{10} sources which cannot be adequately assessed by screening methods, then the authority may proceed to the Third Stage review and assessment. This may require the use of detailed emissions inventories, modelling and monitoring work, and should only be undertaken if necessary. It is also recognised that some authorities may be already undertaking a detailed Third Stage review and assessment of their area, and may not need to carry out the Second Stage review and assessment. However, it is strongly recommended that all authorities complete the information for the First Stage review and assessment, as set out in the guidance note 'Framework for review and assessment of air quality'LAQM.G1(97).

BOX 2: Gravimetric vs TEOM measurement data

Monitoring of PM_{10} levels in the UK has, to date, been largely based upon the use of TEOM analysers. A principal concern with the TEOM instrument is that the filter is held at an elevated temperature (50°C) in order to minimise errors associated with the evaporation and condensation of water vapour. This can lead to the loss of the more volatile species (some hydrocarbons, nitrates etc) and has led to the identification of differences between TEOM and gravimetric measurements at co-located sites. Gravimetric instruments also have the potential to lose some volatile particles, especially ammonium nitrate, the proportion of which is dependent upon the history of the sample.

The recently published Airborne Particles Expert Group (APEG) report concluded that at concentrations around 50 $\mu g/m^3$ the TEOM tends to under-read compared with a gravimetric sampler by between 15 and 30%. However, this effect is not constant, and varies depending upon the mass concentration, the distance from a specific source, and the environmental conditions. Further studies have been commissioned by DETR to investigate these effects, and to provide a more robust relationship between the TEOM and the European transfer gravimetric reference method. In the meantime, it should be borne in mind that the existing objective, which was based upon the air quality standard recommended by the Expert Panel on Air Quality Standards (EPAQS), has been largely based upon epidemiological data derived from measurements made using the TEOM instrument. There is therefore a direct relationship between TEOM measurements and the existing objective.

The proposed EU Stage 1 Limit Values however have been derived from epidemiological studies based upon measurements made using a range of different samplers, and the Directive specifies a gravimetric reference method. There is therefore a potential inconsistency between measurements of PM_{10} concentrations made using a TEOM analyser and the proposed objectives - for example, a daily mean concentration of 45 $\mu g/m^3$ measured using a TEOM analyser could be underestimating the 'gravimetric' concentration by 15 $\mu g/m^3$ or more. It is therefore necessary to apply a 'correction factor' when assessing TEOM measured concentrations against the proposed objectives. For the purpose of this note, a constant factor of 1.3 has been used (consistent with the APEG report), and is applied to all TEOM measured concentrations. For example, a TEOM concentration of 20 $\mu g/m^3$ would be expressed as 20 x 1.3 = 26 $\mu g/m^3$, gravimetric. To make this clear, all data are expressed as [$\mu g/m^3$, TEOM] or [$\mu g/m^3$, gravimetric] as appropriate. To avoid confusion, it is important that authorities follow a similar approach and clearly identify the units of PM_{10} concentrations in all reports that are produced.

8. It should be noted that the methodology described within this note reflects the most up-to-date understanding of airborne particles in the UK, their concentrations, sources, and methods of predicting future levels. However, the science surrounding airborne particulates is rapidly evolving, and further research to improve our knowledge is in progress. It is inevitable that the assessment methodologies may need to be revised at some stage in the future, to better reflect our understanding of both sources and emissions. It is not the intention of this document to be prescriptive in all circumstances, and it is recognised that local authorities will need to use their professional and technical judgement in applying the detail of review and assessment, in the light of local circumstances.

Sources of PM_{10}

9. There is a wide range of emission sources which contribute to PM_{10} concentrations in the UK. These can usefully be divided into 3 main source categories:

- *Primary Combustion Particles* - particles emitted directly from combustion processes such as road traffic, power generation, industrial combustion processes etc. These particles are generally less than 2.5 µm and often well below 1 µm in diameter;
- *Secondary Particles* - particles formed in the atmosphere following their release in the gaseous phase. These include sulphates and nitrates, formed from emissions of SO_2 and NOx; these particles are again generally less than 2.5 µm in diameter;
- *'Coarse' or 'Other' Particles* - the so-called 'coarse' or 'other' particles component comprises of emissions from a wide range of non-combustion sources. These include resuspended dust from road traffic, construction and mineral extraction processes, wind-blown dusts and soils, and sea salt. These particles are generally greater than 2.5 µm in diameter.

10. There are several reasons why it is important to bear in mind the different source categories, and their respective contribution to PM_{10} concentrations, within the review and assessment process:

- The expected reduction in particle emissions in future years is different for each type of source. For example, emissions from road transport will be governed by new legislation on vehicle emission standards; emissions of secondary particles will be largely governed by controls on power generation, industrial and transport SO_2 and NOx emissions, both in the UK and in Europe; emissions of coarse particles are largely uncontrolled, and in general are not expected to decline in future years. In forecasting future emissions it is therefore essential to treat each source category separately. It should be noted that it is not appropriate to extrapolate measured PM_{10} concentrations forwards to 2004 using a simple trend analysis (eg plotting measured PM_{10} concentrations between 1992 and 1998 and then extrapolating this line to 2004) - a suitable methodology for forecasting future concentrations is provided in later sections.
- The principal focus of Local Air Quality Management should be towards the control of emissions at a local level. It is therefore important that the review and assessment process identifies the contribution of local emission sources, so that the effectiveness of control policies or action plans can be evaluated.

11. A description of the different source categories, and their approximate contribution to annual mean background concentrations is described in Box 3. A significant proportion of current annual mean PM_{10} is derived from regional (including long distance transport from Europe) background sources. The exact regional background contribution at any site is variable, and will be dependent upon the precise geographic location. Typical regional annual mean background contributions are currently within the range of about 18-26 $\mu g/m^3$, gravimetric and are outside of the control of local authorities. Where exceedances of the proposed objectives are predicted, local authorities are strongly advised to focus their efforts on the identification of the contribution of local sources to overall PM_{10} concentrations.

BOX 3. Approximate contributions to PM_{10} Concentrations 1998

Type of Particle	Source Location	Main Source Categories	Main Source Types	Typical Contribution to Annual Mean Concentration ($\mu g/m^3$ gravi.)
Coarse 2.5-10 µm	Immediate Local (very close)	Traffic	resuspended dusts tyre wear	1 - 6
		Industry	fugitive dusts stockpiles quarries construction	variable
	Urban Background	Traffic	resuspended dusts tyre wear	1 - 4
		Industry	fugitive dusts stockpiles quarries construction	0.5 - 2
	Regional (including distant sources)	Natural	resuspended dust/soil sea salt biological	2 - 3 1 - 2 1
Fine <2.5µm	Immediate Local (very close)	Traffic	vehicle exhaust	1 - 6
		Industry	combustion industrial processes	variable
		Domestic	coal combustion	variable
	Urban Background	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	0.5 - 2
		Domestic	coal combustion	variable
	Regional (including distant sources)	Secondary	power stations industrial processes vehicles	6 - 16
		Primary (Europe)	vehicles combustion processes	1 - 2
		Natural	sea salt	0.5 - 1

National perspective - what areas are at risk of exceeding the proposed objective?

12. For the purpose of review and assessment of PM_{10}, local authorities should focus their work upon locations where individuals are likely to be exposed over the averaging period of the objectives. It is recommended that the review and assessment should focus upon ground level outdoor locations where the public might reasonably be expected to be exposed over a period of 24 hours or longer. This will include background and roadside sites (i.e. sites close to the facade of a building) where there is housing, and other locations where potentially significant groups may be exposed such as schools or hospitals. It is unlikely to include kerbside sites (i.e. sites within 1 or 2 metres of the kerb) unless there are building facades or other sensitive locations within this distance.

13. PM_{10} data from monitoring sites within the Automatic Urban and Rural Networks are shown summarised in Table 1 for the 1997 calendar year. All of these sites are equipped with TEOM analysers, and the data have been multiplied by 1.3 as previously described in Box 2. These data indicate that the proposed annual mean objective (40 µg/m^3, gravimetric) is estimated to have been met at all sites in 1997, with the exception of a kerbside site in London (Camden Roadside), which exceeded by less than 2 µg/m^3. The 24-hour objective (50 µg/m^3, gravimetric, maximum of 35 exceedances per year) is estimated to have been exceeded at most of the roadside/kerbside sites, and exceeded or closely approached at about 30% of urban and suburban locations. Concentrations at rural/remote sites were well below the objective.

14. The data presented in Table 1 are for 1997, and it is confidently expected that PM_{10} concentrations will have fallen by the end of 2004, when the proposed objectives are to be met. An analysis of PM_{10} projections for 2004 is presented in the review of the National Air Quality Strategy. The analysis was carried out using both 1995 and 1996 monitoring data, because 1996 was characterised by a much higher frequency of easterly winds associated with the transport of polluted air from mainland Europe to the UK. The 1996 meteorology occurs about once every five to ten years and may therefore be described as 'atypical', and as such represents a worst-case, pessimistic scenario upon which to base predictions of future PM_{10} concentrations. The analysis has indicated that with existing national policy measures and atypical meteorology, exceedances of the proposed objectives might be found in the following areas:

    - urban background sites in central London;
    - areas adjacent to busy roads, particularly within major urban areas;
    - areas which have significant emissions from the domestic burning of solid fuels;
    - areas in the vicinity of industrial plant, or which have significant uncontrolled or fugitive emissions (for example quarrying, materials handling facilities etc).

    Such areas are expected to form the focus of more detailed review and assessment for local authorities. It is considered unlikely that the proposed objectives will be exceeded at locations other than those listed above. It is not anticipated that local authorities will generally need to proceed beyond the First Stage review and assessment in areas other than those listed above.

General approach to assessment

15. The monitoring data in Table 1 shows that the proposed 24-hour objective is more stringent than the annual mean objective. However, the 24-hour mean objective (expressed as 50 µg/m^3, gravimetric, to be exceeded no more than 35 times per year) is potentially a difficult standard against which to carry out an assessment, due to the day-to-day variations in PM_{10} concentration and composition. It is therefore recommended that the initial stages of review and assessment are carried out by calculating the annual mean PM_{10} concentration and then estimating the 90th percentile concentration. The 90th percentile of daily means in a calendar year is approximately equivalent to 35 exceedance days.

16. An empirical relationship between the annual mean concentration and the 90th percentile of daily means has been derived from an analysis of monitoring data at UK automatic sites between 1992 and 1997, and is shown in Figure 1.

17. Any approach based upon an empirical relationship needs to be precautionary, and a 'best fit' line has been drawn which ensures that exceedances will not be underestimated, apart from very extreme cases. This gives the equation:

PM_{10} (90^{th} percentile of daily means) = PM_{10} (annual mean)*1.79

The proposed 24-hour objective is therefore highly unlikely to be exceeded if the annual mean concentration is below 28 $\mu g/m^3$, gravimetric.

18. Local authorities undertaking reviews and assessments of the proposed PM_{10} objectives may find the various Technical Guidance Notes published by DETR, the Welsh Office and the Scottish Office (LAQM.TG1, LAQM.TG2 and LAQM.TG3) provide useful supplementary information to this document. Authorities are also reminded that DETR provides a number of telephone advice helplines which can be contacted to give specific advice on any areas of uncertainty. The helpline contact points are shown summarised in Box 4.

BOX 4: Review and assessment helplines

Monitoring Helpline: operated by NETCEN

tel: 01235 463356 e-mail: aqm.helpline@aeat.co.uk

Emissions Helpline: operated by the London Research Centre

tel: 0171 793 1965 e-mail: emissions.factors@london-research.gov.uk

Modelling Helpline: operated by Stanger Science & Environment

tel: 0181 256 4972 e-mail: modelhelp@stanger.co.uk

Industrial Sources Helpline: operated by RSK

tel: 01306 743312 e-mail: industrial.emissions@rsk.co.uk

Pollutant Specific Guidance Helpline: operated by Air Quality Consultants/University of West of England

tel: 0117 976 3837 e-mail: aqm-review@uwe.ac.uk

Access to Internet maps

19. Throughout this document, continued reference is made to the use of background PM_{10} concentration maps which have been published on the Internet. The information in these maps will form an essential component of the review and assessment process, and authorities are advised to try to ensure that access to the Internet is available to them. The relevant maps can be found at the following address (http://www.aeat.co.uk/netcen/airqual)

20. Where authorities experience difficulties in accessing or obtaining the relevant information from the Internet maps, they are advised to contact the Pollutant Specific Guidance Helpline (see Box 4).

First Stage Review & Assessment

21. To carry out the First Stage review and assessment, the authority should collate the following information:
    - estimated annual mean background PM_{10} concentrations (gravimetric) for 2004;
    - traffic data for existing or proposed roads (excluding those with daily average traffic flows of less than 5,000 veh/day)
    - information on domestic solid fuel use (if applicable);
    - information on existing or proposed Part A and Part B authorised processes;
    - information on sources of uncontrolled or fugitive dust emissions, such as quarries, landfill sites, major construction works, coal and aggregate stock yards etc;
    - details of any planned developments in the area, particularly if they will affect traffic flows;
    - details of any significant sources of PM_{10} in neighbouring areas which could impact within the authority's area.
22. For each existing or proposed emissions source, the authority needs to identify those which have the potential, either singly or together, to emit significant quantities of PM_{10}. Clearly, the sources will need to be in existence and/or in operation in 2004. Authorities are also reminded that only those sources which have the potential to cause exposure of the public at relevant locations (as described in para 12 above) need be considered. A recommended step-by-step approach for collating and interpreting this information is described below.

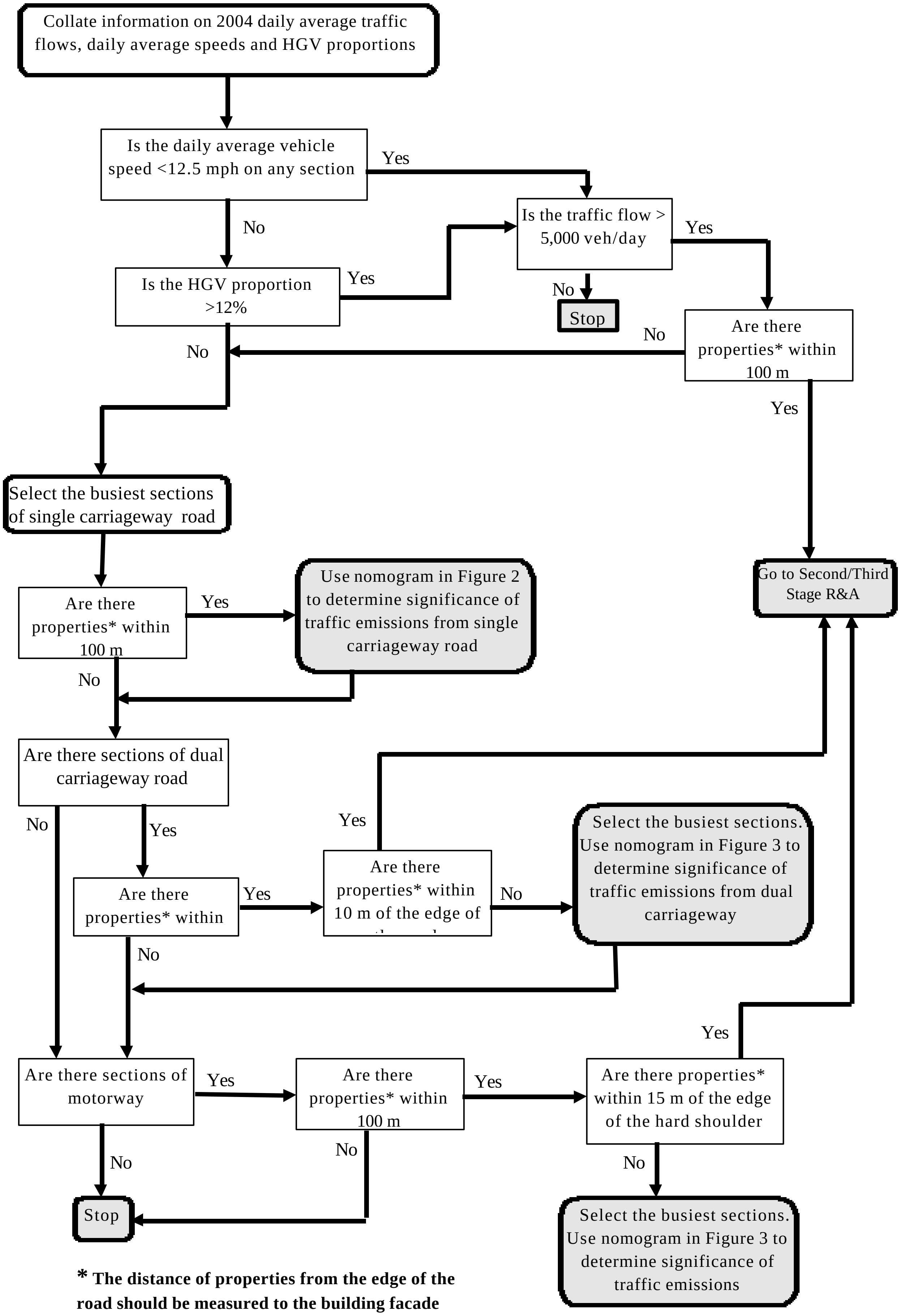
Background PM_{10} concentrations

23. The estimated annual mean background PM_{10} (gravimetric) concentration for 2004 is the starting point for the assessment. These data have been mapped for the UK by NETCEN, and can be accessed via the Internet (http://www.aeat.co.uk/netcen/airqual/). Details of the mapping process can be found at the Internet site. The maps have been prepared based upon atypical 1996 meteorology, and as such represent a worst case scenario. The maps allow the user to zoom in on a particular area of interest, in order to get the forecast PM_{10} concentrations (gravimetric) for 2004. When obtaining this information, authorities should note and record any variations in estimated concentrations across their areas.

Road traffic sources

24. The potential significance of PM_{10} emissions from road traffic is dependent upon a number of factors including the background concentration (for 2004), and traffic conditions such as the traffic flow, speed and HGV mix. The impact of traffic emissions falls off rapidly with increasing distance from the kerbside, and it is also important to take account of where the nearest exposed population will be. A suggested approach for identifying significant traffic emissions is described in Box 5.
25. To simplify the assessment of road traffic emissions, two nomograms have been derived using the methodology set out in the *Design Manual for Roads and Bridges (DMRB*)[7]. These are shown in Figure 2, for a single carriageway road, and in Figure 3 for a dual carriageway road or motorway. Based upon a knowledge of the traffic flow and vehicle speed, it is possible to determine whether there is risk of exceeding the proposed objectives. Roads with daily average traffic flows of less than 5,000 vehicles per day are unlikely to have a significant impact. The nomograms may need to be applied to several roads or sections.

BOX 5: Assessment of the Significance of Traffic Emissions for First Stage Review & Assessment



*** The distance of properties from the edge of the road should be measured to the building facade**

26. It should be noted that these nomograms are not appropriate for use where:

- daily average traffic speeds are less than 12.5 mph (20 kph) on single carriageway roads, or less than 40 mph (65 kph) on dual carriageways or motorways;
- there are properties closer than 2 metres of the kerbside of single carriageway roads, 10 metres of the kerbside of dual carriageways, or 15 metres of the hard shoulder of a motorway; or
- HGV traffic represents more than 12% of the total traffic flow.

In such circumstances, it will be necessary to undertake a Second and/or Third Stage review and assessment.

27. To use the nomograms, identify the point whose co-ordinates are at the annual mean background PM_{10} concentration for 2004 (derived from the Internet site) and the daily mean traffic flow. If this point lies on or above the line, there is a risk of exceeding the proposed objectives. If the point is below the line, the road traffic may be considered to be insignificant, and it should not be necessary to proceed further. For example, on a single carriageway urban road with a predicted 2004 background PM_{10} concentration of 24 $\mu g/m^3$, gravimetric, and an average daily traffic speed of 12.5 mph, it would only be necessary to proceed to a Second and/or Third Stage review and assessment if the traffic flow exceeded 20,000 vehicles per day.

Domestic solid fuel use

28. Solid fuel burning for domestic heating has largely been replaced by alternative fuels throughout most of the UK. However, there are a few areas where there is still significant solid fuel burning, which may have the potential to cause exceedances of the proposed objectives. The risk of exceedance within an area may be quickly assessed by calculating the number of people per square kilometre within coal burning households in the area. A step-by-step procedure for this exercise is given in Box 6. The calculated number of people in coal burning households may then be compared with the nomograms in Figure 4.

29. Three representative 'area types' have been considered i.e.;

- a small village (approx 1 km^2 area)
- a small town (approx 16 km^2 area)
- a large town (approx 100 km^2 area)

30. Users should select the area most appropriate to their situation. Where there is doubt, the larger area should be chosen eg a large village would be represented as a 'small town'.

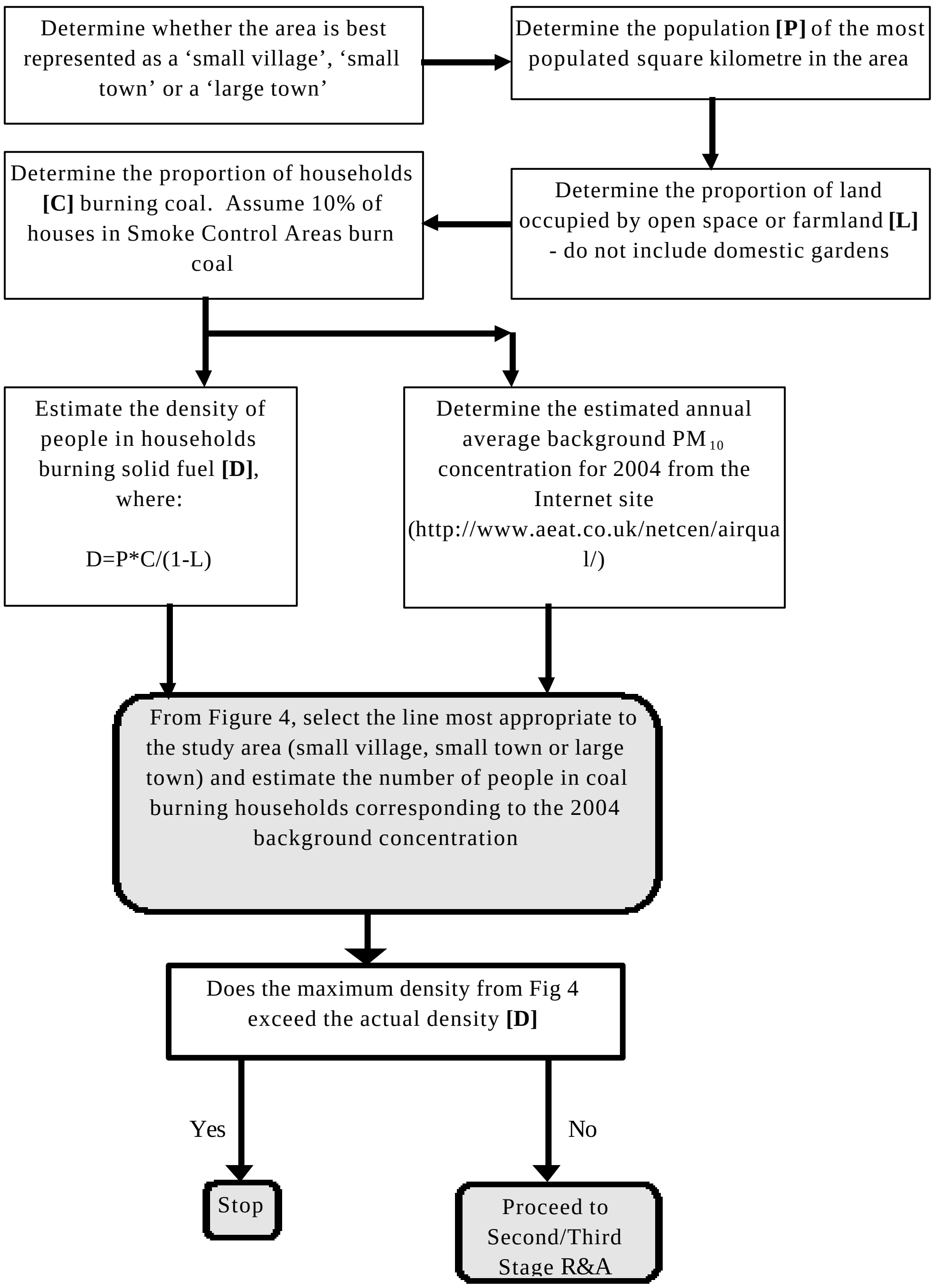
31. As a worked example, assume there is a small town where a significant proportion of the population burns coal. Other assumptions for this example are:

- a density **[P]** of 8000 people per km^2 in the most densely populated area;
- 30% open space or parkland **[L]** in the most densely populated area; and
- 20% of the households in the most populated area burn coal **[C]**.

32. From Box 6, the maximum number of people in households burning coal **[D]** is calculated to be 8000 x 0.2/(1-0.3) = 2285 per km^2. If, for example, a background annual mean PM_{10} concentration in 2004 of 23 $\mu g/m^3$ is assumed (derived from the Internet maps) then Figure 4 shows that for a small town, there is a likelihood of the objectives being exceeded if the density of coal burning exceeds 1000 people per km^2. As the estimated density exceeds this figure, there is a potential to exceed the objectives in this given example, and the authority would proceed to the Second and/or Third Stage.

33. For areas which have Smokeless Solid Fuel (SSF) burning, it is recommended that authorities assume that 10% of the households in the area burn coal (unless precise details are known), and then follow the methodology in Box 6 as described above.

BOX 6: Assessment of the Significance of Domestic Solid Fuel Burning



Part A and Part B authorised processes:

34. A list of both Part A and Part B processes with the potential to emit significant quantities of PM_{10} is provided in Table 2. If any of these processes are present or are planned within the area, the authority should proceed to a Second and/or Third Stage review and assessment. Due to the wide variety of processes and release conditions that may apply, it is difficult to provide suitable screening mechanisms at this stage. However, it is advised that authorities should not need to consider sources which lie at a distance of 5 km or greater from the nearest sensitive receptor location, as these will be insignificant in terms of PM_{10} emissions.

35. The list in Table 2 should not be regarded as definitive or exclusive. Local authorities may wish to use their professional judgment and local knowledge to determine if processes not included in Table 2 should additionally be considered.

Uncontrolled and fugitive emissions

36. There is the potential for dust emissions within the PM_{10} size fraction to arise from a variety of uncontrolled and fugitive sources. These include, but are not limited to:

- quarrying and mineral extraction processes;
- landfill sites;
- coal and material stockyards, or materials loading/unloading;
- major construction works.

37. Emissions from these sources are not well quantified, and it is therefore difficult to predict PM_{10} concentrations with any accuracy. The First Stage review and assessment is therefore based upon practical experience gained from studies in the vicinity of these types of sources, which provide an indication as to whether a problem is likely to exist or not. In all cases, it should be noted that these sources will only impact upon the proposed objectives if they are in operation at the end of 2004. Short-term construction works do not normally need to be considered for the purpose of review and assessment.

Quarrying, stockpiles, landfill sites

38. Dust emissions from quarrying and materials handling tend to be within the larger particle size fractions, and correspondingly fall out from the atmosphere rapidly with increasing distance from the source. Monitoring studies completed by the First Phase authorities (see *The First Phase Air Quality Review and Assessment: A Summary*[8]) have indicated few, if any, exceedances of the proposed objectives in the vicinity of quarrying activities, although the potential for problems does depend upon the type of material handled. Due to the uncertainties involved, where local monitoring data are available, it is recommended that authorities proceed to a Second Stage review and assessment. In the absence of any monitoring data, the following approach is suggested:

- If there are no properties within 400 metres of the dust emissions sources there is no need to proceed further (NOTE: the distance should be taken from the source, and not from the site boundary).
- If there are properties within 200-400 metres of the dust emissions sources, some further selection criteria are provided in Table 3.
- Where properties lie closer than 200 metres to the source, authorities are advised to investigate whether any dust nuisance complaints have been reported. In the absence of any complaints, it may be assumed that the source is insignificant, and there is no need to proceed further.

39. It must be emphasised that these criteria are subject to greater uncertainty than those prepared for other source types. In case of any doubt, authorities are advised to proceed to Second or Third Stage reviews and assessments as necessary.

40. If none of the sources or activities described above exist or are planned in the area, or they fall below the significance criteria provided above, then it may be judged that there is negligible

risk of the proposed objectives being exceeded, and the authority is recommended to proceed no further. Where significant sources have been identified, or the degree of significance cannot be judged without more detailed assessment work, then the authority should proceed to the Second and/or Third Stage review and assessment.

Other transport sources

41. There is the potential for PM_{10} emissions to arise from other forms of transport, apart from road traffic. These include aircraft, railways and shipping.

42. It is well recognised that modern types of aircraft emit very low levels of particles. Previous studies which have been carried out within the UK have demonstrated that the impact of aircraft PM_{10} emissions is negligible at airports with less than about 5 million passengers per year (mppa) throughput, and can be effectively disregarded. For smaller airports (< 5 mppa), authorities may still need to undertake the review and assessment for road traffic emissions, if these are considered to be significant.

43. PM_{10} emissions from railways will only be associated with diesel engines. Emissions are too low to have any significant impact alongside railway tracks, but there is the potential for impact where there are large numbers of stationary idling engines, e.g. a major depot or terminus, with sensitive properties within close proximity.

44. Shipping movements may also give rise to PM_{10} emissions, but, as in the case of railways, there is only the potential for a significant impact where there are large numbers of ships, e.g. major ports with properties within close proximity.

45. Where authorities have identified the potential for these impacts, it is recommended that a modelling study is completed as part of a Third Stage review and assessment.

Second Stage Review & Assessment

46. The Second Stage review and assessment can be largely based upon the application of simple screening methods, for example the *Design Manual for Roads and Bridges (DMRB)* model for roads, and the Environment Agency's *Guidance for Estimating the Air Quality Impact of Stationary Sources*[9] for industrial processes. Wherever possible, local measurements should be taken into account to refine the estimates of both existing and future air quality.

Background PM_{10} concentrations

47. There are clearly uncertainties associated with the 2004 background PM_{10} maps, particularly where the predictions have been based upon interpolations of data to areas where there are no measurements. For the Second Stage review and assessment, authorities are recommended to use actual measurement data wherever these are available. However, the quality of these data should be verified before use, and authorities are advised to take account of the guidance set out in LAQM.TG1(98).

48. The contribution from different sources will not remain uniform between the current monitoring year and 2004. It is therefore not possible to apply a simple extrapolation to existing monitoring data to predict future levels - the data must be divided into the separate source categories ('primary', 'secondary' and 'coarse') and treated separately. Only the 'primary' component is of significance in terms of local emissions - the 'secondary' and 'coarse' components can therefore be removed and added back in once the future predictions from local sources have been performed.

49. The predictions of background PM_{10} in 2004 may be carried out in several different ways depending upon whether monitoring data are available, and whether they are TEOM or gravimetric based. A suggested procedure for using measured background concentrations is described in Box 7. The calculated or estimated 2004 background concentrations should then be used in all of the subsequent predictions. A worked example is provided in Annex 1. If the estimated annual mean background concentration in 2004 exceeds 28 $\mu g/m^3$, gravimetric, authorities may proceed directly to the Third Stage review and assessment.

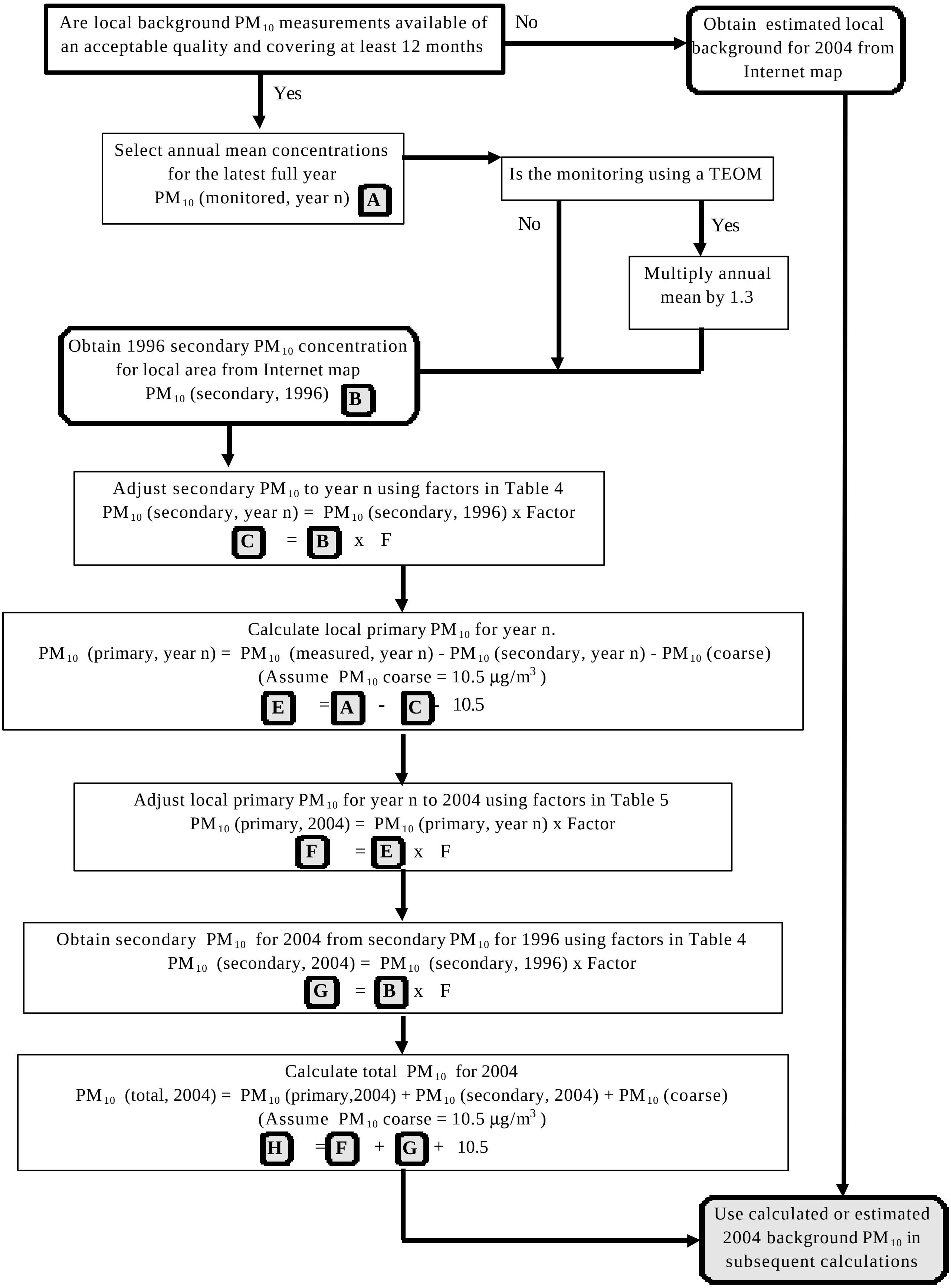
50. It should be noted that the procedure in Box 7 can also be used to correct monitoring data collected at a roadside site. However, in such cases, it will also be necessary to remove the roadside contribution to the primary PM_{10} in the monitoring year, and this will involve an additional stage of modelling. This is described in further detail below.

Road traffic sources

51. The annual mean PM_{10} concentration should be estimated for 2004 at relevant locations (see para 12) close to those sections of the road network identified from the First Stage review and assessment as being of potential concern. The predictions may be carried out using the *Design Manual for Roads and Bridges (DMRB)*, or any other appropriate screening model. Guidance on suitable models is provided in LAQM.TG3(98).

52. The precise relationship between tailpipe emissions, and TEOM and gravimetric measurements is at present uncertain. Due to the method of measuring tailpipe emissions, there is the potential for loss of some volatile components, but this has not yet been quantified. In addition, the recent APEG report has identified the important contribution of coarse particle resuspension to roadside PM_{10} concentrations. Both of these factors could lead road traffic models such as DMRB to underestimate the predicted concentrations.

BOX 7: Calculation of 2004 Background PM_{10} for Second Stage Review & Assessment



53. However, a conservative approach has already been taken with regard to the relationship between the annual mean and the 90th percentile, and the 2004 background PM_{10} concentrations which are based on atypical meteorology. For these reasons, it is not recommended that a 1.3 adjustment factor is applied to the DMRB at this stage.

54. If the DMRB model is used for the Second Stage review and assessment, it is recommended that the background concentrations given within the model are ignored for the purpose of this assessment, and that the model is used to predict the annual mean contribution from the road(s) alone for 2004. The predicted annual mean PM_{10} contribution from the road(s) in 2004 should then be added to the estimated background concentration in 2004 derived from the procedures in Box 7.

55. If local monitoring data from a roadside site are available, then these can be used to supplement other background data, and may be more suitable. In this case, the DMRB (or other model) should be used to estimate the roadside primary PM_{10} contribution for the monitoring year (as well as for 2004) and this value should be subtracted from the measured concentration, along with the secondary and coarse contributions, as shown in Box 7. A number of worked examples are provided in Annex 1.

56. Where the total annual mean concentration is predicted to be greater than 28 $\mu g/m^3$ there is a potential for exceedance of the objectives, and the authority should proceed to the Third Stage review and assessment.

Domestic solid fuel use

57. An assessment of the impact of domestic solid fuel use can be carried out from existing black smoke data, based upon the empirical relationship described in Figure 5. Black smoke data should be available within all areas where domestic solid fuel use is likely to be a problem. The procedure is as follows;

- Determine the annual mean black smoke concentrations for the most recent year
- Determine the 1996 annual mean background secondary PM_{10} concentration for the area, using the Internet maps (http://www.aeat.co.uk/netcen/airqual/)
- Locate the intercept point on Figure 5. If the point is below the line, it is unlikely that the objectives will be exceeded in 2004, and there is no need to proceed further. If the point is on or above the line, then further investigation is necessary, and the authority is advised to proceed to a Third Stage review and assessment.

Part A and Part B authorised processes

58. Predictions of PM_{10} concentrations arising from controlled industrial sources may be carried out using the Environment Agency's *Guidance for Estimating the Air Quality Impact of Stationary Sources (GSS).* Annual total emissions for PM_{10}, stack heights, plume heat content and plume efflux velocity should be obtained or estimated for 2004 for each significant Part A or Part B source identified. There is the potential for loss of volatile components during the determination of PM_{10} stack emissions, but this is not well quantified. A conservative approach has already been taken with regard to the relationship between the annual mean background concentration and the 90th percentile, and the 2004 background PM_{10} concentrations are based on atypical meteorology. For these reasons, it is not recommended that a 1.3 adjustment factor is applied to the emissions at this stage.

59. The assessment may be carried out as follows:

- Determine the 90th percentile background concentration for 2004 by multiplying the estimated annual mean background concentration by 1.79 (see Figure 1);
- Determine the highest annual mean PM_{10} concentration from the stack in 2004. Where there are multiple stacks with the potential for cumulative impact, a worst case assumption can be made by summing the annual means from each stack;
- Calculate the 90th percentile contribution from the stack by multiplying the annual mean by 4;

- Determine whether the 90th percentile contribution from the stack [PM_{10},stack] is higher than the 90th percentile background contribution [PM_{10},background];
- If [PM_{10},stack] is higher, then the total 90th percentile concentration in 2004 can be estimated from [PM_{10},stack] + {[PM_{10},background] x 0.6};
- If [PM_{10},background] is higher, then the total 90th percentile concentration in 2004 can be estimated from [PM_{10},background] + {[PM_{10},stack] x 0.6};

60. If the predicted total 90th percentile concentration exceeds 50 $\mu g/m^3$ the authority should consider undertaking a Third Stage review and assessment. A worked example is provided in Annex 1.

61. It should be noted that the GSS model cannot be applied under the following circumstances:

- stacks lower than 20m or higher than 200m;
- stacks with adjacent tall buildings (defined as 40% of the stack height);
- non-buoyant releases (where the plume is not heated above ambient temperature); and
- stack exit velocities outside of the range 10 to 25 m/s.

62. In such circumstances, it will be necessary to consider the use of an alternative suitable screening model, or to proceed to the Third Stage review and assessment. Guidance may be sought from the Modelling Helpline on the most appropriate manner in which to proceed.

Uncontrolled and fugitive dust emissions:

63. Due to the considerable uncertainties in emissions estimates for uncontrolled or fugitive dust releases, there is no suitable screening approach which can be confidently applied to the Second Stage review and assessment. In the absence of local monitoring data, authorities may need to undertake a detailed Third Stage review and assessment where such sources are considered to represent a problem.

64. However, where local monitoring data of a suitable quality have been collected, and which coincide with the nearest relevant location (see para 12), these can be used to indicate the likelihood of a problem. Provided no significant changes to the operations are expected, it can be assumed that PM_{10} emissions will remain constant until 2004. It is suggested that existing monitoring data are compared with the proposed objectives, although this is a conservative approach as the background component will decline by 2004. Where concentrations exceed the criteria, authorities should proceed to a Third Stage review and assessment.

Combined source impacts

65. There are circumstances in which it may be necessary to take account of the potential combined impact of different sources, eg an industrial process adjacent to a major road, or a major road within a coal burning area. The process of combining these source impacts is relatively straightforward, and a number of worked examples are provided in Annex 1:

Combining the impacts of an industrial process adjacent to a major road

- Determine the 2004 annual mean background concentration as previously described in para 46-49;
- Determine the contribution of road traffic emissions to the annual mean concentration as previously described. Add this to the background concentration to provide a combined annual mean figure. Multiply the total concentration by 1.79 to estimate the 90th percentile concentration, [PM_{10},background+road]
- Estimate the 90th percentile contribution from the stack(s), [PM_{10},stack] as described in para 58.
- Determine whether the 90th percentile contribution from the stack [PM_{10},stack] is higher than the 90th percentile background and roadside contribution [PM_{10},background+road].

- If [PM_{10},stack] is higher, then the total 90th percentile concentration in 2004 can be estimated from [PM_{10},stack] +{[PM_{10},background+road] x 0.6};
- If [PM_{10},background] is higher, then the total 90th percentile concentration in 2004 can be estimated from [PM_{10},background+road] + {[PM_{10},stack] x 0.6};
- If the predicted 90th percentile concentration exceeds 50 $\mu g/m^3$ the authority should consider undertaking a Third Stage review and assessment.

Combining the impacts of a major road within a coal burning area

- Determine the 2004 annual mean PM_{10} background concentration *including* the contribution from the coal burning areas. To do this, it is necessary to use the equation that has been used to derive Figure 5 *viz*

  Annual mean PM_{10} background (2004) = Annual mean secondary PM_{10} (1996) x 0.8 + PM_{10}(coarse) + Annual mean black smoke x 0.8, where;

  The annual mean PM_{10} background (2004) concentration is given in units of $\mu g/m^3$,gravimetric; the annual mean secondary PM_{10} (1996) is derived from the Internet maps (http://www.aeat.co.uk/netcen/airqual/) and is given in units of $\mu g/m^3$,gravimetric; PM_{10}(coarse) is assumed to be 8 $\mu g/m^3$,TEOM; and the annual mean black smoke concentration is given in units of original BS $\mu g/m^3$.

- The predicted annual mean PM_{10} contribution from the road(s) should then be added to the annual mean PM_{10} background (2004) concentration as calculated from the equation above. If the predicted total concentration exceeds 28 $\mu g/m^3$,gravimetric the authority should consider undertaking a Third Stage review and assessment.

Third Stage Review & Assessment

66. Where both the First and, if undertaken, Second Stage reviews and assessments indicate that there is a significant risk of the proposed objectives for PM_{10} not being achieved by 2004, the authorities are advised to undertake a Third Stage review and assessment. This will require a detailed and robust assessment of the potential impacts. This does not necessarily mean that expensive and/or sophisticated modelling and monitoring tools have to be used, but does require that the assumptions within the review and assessment process are considered in depth, and the data which are collected or used are quality-assured to a high standard.

67. Due to the potential wide variety of sources and local circumstances that may prevail, it is not possible to be prescriptive for the Third Stage review and assessment. Rather, this document aims to set out appropriate guidelines for the assessment approach. The scope of work will depend upon the nature of the exceedances indicated during the Second Stage review and assessment. For example, where the concern is limited to a clearly defined road or industrial process, then the assessment can be limited to a detailed investigation of these specific sources. However, where there is concern regarding a widespread area of exceedance, for example within a major urban area, then it may prove necessary to undertake more extensive emissions inventories and modelling work.

68. The Department of the Environment, Transport and the Regions, the Welsh Office and the Scottish Office, have published detailed guidance documents[3,4,5,6] that provide advice and set appropriate standards for undertaking a Third Stage review and assessment. Authorities are advised to refer to the relevant chapters within these documents before commencing any detailed assessment work.

Monitoring PM_{10} concentrations

69. Due to the uncertainties associated with PM_{10} source emissions, a programme of PM_{10} monitoring is likely to form an important element of the Third Stage review and assessment study. Suitable QA/QC procedures for PM_{10} monitoring are detailed within LAQM.TG1(98).

70. A principal area of consideration for authorities considering a monitoring campaign may be whether to use a TEOM (or equivalent) analyser or a gravimetric sampler. The potential discrepancy between the two methods has been described above in Box 2. At this point in time it must be accepted that the two methods will return different results, and that the relationship between them (used in this report) is, as yet, only provisional. It must also be accepted that TEOM analysers and gravimetric samplers have different advantages and disadvantages, both in terms of operation and performance.

71. The majority of PM_{10} monitoring at a national level is currently founded on the use of the TEOM analyser, and these data can be directly compared with the existing prescribed objective. However, a correction factor has to be applied to TEOM data for comparison with the new proposed objectives (which are based on the European gravimetric transfer reference sampler, or equivalent). The DETR are currently undertaking detailed intercomparisons of the TEOM analyser and the European gravimetric transfer reference sampler in order to develop a more robust relationship between the two methods. Pending the results of these investigations, the use of gravimetric samplers clearly offers a more direct approach to collecting monitoring data for comparison against the proposed objectives. However, care should be taken in the selection of gravimetric samplers used for the review and assessment of the proposed objectives, as at this time only a limited number of instruments can demonstrate equivalence to the European reference method.

72. However, it is emphasised that it is not the intention to imply that data from TEOM instruments should be disregarded, or that authorities with these instruments should not effectively use them during the Third Stage review and assessment process. It is considered that TEOM data can be used with a reasonable degree of confidence provided that the adjustment factor of 1.3 is applied.

73. If gravimetric samplers are used, authorities are reminded that considerable care and attention will need to be given to the processes of filter handling, pre and post-conditioning, and weighing, as these can significantly affect the quality of reported data. Suitable guidance on procedures may be sought from the Monitoring helpline.

74. An issue of particular importance to bear in mind with PM_{10} monitoring is the length of sampling period. This is particularly important when considering the 24 hour objective, which allows 35 days exceedance in a calendar year. In order to accurately assess whether this objective is being exceeded, it is recommended that a full year of monitoring is carried out, and that a minimum of 90% data capture is achieved, with any data gaps evenly spread across the year. In cases where monitoring data extend over a shorter period of time, it is strongly recommended that a comparative assessment is carried out with long-term sites (e.g. national network sites) to assist with the interpretation of findings.

Road traffic sources

75. The Third Stage review and assessment associated with road traffic emissions is likely to focus upon:

- A compilation of more detailed and accurate road traffic emissions data;
- A more detailed assessment of the road traffic emissions contribution to PM_{10} concentrations; and
- A more accurate description of existing background levels, possibly supported by roadside monitoring.

76. There are a wide variety of dispersion models available to authorities which may be used in addition to, or in support of, the DMRB model. Guidance on the use and selection of these models, and the types of input data that are required, is set out in LAQM.TG3(98), and further advice may be sought from the Modelling Helpline. In many circumstances however, it is considered unlikely that these more sophisticated models will provide much additional information over that gained from the DMRB or other screening models. This may particularly be the case where exceedances of the proposed objectives are only predicted for isolated roads or small groups of roads. Any enhanced accuracy in the predictions is more likely to be achieved from a more detailed appraisal of the traffic input data and the treatment of the background contribution. Where more sophisticated models prove to be either advantageous or necessary, for example in the review and assessment of major urban areas, the treatment of emissions and background concentrations will still remain a fundamental concern.

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

78. In addition, the method of defining vehicle types within the DMRB model is relatively simplistic (i.e. vehicles are classified into LGVs and HGVs only). Such a classification may not accurately reflect actual traffic circumstances, and it is therefore recommended that authorities attempt to define the vehicle types more reliably. Types of vehicle classification that are commonly used include:

- cars (petrol and diesel)
- LGV (petrol and diesel)

- HGV (small and large)
- buses
- motorcycles

79. Local emissions estimates can be refined using the methods in LAQM.TG2(98), and advice may be sought from the Emissions Inventory Helpline.

80. The calculation of the ‘roadside enhancement’ to the 2004 background is of fundamental importance in predicting compliance with the proposed objectives, and needs to be given more detailed consideration at this stage. The recent APEG report has indicated that the roadside enhancement to PM_{10} concentrations comprises of roughly equal halves of fine particles (emitted from the vehicle exhausts) and coarse particles (generated by resuspension). Whilst vehicle emissions are confidently expected to decline by 2004, resuspended particle emissions are unlikely to reduce, unless traffic flows change substantially. Predictions of PM_{10} concentrations in 2004 should attempt to deal with these aspects separately. It should be noted that the resuspension component is not included in the DMRB model.

81. Where more accurate vehicle emissions data are used, the following approach is therefore suggested:
    - Estimate the current background contribution from ‘primary’, ‘secondary’ and ‘coarse’ particles as described in paras 47 to 50 above;
    - Predict the current contribution of road traffic to PM_{10} concentrations using detailed emissions data and vehicle operating characteristics input to a dispersion model;
    - Assume that PM_{10} from resuspension is equal to PM_{10} from road traffic exhaust emissions in the current year;
    - Estimate the 2004 background contribution from ‘primary’, ‘secondary’ and ‘coarse’ particles as described in para 32 above;
    - Calculate the total PM_{10} concentration in 2004 by adding the total 2004 background contribution to the predicted 2004 road traffic contribution, plus the current year resuspension contribution.

82. Due to some of the uncertainties associated with defining vehicle emissions and the resuspension component, it is strongly recommended that the model is calibrated against actual monitoring data. Where suitable roadside monitoring data are not available for the assessment area, then both the model and the assumptions should be tested at a similar roadside site elsewhere, where monitoring does take place.

Domestic solid fuel use

83. The Third Stage review and assessment associated with domestic solid fuel use is likely to focus upon:
    - An assessment of solid fuel use in the area to determine emissions;
    - The application of detailed dispersion modelling; and
    - Local monitoring to confirm existing concentrations.

84. As a first step, it is recommended that authorities should undertake a detailed assessment of solid fuel use within the area of concern, characterising the different fuels and combustion methods used in order to more accurately quantify the emissions. Guidance on emissions calculations is given in LAQM.TG2(98), and additional advice may be obtained from the Emissions Inventory Helpline. These data may then be input to a suitable air quality dispersion model, in order to predict the ground level impact. Guidance on the selection of suitable dispersion models is given in LAQM.TG3(98), and additional advice may be obtained from the Modelling Helpline.

85. In the absence of local monitoring data of suitable quality, it is recommended that a monitoring programme is carried out in order to more accurately define current PM_{10} concentrations in the area of concern. It is suggested that monitoring equipment is sited at relevant locations (see

para 12) and ideally, monitoring carried out for a period of 12 months. Where this is not possible, authorities are advised to compare the results of local monitoring with data from national network sites, to assist with the interpretation of findings.

Part A and Part B authorised processes

86. The Third Stage review and assessment associated with Part A and Part B processes is likely to focus upon:

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

87. There are a variety of dispersion models which can be used to assess the impact of emissions arising from elevated point sources (stacks). Guidance on the selection of suitable dispersion models is given in LAQM.TG3(98), and additional advice may be obtained from the Modelling Helpline. Authorities are advised to consider the following issues:

- Accurate description of PM_{10} emissions - many processes operate well within their emissions limits, and actual emissions data should be used if at all possible. For certain types of process, both seasonal and daily variations in emissions are significant, and should also be considered wherever possible and input to the model;
- Elevated point sources will have little impact upon the annual mean concentration, and the assessment should focus upon an accurate prediction of the 90^{th} percentile of daily mean concentrations. The modelling approach should therefore seek to predict day-by-day ground level concentrations arising from the stack(s), which will then be added to suitable sequential daily background concentrations for 2004. Whilst the application of single 'uniform' factors to correct current daily background 'primary', 'secondary' and 'coarse' concentrations to 2004 is not ideal (as these will change from day to day) this may form a useful first step. Where a more detailed analysis of the background component is required, authorities are advised to consult the relevant sections of the APEG report, or to contact the Pollutant Specific Guidance Helpline.

Uncontrolled and fugitive dust emissions

88. Due to the uncertainties associated with PM_{10} emission rates from uncontrolled and fugitive sources, it is likely that the Third Stage review and assessment will need to focus upon a detailed monitoring programme. Whilst emissions data are available for a variety of fugitive sources, for example those published within the *Compilation of Air Pollution Emission Factors (USEPA-42)*, these factors are subject to a variable degree of uncertainty, and frequently require default assumptions to be made. Their principal application lies in allowing predictions to be made for the impact of operations which are currently not in existence, or which are expected to undergo significant change by 2004. If applicable, guidance on emissions data and dispersion models may be sought from the relevant Emissions and Modelling Helplines.

89. It is suggested that in many cases a suitable monitoring programme will need to be established to determine the impact of these uncontrolled sources. In addition to those points discussed in paras 69 to 74 above, the following points should be borne in mind:

- Monitoring should be undertaken at relevant locations (see para 12). Consideration should be given to the siting of dust-emitting processes and their location with regard to these locations.
- Monitoring should focus upon those relevant locations where exposure to dust emissions is likely to be highest (eg downwind from the source);
- Ideally monitoring should be carried out for a period of at least 12 months. Where this is not possible, it is recommended that measurements should be carried out over the summer months, when wind-blown resuspension is likely to be highest;

- In all cases, authorities are advised to compare the results of local monitoring programmes with data from national network sites, to assist with the interpretation of findings.

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

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

91. Various examples of PM_{10} monitoring strategies in the vicinity of uncontrolled dust sources are described with *The First Phase Air Quality Review and Assessment: A Summary* which has been published by the Department of the Environment, Transport and the Regions, the Welsh Office, the Scottish Office and the Department of the Environment (Northern Ireland).

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7. The Highways Agency (1999, in press) *The Design Manual for Roads and Bridges (DMRB)*
8. The Environment Agency (1998) *Guidance for estimating the air quality impact of stationary sources*
9. NETCEN (1999, in press) *The First Phase Air Quality Review and Assessment Studies: A Summary*, Report to the Department of the Environment, Transport and the Regions, the Welsh Office, the Scottish Office and the Department of the Environment for Northern Ireland.

Tables

Table 1: Summary of PM_{10} concentrations (µg/m^3, gravimetric) for Automatic Urban and Rural Network sites, 1997 (obtained by applying a factor of 1.3 to the measured TEOM data). A data capture threshold of 75% has been applied.

Site Classification	Site	Annual mean	No. Days >50 µg/m^3
Kerbside	Camden Roadside	41.6	89
Roadside	Bury Roadside	39.0	65
Roadside	Haringey Roadside	33.8	51
Roadside	Sutton Roadside	31.2	34
Urban Centre	Belfast Centre	32.5	41
Urban Centre	Birmingham Centre	27.3	22
Urban Centre	Bristol Centre	29.9	32
Urban Centre	Cardiff Centre	33.8	40
Urban Centre	Edinburgh Centre	23.4	8
Urban Centre	Glasgow Centre	27.3	18
Urban Centre	Hull Centre	31.2	34
Urban Centre	Leeds Centre	36.4	60
Urban Centre	Leicester Centre	26.0	21
Urban Centre	Liverpool Centre	32.5	36
Urban Centre	London Bloomsbury	35.1	43
Urban Centre	Manchester Piccadilly	31.2	32
Urban Centre	Newcastle Centre	27.3	20
Urban Centre	Nottingham Centre	29.9	31
Urban Centre	Sheffield Centre	32.5	39
Urban Centre	Southampton Centre	31.2	25
Urban Centre	Swansea Centre	31.2	25
Urban Centre	Wolverhampton Centre	28.6	30
Urban Background	Birmingham East	26.0	21
Urban Background	Bolton	26.0	17
Urban Background	Leamington Spa	24.7	13
Urban Background	London Brent	28.6	24
Urban Background	London N Kensington	31.2	34
Urban Background	Port Talbot	35.1	60
Urban Background	Stockport	27.3	17
Urban Background	Thurrock	28.6	28
Urban Industrial	Middlesbrough	24.7	21
Suburban	London Bexley	29.9	33
Suburban	London Eltham	27.3	24
Suburban	London Hillingdon	32.5	50
Rural	Narberth	18.2	1
Rural	Rochester	26.0	18
Remote	Lough Navar	13.0	0

Table 2: Part A and Part B Processes with the potential to release significant quantities of PM_{10}

Part A Processes

Process	Section No.
Gasification	1.1 (c) and (d)
Pyrolysis, carbonisation etc	1.2
CI Engines	1.3 (b)
Waste Oil Burning	1.3 (c)
Other Waste Burning	1.3 (c)
Crude Oil Handling, Refining & Conversion	1.4
Iron, Steel & Alloys	2.1
Non-ferrous	2.2
Cement & Lime	3.1
Asbestos	3.2
Other Fibres	3.3
Glass	3.5
Ceramics (Felton Bricks)	3.6
Petrochemicals	4.1
Organic Chemicals	4.2
Acids	4.3
Halogens	4.4
Inorganics	4.5
Fertilisers	4.6
Pesticides	4.7
Pharmaceuticals	4.8
Incineration	5.1
Oil & Solvent Recovery	5.2
Fuel from Waste	5.3
Paper	6.1
Di-Isocyantes	6.2
Tar & Bitumen	6.3
Coating & Printing	6.5
Dyestuffs, Inks etc	6.6
Timber	6.7

Part B Processes

Process	PG Note(s)
Combustion Plant 20-50 MWth (if fired with coal or heavy fuel oil)	1/1, 1/4, 1/6
Reheat Furnaces	1/11
Coal, coke, coal product and petroleum coke processes	3/5
Quarry processes	3/8
Roadstone coating	3/15
China and ball-clay, including spray drying of ceramics	3/17
Manufacture of coating powder	6/9
Rubber processes	6/28

TABLE 3: Proposed action/criteria for the review and assessment of quarrying and mineral extraction processes

Source type	Notes	Proposed action/criteria
Chalk	Only large quarries extracting industrial chalk need be considered. Material is soft, easily crushed, and absorbs water. Potential for dust emissions is low	No further assessment unless properties within 100 metres
China Clay	Material extracted wet, but there is potential for dust emissions from soil stripping and overburden.	No further assessment unless properties within 100 metres
Common clays/ shale	Material extracted wet, but there is potential for dust emissions from soil stripping and overburden	No further assessment unless properties within 100 metres
Opencast coal	Overburden handling and materials haulage are main emissions sources.	Second/Third Stage R&A advised if >150 hectares (total site area) and properties within 400 metres
Gypsum/anhydrite	Material is soft, easily crushed, but potential emissions from grading plant	Second/Third Stage R&A advised if properties within 200 metres
Igneous rock	Soil stripping and overburden removal is low, but potential for emissions during blasting	Second/Third Stage R&A advised if properties within 200 metres
Limestone/dolomite	Soil stripping and overburden removal is low, but potential for emissions during blasting	Second/Third Stage R&A advised if properties within 200 metres
Sand/gravel	Material usually extracted wet, but potential for dust emissions from drying plant/stockpiles	Second/Third Stage R&A advised if properties within 200 metres of plant or stockpiles
Landfill operations	Tipping and/or surface soil movement may give rise to emissions	Second/Third Stage R&A advised if properties within 200 metres

NOTE: For all quarrying and mineral extraction processes, PM_{10} emissions from the movement of vehicles across the haulage routes are likely to represent the most significant source.

Table 4: Correction factors to estimate secondary PM_{10} concentration in future years from 1996 mapped data

Year	Correction factor to be applied
1996	1.000
1997	0.979
1998	0.957
1999	0.936
2000	0.914
2001	0.893
2002	0.871
2003	0.850
2004	0.829

Example: If the estimated secondary PM_{10} concentration for 1996 is 11 ug/m^3 (derived from the Internet map), the secondary PM_{10} concentration in 1998 is predicted to be 11 x 0.957 = 10.5 $\mu g/m^3$.

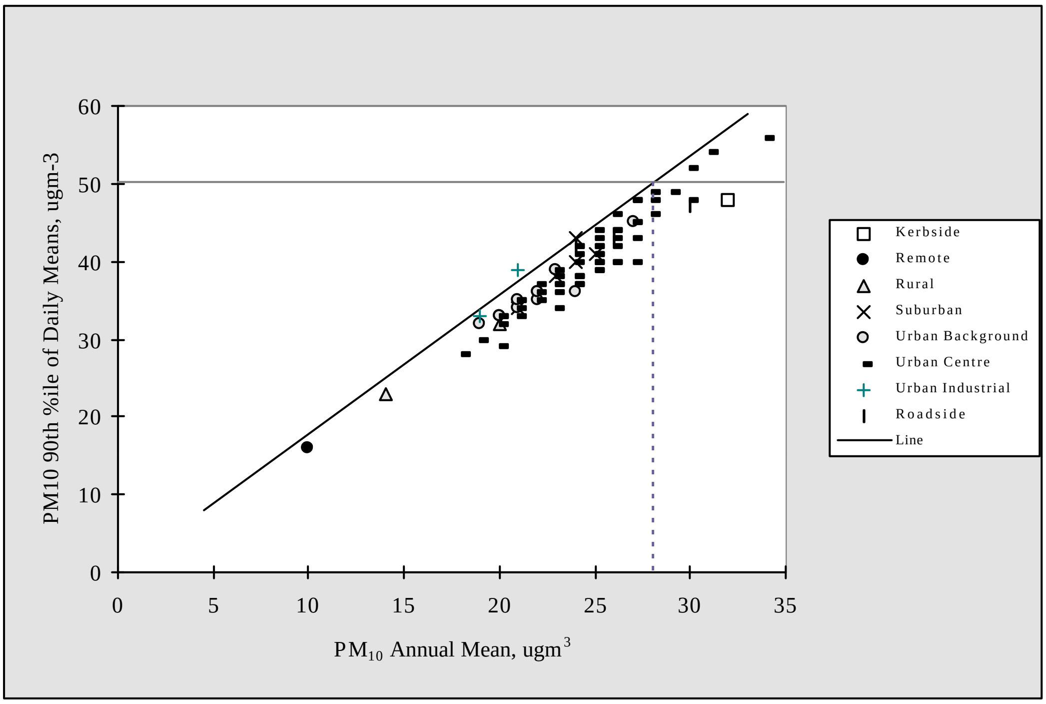
Table 5: Correction factors to estimate primary combustion PM_{10} concentration in 2004

Year	Correction factor to be applied
1996	0.651
1997	0.729
1998	0.774
1999	0.821
2000	0.871
2001	0.900
2002	0.934
2003	0.968
2004	1.000

Example: If the predicted primary combustion PM_{10} concentration in 1998 were 4 $\mu g/m^3$, this would be estimated to fall to 4 x 0.774 = 3.1 $\mu g/m^3$ by 2004.

Figures

Figure 1: PM_{10} 90th percentile of daily means vs PM_{10} annual mean. Data derived from UK Automatic Network sites 1992-97. (µg/m³, TEOM)



Notes

A worst case 'best fit' line has been applied, equivalent to the 95th percentile of the measured ratios. This gives the following relationship;

PM_{10} 90th percentile of daily means = 1.79 PM_{10} annual mean

This compares to the regression analysis which gives the relationship;

$y = 1.68x$, $R^2 = 0.87$

Figure 2: Relationship between daily mean traffic flow, annual mean background PM_{10} (2004) and the risk of exceeding the proposed objective. Single carriageway road, 12% HGV, receptor location 2 metres from kerbside

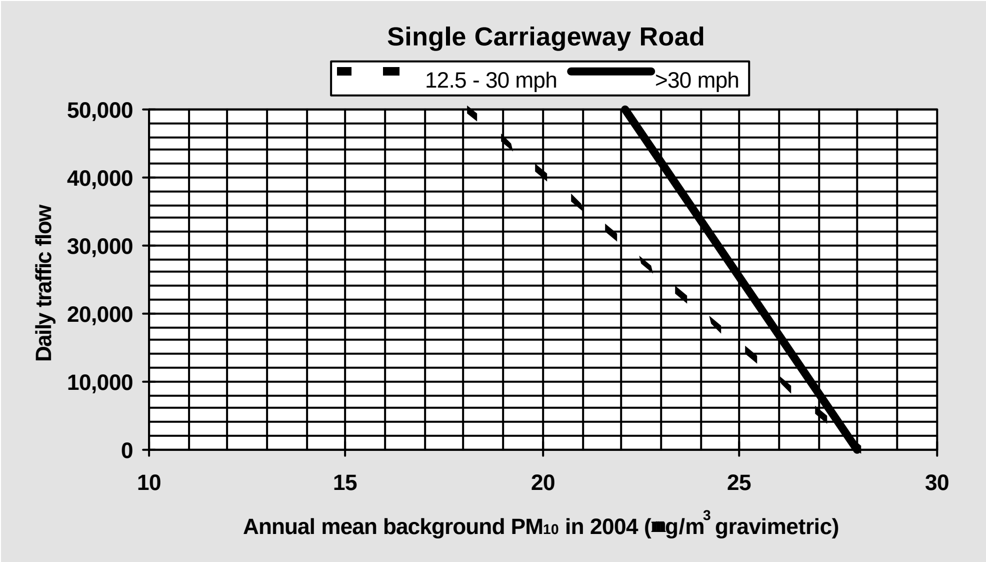
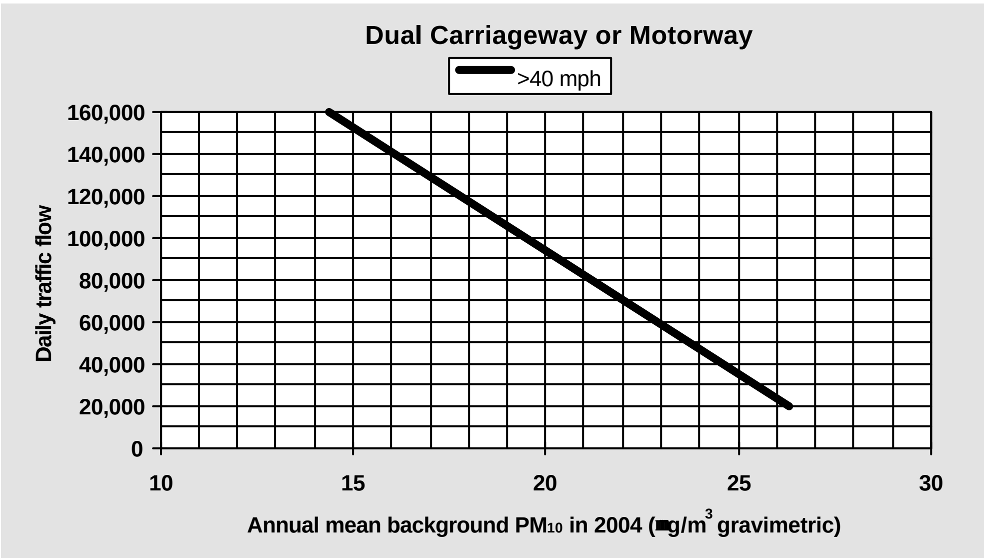


Figure 3: Relationship between daily mean traffic flow, annual mean background PM_{10} (2004) and the risk of exceeding the proposed objective. Dual carriageway, 12% HGV, receptor location 10 metres from kerbside; Motorway, 12% HGV, receptor location 15 metres from hard shoulder



Note:

The relationships between tailpipe emissions and TEOM and gravimetric measurements are uncertain, but there is the potential for loss of some of the volatile components. In addition, the DMRB model, which has been used to prepare the above nomograms, does not take account of the contribution of resuspended material to roadside PM_{10} concentrations. However, a conservative approach has been taken in deriving the relationship between the 90^{th} percentile and the annual mean, and in the use of 1996 atypical meteorology to prepare the 2004 background PM_{10} maps. Therefore, a 1.3 adjustment factor has not been applied in the preparation of these nomograms.

Figure 4: Estimated density of people in coal burning households per km^2 which justifies the need for a Stage 2 review and assessment

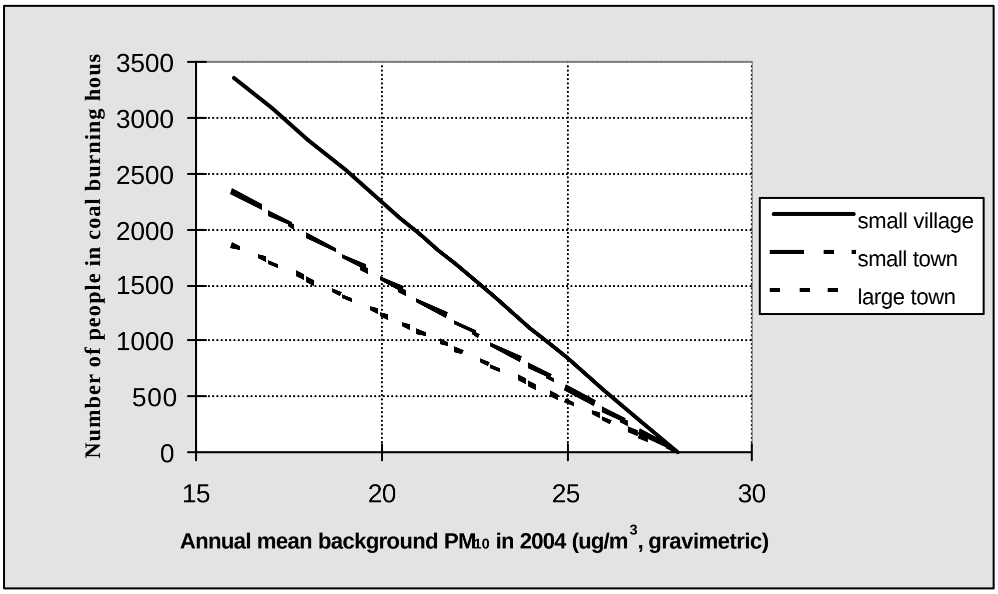
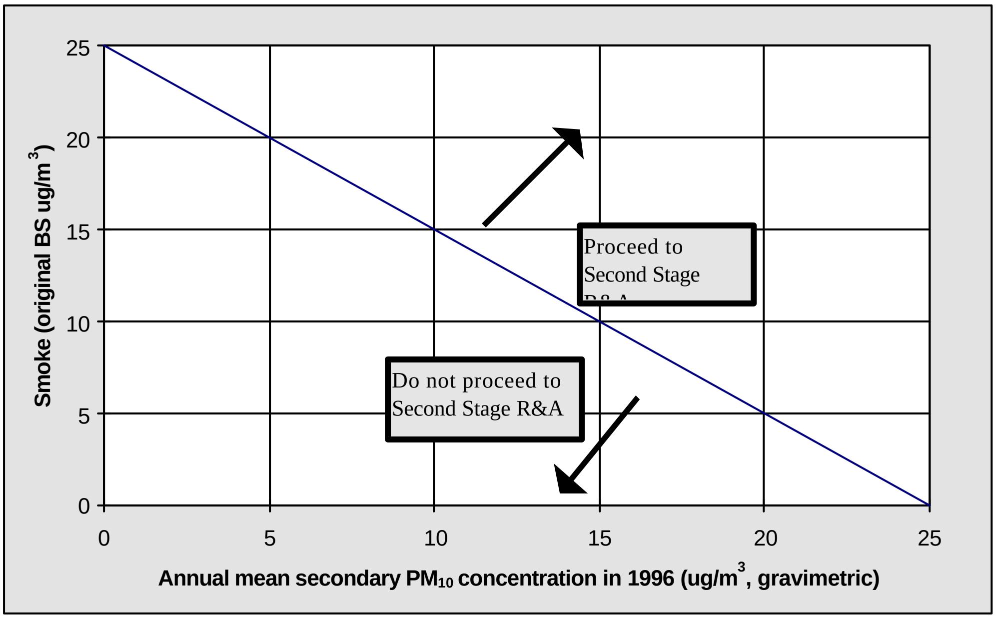


Figure 5: Relationship between annual mean black smoke measurement and the annual mean secondary PM_{10} concentration, which justifies the need for a Stage 2 review and assessment



Notes:

The above nomogram is based upon the following equation:

Total annual mean PM_{10} (2004) = Annual mean secondary PM_{10} (1996) x 0.8 + PM_{10} (coarse) + Annual mean black smoke x 0.8

Total PM_{10} (2004) is expressed in units of µg/m^3, gravimetric. PM_{10} (coarse) is expressed in units of µg/m^3, TEOM, and is assumed to be 8 µg/m^3.

1

Annex 1 - Worked Examples

Example 1:
Calculation of 2004 background PM_{10} from local monitoring data

1. Assume that there are suitable monitoring data for the calendar year 1998, from a local background monitoring station. The data have been measured using a TEOM analyser. The annual mean concentration for 1998 is 20.7 µg/m^3, TEOM.
2. Adjust the monitoring data to gravimetric units:

   annual mean PM_{10} (µg/m^3, gravimetric) = annual mean PM_{10} (µg/m^3, TEOM) x 1.3

   [A] = 20.7 x 1.3 = 26.9 µg/m^3, gravimetric.
3. The secondary PM_{10} maps on the Internet indicate that the local secondary background **[B]** is 9 µg/m^3, gravimetric in 1996.
4. The 1996 secondary background concentration is adjusted for the year of monitoring, using the appropriate factor in Table 3. This gives the PM_{10} (secondary, 1998) **[C]**

   [C] = **[B]** x 0.957

   [C] = 9 x 0.957 = 8.6 µg/m^3, gravimetric
5. The local primary PM_{10} for 1998 **[E]** is calculated by subtracting the measured PM_{10} in 1998 **[A]**, the estimated secondary PM_{10} in 1998 **[C]**, and the coarse component PM_{10} (assumed to be 10.5 µg/m^3, gravimetric)

   [E] = **[A]** - **[C]** - 10.5

   [E] = 26.9 - 8.6 - 10.5 = 7.8 µg/m^3, gravimetric
6. Adjust the local primary PM_{10} from 1998 to 2004 **[F]** using the factors given in Table 4

   [F] = **[E]** x 0.774

   [F] = 7.8 x 0.774 = 6.0 µg/m^3, gravimetric
7. Calculate the secondary PM_{10} in 2004 **[G]** from the secondary PM_{10} in 1996 using the factors in Table 3.

   [G] = **[B]** x 0.829

   [G] = 7.5 µg/m^3, gravimetric
8. Calculate the total background concentration in 2004 **[H]** by adding the components together, assuming that the coarse component is unchanged:

   [H] = **[F]** + **[G]** + 10.5

   [H] = 6.0 + 7.5 + 10.5 = **24.0 µg/m^3, gravimetric**
9. This background concentration should be used to add to subsequent predictions of local source impacts.

Example 2:
Second Stage review and assessment of road traffic emissions

1. Assume a single carriageway road in an urban area, with a row of houses set back 5 metres from the edge of the kerb. The required input data for the assessment are as follows:
   - daily average traffic speed - 20 mph (32 kph)
   - daily average traffic flow - 25,000 vehicles per day (equivalent to 1041.7 vehicles/hr)
   - width of the road - 10 metres
   - HGV mix of traffic - 12%
2. Using the graphs in DMRB, corrections are made to account for the vehicle speed, and the year of assessment;

For LGVs:	speed correction = 1.05	relative to 100 kph
	year correction = 0.39	relative to 1996

For HGVs	speed correction = 1.79	relative to LGV at 100 kph
	year correction = 3.76	relative to LGV in 1996

3. Correct the actual hourly traffic flow to an ‘equivalent’ flow based upon the proportion of HGVs, vehicle speed and year.
   - Actual LGV flow = 916.6 (88% of 1041.7)
   - Equivalent LGV flow = 0.4095 x 916.6 = 375.4 veh/hr
   - Actual HGV flow = 125.0 (12% of 1041.7)
   - Equivalent LGV flow = 6.7304 x 125.0 = 841.3 veh/hr
   - Total equivalent flow = 1216.7 veh/hr
4. DMRB (Table A1.4) shows that for a traffic flow of 1000 veh/hr at 100 kph in 1996,at a distance of 10 metres from the road centre, the predicted annual mean PM_{10} concentration is 2.88 $\mu g/m^3$.
5. Using the ‘equivalent’ vehicle flow of 1216.7 veh/hr, the annual mean PM_{10} concentration in 2004 is predicted to be 3.5 $\mu g/m^3$ **.**
6. If the predicted contribution from the road is added to the estimated background contribution in 2004 (assumed to be 24 $\mu g/m^3$,gravimetric as determined in Example 1 above), the total concentration of **27.5 $\mu g/m^3$,gravimetric** is slightly below the proposed objectives. A more detailed Third Stage review and assessment would not be required.

Use of roadside monitoring data

7. If there are suitable quality monitoring data available from a roadside monitoring station, then these data can be taken into account within the above assessment, with a few additional steps.
8. To calculate the PM_{10} (primary, 1998) concentration **[E]**, follow the steps given in Example 1 above, but also subtract the roadside contribution for 1998. This can be simply achieved by repeating the DMRB assessment using 1998 traffic data and vehicle emissions. The DMRB assessment should be carried out for a receptor location equal to the distance of the monitoring site from the road.
9. For example, assume that data from a monitoring station situated 5 metres from the kerb gives an annual mean PM_{10} concentration of 39 $\mu g/m^3$, gravimetric for 1998 **[A]**. Repeating step (5) above for 1998, gives an ‘equivalent’ vehicle flow of 2739.6 veh/hr, and a predicted annual mean PM_{10} contribution from the road of 7.9 $\mu g/m^3$, gravimetric **[R_{1998}]** at 5 metres distance from the kerb.
10. Then, **[E]** = **[A] - [R_{1998}] - [C] -** 10.5

    [E] = 39 **-** 7.9 **-** 8.6 **-** 10.5 = 12.0 $\mu g/m^3$,gravimetric
11. The remainder of the assessment is carried out as described above.

    [F] = **[E]** x 0.774 = 9.3 $\mu g/m^3$,gravimetric

    [G] = **[B]** x 0.829 = 7.5 $\mu g/m^3$, gravimetric
12. The total concentration in 2004 **[H]** is calculated from:

    [H] = [F] + **[R_{2004}]** + **[G]** + 10.5, where **[R_{2004}]** is the DMRB prediction in 2004, ie 3.5 $\mu g/m^3$,gravimetric

    [H] = 9.3 + 3.5 + 7.5 + 10.5 = **30.8 $\mu g/m^3$,gravimetric**
13. It should be noted that this approach will tend to overestimate the reduction in the roadside contribution by 2004, as the resuspension contribution is not explicitly determined. It is not expected that resuspension will decline significantly in future years. However, due to the uncertainties of the resuspension contribution, and the fact that the approach taken above is a conservative one, it is not considered at this stage to represent a serious problem.

Example 3:
Second stage review and assessment of industrial emissions

1. Assume a industrial process with a single stack as follows:
2. The annual mean background PM_{10} concentration in 2004 is estimated to be 24 ug/m^3, gravimetric (as in the example above).
3. From the annual mean concentration, the background 90^{th} percentile of daily means is estimated to be 1.79 times higher, that is 43.2 $\mu g/m^3$, gravimetric .
4. The Environment Agency GSS model predicts a maximum annual mean ground level concentration of 2.3 $\mu g/m^3$, gravimetric, for 2004.
5. The 90^{th} percentile is estimated to be 4 times the predicted annual mean, ie 9.2 $\mu g/m^3$, gravimetric.
6. The estimated 90^{th} percentile in 2004 is higher for the background than for the stack. The total 90^{th} percentile in 2004 is therefore estimated to be:

   PM_{10} (background) + PM_{10} (stack) x 0.6, ie 43.2 + (9.2 x 0.6) **= 48.7 $\mu g/m^3$, gravimetric**
7. The estimated 90^{th} percentile for 2004 is below the objective of 50 $\mu g/m^3$ and there is no need to proceed further.

Example 4:
Second stage review and assessment of combined source impacts

The combined impact of an industrial process adjacent to a busy road

1. Determine the 2004 annual mean background PM_{10} concentration as described in Example 1 above. Assume this to be 24 $\mu g/m^3$, gravimetric.
2. Determine the contribution of road traffic emissions to the annual mean 2004 concentration as described in Example 2 above. Assume this to be 2.2 $\mu g/m^3$, gravimetric. Add this concentration to the background concentration to provide a combined annual mean figure = 24+2.2 = 26.2 $\mu g/m^3$, gravimetric. Multiply this by 1.79 to estimate the 90^{th} percentile combined background concentration [PM_{10},background+road] = 1.79 x 26.2 = 46.9 $\mu g/m^3$, gravimetric..
3. Estimate the 90^{th} percentile contribution from the industrial stack(s) as described in Example 3 above. Assume [PM_{10},stack] to be 9.2 $\mu g/m^3$, gravimetric.
4. Determine whether [PM_{10},stack] is higher or lower than [PM_{10},background+road].
5. If [PM_{10},stack] is higher, then the total 90^{th} percentile concentration in 2004 can be estimated from [PM_{10},stack] + {[PM_{10},background+road] x 0.6}. If [PM_{10},background+road] is higher, then the total 90^{th} percentile concentration in 2004 can be estimated from [PM_{10},background+road] + {[PM_{10},stack] x 0.6}.
6. In this case, [PM_{10},background+road] is higher than [PM_{10},stack]. The estimated 90^{th} percentile for 2004 is therefore 46.9 + {9.2 x 0.6} = 52.4 9.2 $\mu g/m^3$, gravimetric. The estimated 90^{th} percentile for 2004 is above the proposed 24 hour objective of 50 $\mu g/m^3$. A more detailed Third Stage review and assessment would be required.

The combined impact of a busy road within a coal burning area

1. Determine the annual mean secondary PM_{10} concentration for 1996 for the Internet site (http://www.aeat.co.uk/netcen/airqual/). Assume this to be 9 $\mu g/m^3$, gravimetric.
2. Assume PM_{10} (coarse) is equal to 9 $\mu g/m^3$, TEOM.
3. Determine the annual mean black smoke concentration for the most recent year. Assume this to be 11 $\mu g/m^3$, original BS units.
4. Determine the 2004 annual mean background PM_{10} concentration *including* the contribution from the coal burning areas using the following equation:

Annual mean PM_{10} background (2004) = Annual mean secondary PM_{10} (1996) x 0.8 + PM_{10} (coarse) + Annual mean black smoke x 0.8.

Annual mean PM_{10} background (2004) = (9 x 0.8) + (9) + (11 x 0.8) = 25.0 $\mu g/m^3$, gravimetric.

5. Determine the contribution of road traffic emissions to the annual mean 2004 concentration as described in Example 2 above. Assume this to be 2.2 $\mu g/m^3$, gravimetric.
6. Add the predicted road impact (2.2 $\mu g/m^3$, gravimetric) to the combined annual mean background concentration (25.0 $\mu g/m^3$, gravimetric). This is equal to 27.2 $\mu g/m^3$, gravimetric. This is below 28 $\mu g/m^3$, gravimetric and there should be no need to proceed further