National Roads Authority

Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes

NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

Revision 1, 8th May 2011

CONTENTS

Appendices

REVISION

This document was revised in 2011 to incorporate new policies and best practice findings resulting from the post-EIA air quality evaluation research studies conducted by Halcrow Barry/TRL on behalf of the National Roads Authority.

With regard to new procedural requirements, this document has been updated to incorporate the new phased approach to the planning of national road schemes as outlined in the 2010 Project Management Guidelines.

Following on from the findings of the post-EIA air quality evaluation research studies, this document has been revised to incorporate the following:

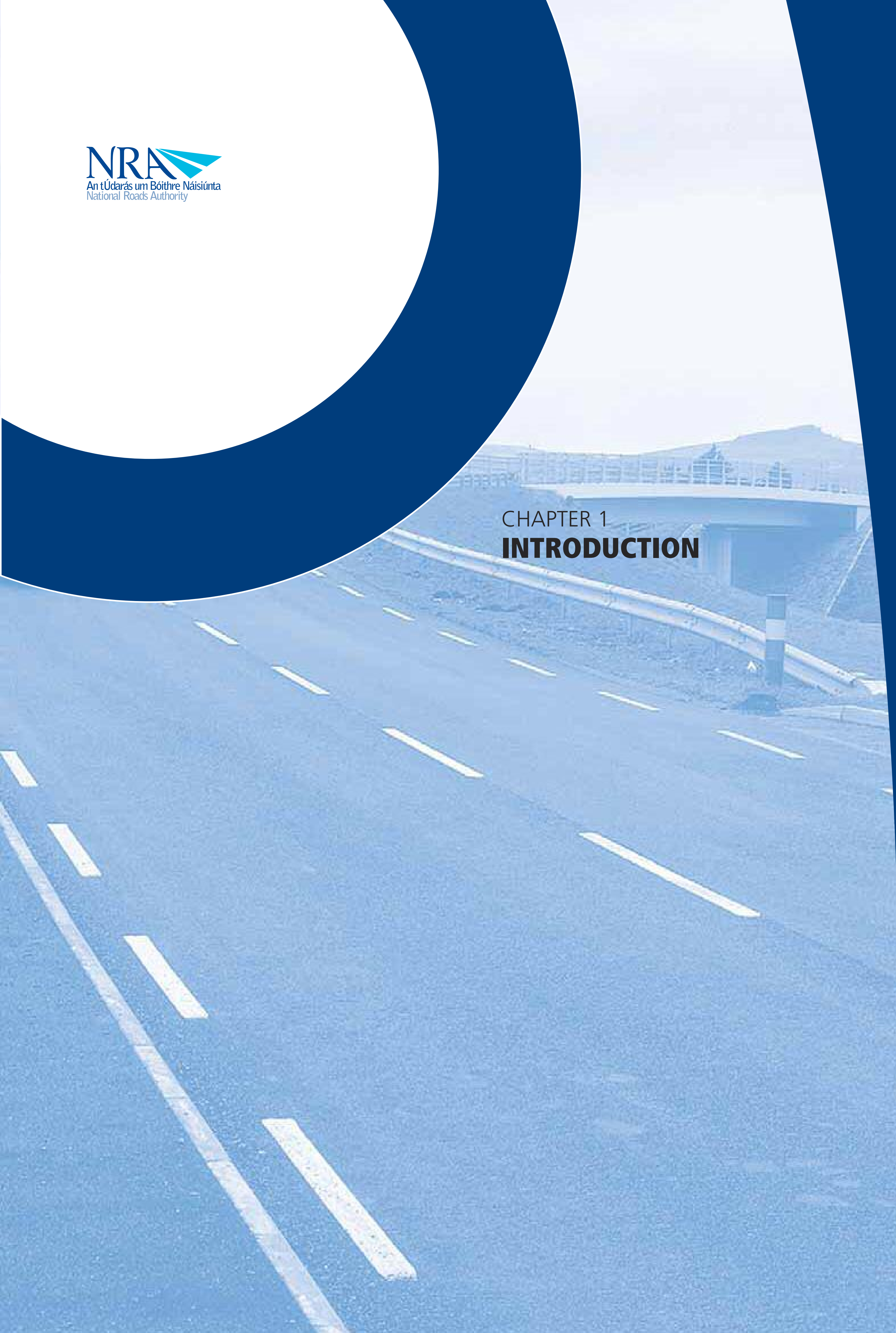
- requirements for reporting and archiving data,
- procedures to address $PM_{2.5}$ particulates,
- revised and updated procedures for addressing background concentration and monitoring,
- additional information on the approach to dispersion modelling,
- changes in the approach to future year projections of monitoring data,
- update on trend analysis for NO_x and NO_2 concentrations,
- revised approach to assessing significance criteria, and
- the incorporation of an approach for the derivation of regional background concentrations for the NO_x:NO_2 model.

ACKNOWLEDGEMENTS

These updated Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes have been prepared by Air Quality Consultants Ltd in association with the National Roads Authority.

The Authority wishes to express its thanks to the Environmental Protection Agency, AWN consulting and Arup Consulting for providing comments on the original document during the consultation period.

DISCLAIMER



CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1. Background and Policy Context

Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes were published by the National Roads Authority (NRA) in 2006. Subsequent to the publication of the Guidelines, the NRA commissioned a study to evaluate the effectiveness of the methodologies applied to the assessment of the air quality impacts of national road schemes. This study included a review of international best practice and a post-Environmental Impact Assessment (EIA) evaluation to determine how well the methodologies perform in predicting the actual air quality impacts of national road schemes. The study culminated in a number of recommendations as to how the guidelines could be improved (Halcrow Barry, 2010).

In addition, since the 2006 Guidelines were published there have been a number of important changes and improvements to the science underpinning the methodologies, and also changes to the legislation. This document provides updated guidance for the assessment of air quality impacts during the planning and design of national road schemes. These Guidelines are not mandatory, but are recommended in order to achieve consistency with respect to the Route Selection, Design and Environmental Impact Assessment phases of road scheme planning and development undertaken in accordance with the NRA's *2010 Project Management Guidelines* (PMG) (National Roads Authority, 2010).

At the time of preparing these revised Guidelines, the UK Highways Agency was undertaking a major revision to the Design Manual for Roads and Bridges (DMRB) model to take account of the new emissions factors published by the UK Department for Transport. It is expected that the revised DMRB model will be available in mid-2011. If necessary, these Guidelines will be further updated to reflect the new DMRB model.

1.2 National Roads Project Management Guidelines

The statutory procedures followed by the NRA and the local authorities/National Roads Regional Design Offices (NRRDO's) in the planning, design and implementation of national roads schemes are currently specified in the Roads Act, 1993, as amended. For a more detailed description of the legislation, both domestic and European, covering the planning, design and implementation of national roads schemes and relating to Environmental Impact Statements please refer to the NRA's *Environmental Impact Assessment of National Road Schemes – A Practical Guide* (Rev 1, National Roads Authority, 2008).

Public consultation is catered for at a number of phases in the planning process and, as a matter of good practice, is generally engaged in at the earliest opportunity. There are a number of phases to the planning and consultation process as set out in the Authority's PMG.

The PMG were prepared to allow a phased approach to the project management of national road schemes. For the purposes of these Guidelines, three phases of the guidelines are considered: the Route Selection (Phase 2); Design (Phase 3); and, the Environmental Impact Assessment (EIA)/Environmental Assessment Report (EAR) and The Statutory Process (Phase 4) - see Figure 1. The aim of this guidance is to provide advice as to the scope of activities as they pertain to air quality impacts for each of these three phases. The air quality assessment becomes more detailed as the assessment activities progress from Phase 2 to Phase 4.

The air quality input into each of the three phases should not be seen in isolation. The conclusions of each phase should set the foundation for the next activity and collectively should assist in the final design of the road scheme. In this case, the report for inclusion into the Route Selection phase should concentrate on the avoidance of unacceptable air quality impacts. Phases 3 and 4 should describe any further steps taken to avoid impacts and should thereafter consider any further mitigation of impacts, which may be incorporated into the preferred route corridor as necessary.

Air quality impacts should be evaluated in conjunction with the engineering constraints of the scheme, and other environmental, socio-economic and visual amenity impacts. Each selected route will have unique features and constraints. In some cases, the optimum route from an air quality perspective may not be the optimum route when other impacts are taken into account. However, air quality impacts should receive detailed consideration and indeed, in some cases, they may be the most important factor to be addressed during Route Selection and subsequent design of the road scheme.

1.3 Pollutants of Concern and Air Quality Standards

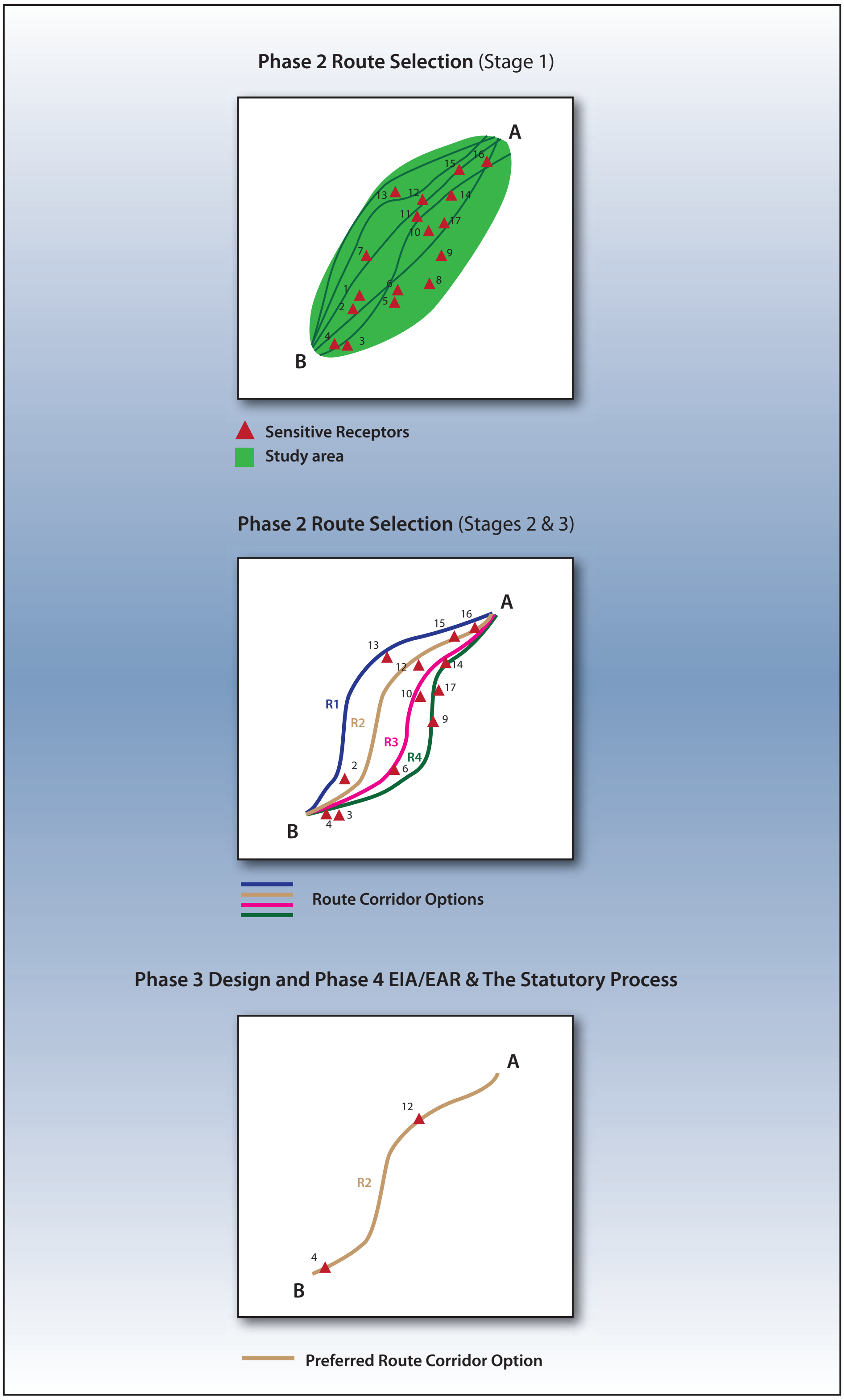
Pollutant emissions from road traffic may cause impacts at both the local and national/international level. At the local scale, the principal pollutants that need to be considered are nitrogen dioxide (NO_2) and fine particulate matter (both PM_{10} and $PM_{2.5}$). Empirical evidence has shown that there is no risk of emissions from road traffic leading to exceedences of the relevant air quality standards for any other pollutants, at even the most heavily-trafficked locations. At the national/international level, emissions of nitrogen oxides (NO_x) are of concern with respect to nitrogen deposition and the formation of ozone, while emissions of carbon dioxide (CO_2) are associated with climate change[1].

Air quality criteria applicable to the assessment of local impacts upon human health and vegetation were initially set out in various EU Directives which were transposed into Irish legislation.

However, a new air quality Directive (2008/50/EC) was adopted in May 2008. This streamlines and replaces four previous Directives (including 96/62/EC, the so-called Air Quality Framework Directive and 1999/30/EC, which set limit values for nitrogen dioxide and PM_{10}) and confirms the previous obligations, but introduces a new national exposure reduction target, a target value and limit values for $PM_{2.5}$. This new Directive was transposed into Irish legislation through the 2011 Air Quality Standards Regulations, S.I. 180 of 2011. The previous air quality standards for nitrogen dioxide and PM_{10} and the new limit value for $PM_{2.5}$ are set out in Appendix 1. The national exposure reduction target is focused on reducing average exposures across the most heavily populated areas of Ireland, and is therefore not directly relevant to individual road schemes. Air quality assessments of national road schemes should, however, take account of the $PM_{2.5}$ limit values (see Appendix 1) at the Environmental Impact Assessment (EIA)/Environmental Assessment Report (EAR) and The Statutory Process phase.

[1] Thematic strategy on air pollution, COM(2005) 446, and Proposal for a Directive on ambient air quality and cleaner air for Europe, COM (2005) 447.

Figure 1: The phases of planning for air quality assessment of national road schemes showing a typical study area and route options



Impacts at national/international level include climate change and acid deposition. Measures to reduce greenhouse gas emissions generally (associated with climate change) are subject to international and national policy. A range of these measures are provided in the *National Climate Change Strategy* (DoEHLG, 2007-2012). Measures to address acid deposition are provided in the *National Programme for Ireland for the Progressive Reduction of National Emissions of Transboundary Air Pollutants by 2010* (DoEHLG, 2004). There are no standards applicable to the assessment of national/international impacts, and the significance of the impact is normally based on relative changes in emissions on a regional or national scale.

Readers should also be familiar with the measures governing the protection of 'European sites' (e.g. Special Areas of Conservation (SACs and Special Protection Areas (SPAs). In particular, careful regard should be had to Articles 6(3) and 6(4) of the Habitats Directive (92/43/EEC) and transposing measures. Readers are referred to the NRA's *Guidelines for Assessment of Ecological Impacts of National Roads Schemes* (Rev. 2, National Roads Authority, 2009) and to *Appropriate Assessment of Plans and Projects in Ireland – Guidance for Planning Authorities* (Department of the Environment, Heritage and Local Government, 2010) in relation to these matters.

1.4 Requirements for an Air Quality Specialist

The assessment of air quality for the purpose of these Guidelines requires expertise, independence and objectivity. The air quality specialist should be capable of characterising the existing environment and assessing how the proposed road scheme will impact upon it. Where mitigation measures are deemed necessary, the specialist must be capable of assisting in the incorporation of these measures into the preferred route option; the specialist should, therefore, have a thorough knowledge of suitable measures that can be applied. The specialist should have knowledge of, and be up-to-date with, the relevant standards and legislation that apply, and be familiar with the criteria for evaluation and classification of the significance of impacts. The specialist should also be able to identify and incorporate any potential construction impacts into the overall air quality assessment and should be able to interpret and describe the findings of the assessment in a clear, concise and comprehensive manner.

Air quality specialists should be able to demonstrate that they have the necessary knowledge and skill through reference to suitable qualifications and experience.

The Authority recognises that a significant amount of survey and other work is often required to support the air quality study and it is neither reasonable nor necessary to require that all such work be undertaken by the qualified specialist meeting the above requirements. However, the specialist must supervise the project and ensure that all aspects of the study are carried out in accordance with appropriate standards, using people with a suitable level of training and expertise.

1.5 Overall Approach

The assessment of the air quality impacts of national road schemes should follow the Route Selection, Design and EIA/EAR and the Statutory Process phases specified in the PMG. The overall approach to the air quality assessment at each stage is outlined is Figure 2.

1.6 Reporting and Archiving

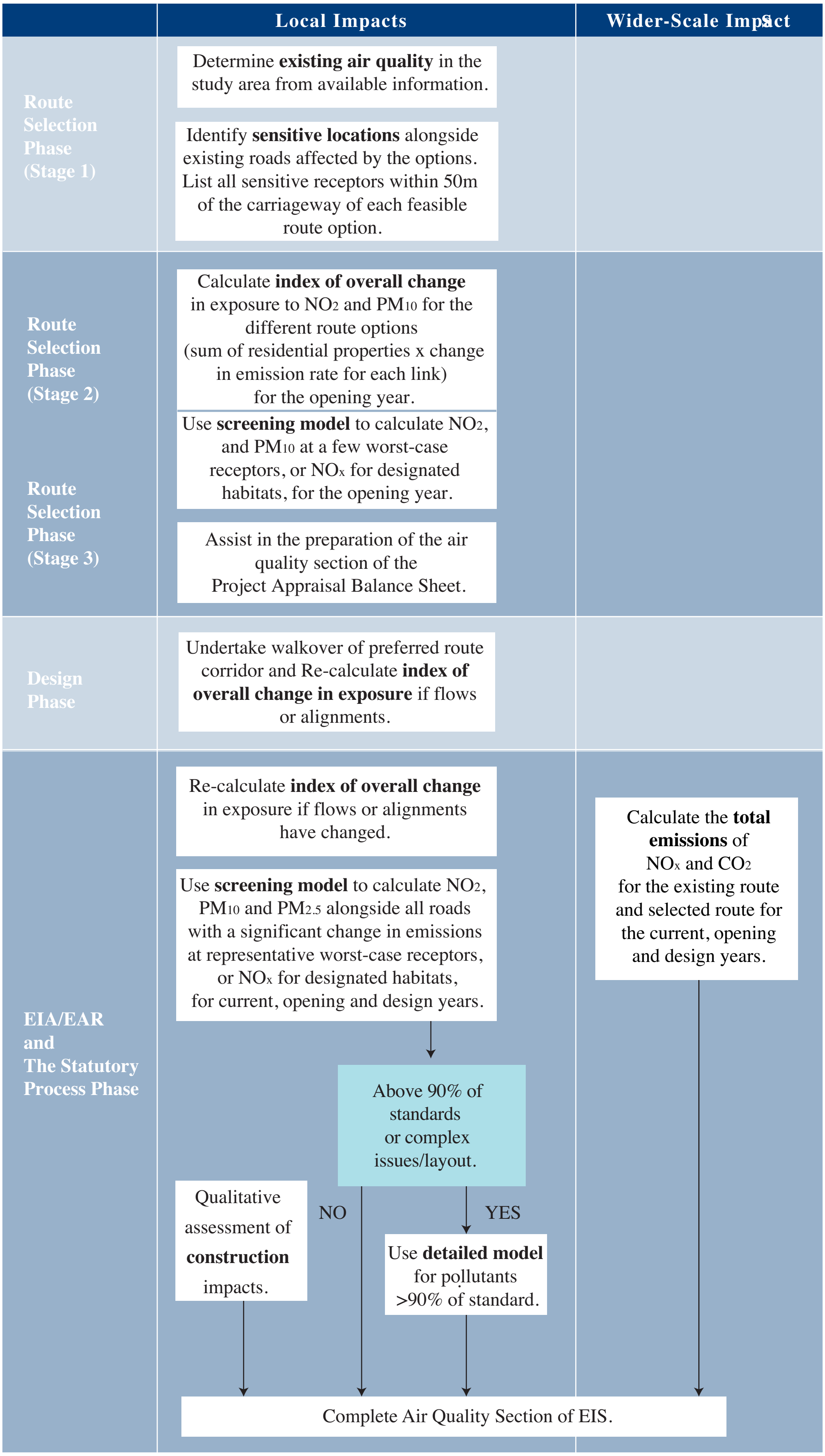
It is important that all assessments carried out for national road schemes are completed in a manner that is transparent and repeatable and that all sources of information are fully documented. Reports at all stages of assessment must document as relevant:

- Sources of monitoring data;
- Sources of traffic data and specific links to where the data can be found, if not explicitly included in the report, and
- Version numbers and/or dates of all models and tools used for the assessment.

S.I. No. 382 of 2010 - European Communities (Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)) Regulations transposing Directive 2007/2/EC- came into force on 3rd August 2010. The intent of these Regulations is to provide underlying rules for exchanging data across national boundaries. The broad principle is that data should be collected once only and shared by all levels of government and stakeholders.

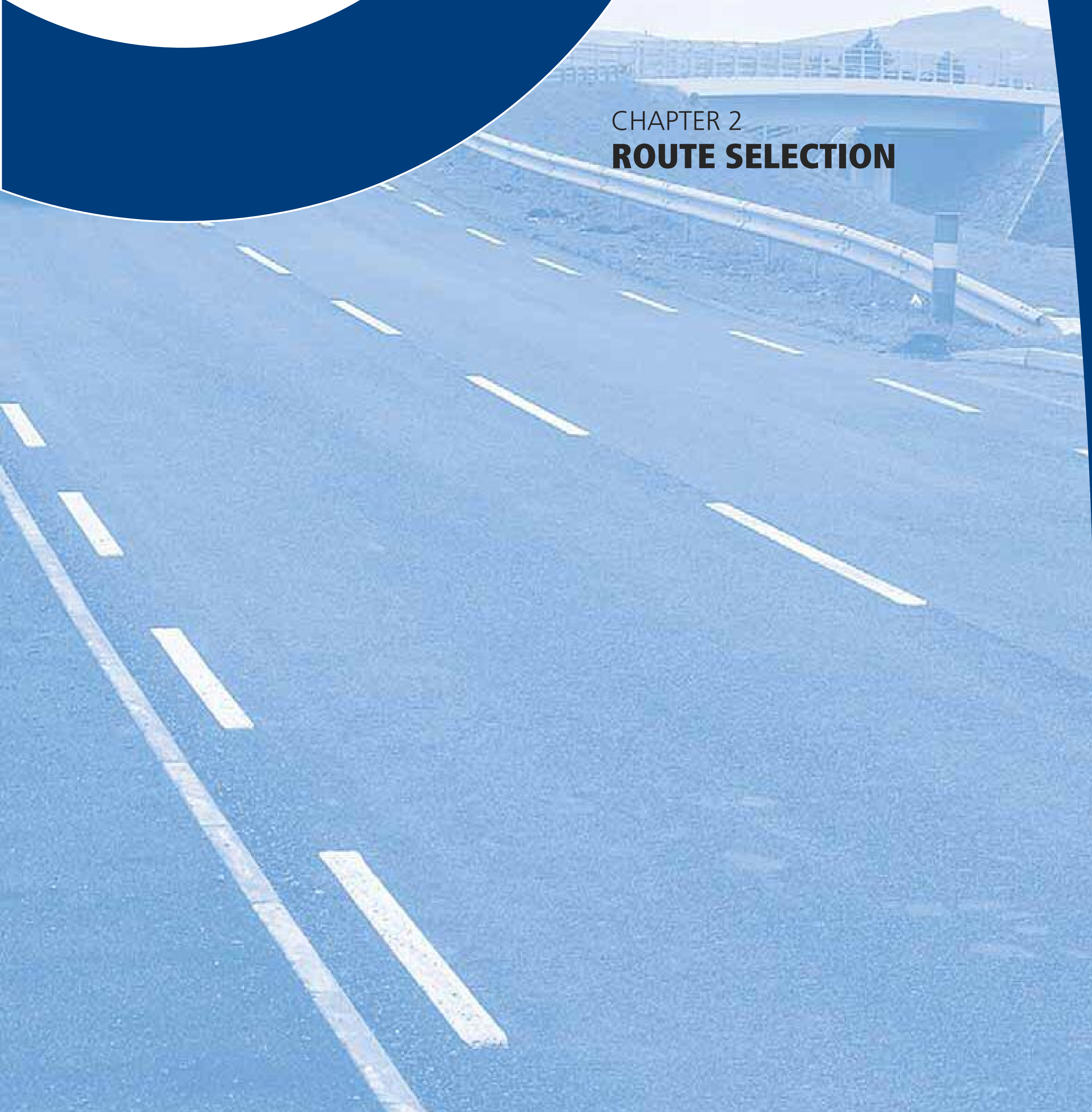
To ensure traceability of monitoring data and that any analysis is repeatable by third parties and in order to comply with the future requirements of the INSPIRE Directive, all data used in the various stages of the assessments for national road schemes should be archived in a consistent format. The basic principles of the INSPIRE Regulations should be used to govern the minimum requirements of this archiving.

Figure 2: : Air Quality Assessment of National Road Schemes.



CHAPTER 2

ROUTE SELECTION



2.0 ROUTE SELECTION

2.1 Objectives

The PMG state "*Phase 2* [Route Selection Phase] *is to identify a suitable Study Area for the examination of alternative routes, to identify key constraints within that Study Area, to develop feasible route options and to carry out a systematic assessment of these options leading to the selection of a Preferred Route Corridor which will form the basis for the detailed design to follow. This phase also outlines the requirements for public consultation associated with the development of routes and alternatives. Both "online" and "green field" route options are to be considered during the planning and design of the preferred route for the scheme"*.

2.2 Approach to Route Selection

The Route Selection Process is a 3-stage process as outlined hereunder:

Stage 1 - Involves the development of a number of feasible route options (typically 6 or more and including 'Do-Nothing' and 'Do-Minimum' alternatives) and the carrying out of a Preliminary Options Assessment using a Framework Matrix (comprising the assessment criteria of Engineering, Environment and Economy). This will result in the number of route options being refined to a maximum of 3 - 5.

Stage 2 - On completion of Stage 1, a Project Appraisal of the remaining route options will be carried out using the Project Appraisal Matrix (comprising the 5 Common Appraisal Criteria of Economy, Safety, Environment, Accessibility & Social Inclusion and Integration).

Stage 3 - After Stage 2, select a Preferred Route Corridor for the scheme. Following this, prepare a Project Appraisal Balance Sheet (PABS) for the Preferred Route as described in the NRA Project Appraisal Guidelines.

2.3 Route Selection Process Stage 1 Preliminary Options Assessment

The initial step (Stage 1, i.e., Preliminary Options Assessment) in the Route Selection Process is to identify the nature and extent of significant constraints within a defined Study Area. These constraints should be documented and mapped so that feasible route options can be designed to avoid such constraints, where possible. The first part of this data collection should be based on deskbound research studies. All known physical constraints from an air quality perspective should be identified and recorded on suitably scaled maps.

The specific objectives of the air quality input to the Stage 1 Preliminary Options Assessment of the Route Selection Process are to characterise the existing ambient air quality in the study area and to initially identify all sensitive receptor locations within the study area likely to be impacted by a proposed scheme before feasible route options are identified. Once feasible route options are identified and in order to undertake the preliminary options assessment, the total number of sensitive receptors (e.g. residential properties) within 50 m of the carriageway[2] of each feasible route option should be recorded with a view to eliminating those routes with the greater number

[2] If the road layout details are not known, it may be assumed that the carriageway edge is 8 metres from the road centreline of a dual-carriageway road, and 4 metres from the road centreline of a single road.

of sensitive receptors likely to be impacted by the proposed scheme.

The air quality input to the Stage 1 Preliminary Options Assessment should include an examination of the area or areas through which feasible route options might potentially pass. The input should:

- describe existing local air quality conditions within the study corridor in relation to nitrogen dioxide and PM_{10}.This should take full account of any existing monitoring data from networks established by the Environmental Protection Agency (EPA) and local authorities and monitoring carried out by other organisations, as relevant. It should also identify any areas where the standards are exceeded;
- describe any non-road sources that may significantly affect air quality within the study corridor, for example, industry, ports, areas of domestic solid fuel combustion, or power stations;
- identify and record all sensitive receptor locations within the study area and all sensitive receptors within 50 m of the carriageway of each feasible route option that are, or have the potential to be significantly affected by a proposed scheme;
- take full account of all previous studies, local air quality assessments or reports, and any other air quality work undertaken by the NRA, EPA or local authorities, and
- include a review of planning permissions granted within the Study Area of relevance from an air quality perspective (e.g. significant sensitive receptors and developments likely to have a significant impact on air quality.)

2.3.1 Local air quality conditions

For the Stage 1 Preliminary Options Assessment, the local air quality assessment should focus upon nitrogen dioxide and PM10, as these are the pollutants of greatest concern with respect to road traffic emissions, i.e. they are the pollutants at greatest risk of exceeding the standards. Existing conditions should be defined from a desktop study, using local air quality monitoring data wherever possible. This may rely on monitoring data collected by both automatic and non-automatic (e.g. passive diffusion tube) samplers. Consideration should be given to the monitoring locations from which any data are collected, e.g. whether they are kerbside, roadside or background, and the duration and quality of the data (see Appendix 2 for further details). Where monitoring has only been carried out for a short period of time (e.g. three months or less), then ideally the data should be adjusted to describe the annual mean using the approach set out in Appendix 2. If this cannot be done, then an appropriate caveat should be appended and caution applied to any subsequent data interpretation.

Where local air quality monitoring data are not available, reference should be made to measurements or studies in other comparable areas. The comparison should take account of:

- the type of area (e.g. urban, suburban or rural), which will influence local background concentrations;
- the exact location of any sensitive receptor locations relative to the road and, in particular, those within 50m of the proposed route carriageway, and
- specific local conditions, such as areas of congestion, or ‘street canyons’.

Sources of pollution other than vehicle emissions, which could lead to elevated background concentrations or higher incidences of exceedence of short-term standards, should be identified at this stage. This assessment needs only consider potential sources of NO_x and PM_{10}. These include industrial sources (both point sources and fugitive emissions), ports and areas with a high density of domestic solid-fuel combustion. Sources within 1 km of the study corridor should be identified; this should be extended to 3 km in the case of large industrial sources such as power stations.

2.3.2 Sensitive receptor locations

Sensitive receptor locations include: residential housing, schools, hospitals, places of worship, sports centres and shopping areas, i.e. locations where members of the public are likely to be regularly present. In identifying sensitive receptors, consideration should be given to the averaging periods of the standards (see Appendix 1). For example, short-term standards, such as the 1-hour mean for nitrogen dioxide would apply at all locations where the public might reasonably be expected to be present for an hour or more, including kerbside locations. The longer-term standards, such as the 24-hour and annual means, would not apply at such kerbside locations, as they would not reasonably represent longer-term public exposure.

Designated habitats are also potentially sensitive receptors. Such sites include, Natural Heritage Areas (NHA), Special Areas of Conservation (SAC), Special Protection Areas (SPA), National Parks, Nature Reserves, Refuges for Fauna, Refuges for Flora, Wildfowl Sanctuaries, Ramsar Sites, Biogenetic Reserves and UNESCO Biosphere Reserves. Any of the above sites within 2 km of the study corridor should be identified, in close consultation with the Ecologist. The reason for the designation should then be investigated. Sites which have been designated for geological reasons or for fauna that are not dependant on habitats that are sensitive to air pollution do not need to be considered further in the air quality assessment, but this should be clearly identified within the report.

2.4 Contents of the Air Quality Input to the Stage 1 Preliminary Options Assessment of the Route Selection Process

The air quality input should include:

- a list of all receptors deemed sensitive, or potentially sensitive, to air quality impacts within the study area;
- a list of all sensitive receptors within 50m of the carriageway of each feasible route option;
- a general description of the prevailing ambient air quality environment (for nitrogen dioxide and PM_{10});
- a list of any significant non-traffic sources in the study area;,
- a discussion of any opportunities for mitigation, and
- where practicable, a suitably scaled map showing the locations of sensitive receptors, particularly those within 50m of the carriageway of each feasible route option, and any significant pollutant emission sources.

2.5 Route Selection Process Stage 2 Project Appraisal Approach

Following an examination of the Stage 1 Preliminary Options Assessment of the Route Selection Process, route selection continues with the Design team developing a number of feasible route options in accordance with the project appraisal matrix.

The 'consideration of alternatives' (assessment of route options) and the identification of the main reasons for selecting a preferred route option is a key aspect of the Environmental Assessment Process as described in Phase 4 of the PMG and is a requirement of the Roads Act, 1993 as amended. Further information on the importance of the consideration of alternatives as part of the EIA/EIS process is provided in the NRA *Environmental Assessment & Construction Guidelines*.

The air quality input for the refined route options should consider the relative impacts of each of the route options on exposure to air pollution at sensitive locations. The assessment should focus on nitrogen dioxide and PM_{10} which are the pollutants of greatest concern with respect to road traffic emissions[3]. The input should:

- consider any changes to baseline air quality noted in the Stage 1 assessment. This should include updating any available monitoring data[4], information about existing pollution sources and the location of sensitive receptors;
- compare the relative impact of each of the route options on the likely population exposure to nitrogen dioxide[5] and PM_{10} concentrations. This should involve calculating the Index of Overall Change in Exposure for the existing route and each route option in the opening year (see below and Appendix 3);
- depending upon local circumstances, determine the magnitude of changes in nitrogen dioxide and PM_{10} concentrations as a result of the route options at a few worst-case locations for the opening year, and
- if there are any relevant designated habitat sites within 200m of any route options with significant changes in emissions, calculate the nitrogen oxides concentrations and nitrogen deposition rates at these locations.

2.5.1 Changes to baseline air quality conditions

The information collated during the Stage 1 Preliminary Options Assessment should be reviewed to include any new monitoring data that have become available and to take into account any new pollution sources and/or new sensitive receptors along each feasible route option.

2.5.2 Calculation of the Index of Overall Change in Exposure. (See Appendix 3)

Calculation of the Index of Overall Change in Exposure allows a comparison of the overall impact on people of each route option to be carried out. The Index is based on taking the number of sensitive receptor locations within 50m of the carriageway of all road links that would experience a significant change in traffic for each of the route options. Fifty metres represents the distance within which detectable impacts of a road might be found, while a significant change can be considered to be an increase or decrease in traffic emissions of 10% or more[6]. It is important to

3 There is no need to include an assessment of $PM_{2.5}$ at the Route Selection stage.
4 Specific consideration of $PM_{2.5}$ concentrations is not required at the Route Selection stage, but it is often simpler to collate all baseline data at the same time.
5 The calculation is actually carried out for NO_x emissions, but will represent likely changes to NO_2 exposure
6 If there are local circumstances where there is specific concern regarding receptor locations at distances beyond 50 metres from the carriageway (for example, an extremely busy road in a remote location), then a calculation of local scale pollutant concentrations should be carried out, as detailed in Section 3.2.3.

note that there will, in general, be an improvement in traffic emissions on existing national roads being bypassed (hence a route corridor option may possess a negative score as indicated in Table 1). The changes in emissions will be influenced by changes in traffic flow, composition and speed. The number of properties is then multiplied by the predicted change in the emission rate along that link and then summed across all links for that route option.

An example of the Index of Overall Change in Exposure for three route options is provided in the table below.

Table 1: Example Assessment: Index of Overall Change in Exposure

Option	NO_x Index	Better or Worse?	PM_{10} Index	Better or Worse?
Option 1	+2500	Worse	+1750	Worse
Option 2	-500	Better	+80	Worse
Option 3	-4000	Better	-2500	Better

A negative Index score indicates that there would be an overall reduction in exposure to pollution, i.e. a benefit, a positive Index score indicates an increase in exposure to pollution, i.e. adverse impact. Option 3 in this example would therefore be the most desirable in terms of air quality.

2.5.3 Calculation of local-scale pollutant concentrations.

If there is limited information about existing air quality near to roads, or there are sensitive receptors within close proximity to one or more route options, i.e. within 10m of the edge of the road, it will be necessary to predict pollutant concentrations at the Stage 2 Project Appraisal. It would be appropriate, in these circumstances, to calculate concentrations of both nitrogen dioxide and PM_{10} at a small number of 'worst case' receptor locations for the opening year. These locations should be selected so as to represent the maximum likely impact of each of the route options. They should cover locations where air quality is expected to improve as well as those where it is expected to deteriorate. Predictions should be carried out using the screening model method described in the Design Manual for Roads and Bridges (DMRB), published by the UK Highways Agency[7] . A detailed description of the approach is provided in Appendix 4.

The DMRB model requires a number of inputs to be provided, including the traffic flow (as AADT), speed, vehicle mix, and the background pollutant concentration for each year of interest. Existing concentrations of NOx, NO_2 and PM_{10} can be derived from the baseline air quality assessment described above. For the purpose of the Route Selection Report, it should be assumed that pollutant concentrations will decline in future years, as a result of various initiatives to reduce vehicle emissions both in Europe and in Ireland. The spreadsheet tool that was previously available to adjust measured background concentrations to a future year has now been replaced in the UK by the use of mapped concentrations for each year up until 2020. To assist users of these Guidelines, a series of adjustment factors that can be applied in Ireland has been prepared and these are set out in Appendix 5. This Appendix also contains factors that can be used to adjust measured roadside nitrogen dioxide concentrations to a future year.

[7] The DMRB model is currently being updated by the UK Highways Agency. The use of the DMRB model is sufficient at the Route Selection stage, but practitioners should be aware that the current version of DMRB does not include the updated emissions factors that have been published by the UK Department for Transport.

The predicted concentrations should be compared with the air quality standards. If concentrations are predicted to exceed or approach (defined as greater than 90%) the standards for any of the route options, this should be identified in the Route Selection report.

2.5.4 Impacts on sensitive ecosystems.

Any assessment of air quality impacts on sensitive ecosystems should be discussed and agreed with the Ecologist. The potential impact of the road scheme on sensitive ecosystems is limited to the local level. Consideration should therefore be given to all designated sensitive sites that are within 200m of any road that could be affected by the proposed scheme, both during operation and construction. For the purpose of the Route Selection, it should only be necessary to consider roads where there would be a 5% change or greater in traffic flows[8].

For each affected route option, calculate the nitrogen oxides concentrations and nitrogen deposition rates within the designated site, in a transect up to 200 m away from the road carriageway using the DMRB screening model described in Appendices 4 and 7. The results should be compared with the standard for the protection of vegetation of 30 $\mu g/m^3$.

2.6 Contents of the Air Quality Input to the Project Appraisal Process

The air quality input to the project appraisal process which feeds into the project appraisal matrix[9] should include:

- an update on any changes to the location of sensitive receptors or local emissions sources since the preparation of the Stage 1 Preliminary Options Assessment;
- any additional monitoring data that have become available following preparation of the Stage 1 Preliminary Options Assessment;
- a table showing the Index of Overall Change in Exposure for each of the Route Options.
- if relevant, predicted nitrogen dioxide and PM_{10} concentrations with the existing route and the route options at a few worst-case relevant locations;
- if predictions of pollutant concentrations at the local scale have been carried out, identification of any locations where concentrations are likely to exceed, or are above 90% of the standards;
- where practicable, a suitably scaled map showing the locations of sensitive receptors and the roads where significant traffic changes (greater than 10% AADT) would occur;
- a table showing calculated nitrogen oxides concentrations within any designated sites/sensitive ecosystems for comparison with the relevant standard, and
- a discussion of opportunities for mitigation.

2.7 Route Selection Process: Stage 3 Selection of the Preferred Route Corridor Approach

After completion of the Stage 2 Project Appraisal, the final stage of the route selection process involves the selection of the Preferred Route Corridor for the scheme. Once selected, the air quality specialist should assist, where necessary, the Design team in preparing the air quality section of the Project Appraisal Balance Sheet in accordance with the NRA's *Project Appraisal*

[8] This is a conservative change based on values of 5-10% in the DMRB.
[9] See Page 122 of the PMG 2010.

Guidelines (National Roads Authority, 2008). The work undertaken during Stage 2 should be reviewed by the air quality specialist and the Index of Overall

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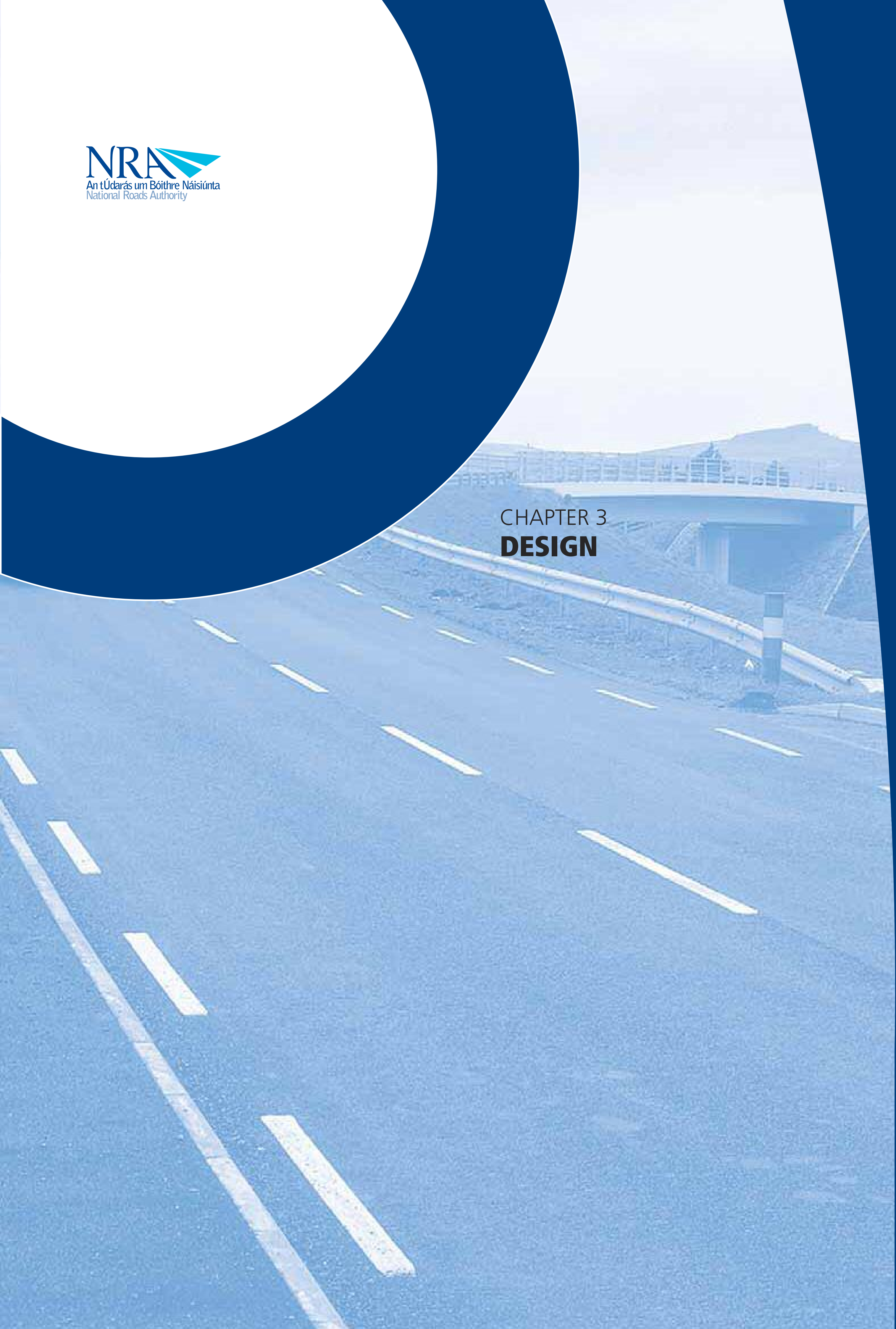

CHAPTER 3
DESIGN

3.0 DESIGN

3.1 Objectives

The purpose of Phase 3 is to develop the design of a scheme, following the selection of a Preferred Route Corridor, to a stage where sufficient levels of detail exist to establish likely land-take requirements and to start the process of bring the scheme through the statutory process. The design may be completed to sufficient detail to identify junction types, locations, accommodation works etc. and to assist in the scoping of the environmental assessments required to develop proposals to go forward to the statutory process in Phase 4.

3.2 Approach

Following the identification of the Preferred Route Corridor as outlined in Phase 2, the Air Quality Specialist should participate in the EIA screening process and, if necessary, Article 6(3) Screening (as specified in S.I. No. 94 of 1997). The Air Quality Specialist should consider the following as part of the Design phase:

- Undertaking a Walkover Survey of the Preferred Route Corridor to ensure that all significant features have been identified and properly assessed in the Route Selection Process;
- Assess any likely changes to baseline air quality since the Route Selection study. This should include updating any monitoring data and information about existing pollution sources, as well as any changes to the location of sensitive receptors;
- Participate in the EIA Screening process to ascertain whether there is a likelihood of significant environmental effects from an air quality perspective.
- Identify any areas with unusual features, such as complex junctions. These areas may need detailed dispersion modelling to be carried out for the Phase 4 EIA/EAR & The Statutory Processes assessment;
- Scope the detailed air quality assessment for the Phase 4 EIA/EAR & The Statutory Processes. Particular regard should be had to establishing the extent of any new monitoring surveys specifically required for Phase 4. This will be particularly important to verify any detailed dispersion modelling. It should be noted that the project programme should take into account the timescales required to complete baseline monitoring surveys; as a minimum, three months monitoring is strongly recommended (see Appendix 2). The requirements for baseline surveys should be given consideration in the Design Phase or early in the EIA/EAR & The Statutory Process phase;
- Particular regard should be had to $PM_{2.5}$ concentrations at this stage. If information on $PM_{2.5}$ concentrations was not collated at the earlier stages, then this data should now be collated and any implications for the Phase 4 assessment should be considered;
- Consult with the Ecologist regarding Article 6(3) Screening.
- Recalculate the Index of Overall Change in Exposure for the existing route and the preferred route option, if predicted traffic flows or road alignments have changed or new sensitive receptors have been identified.

3.3 Reporting

- The Air Quality Specialist should participate in the preparation of the EIA screening and Article 6(3) screening reports, if required.
- The Air Quality Specialist should also liaise with the Project Manager during the preparation of the Design report to incorporate all findings arising from the walkover survey and all air quality monitoring and modelling requirements necessary to progress the scheme.

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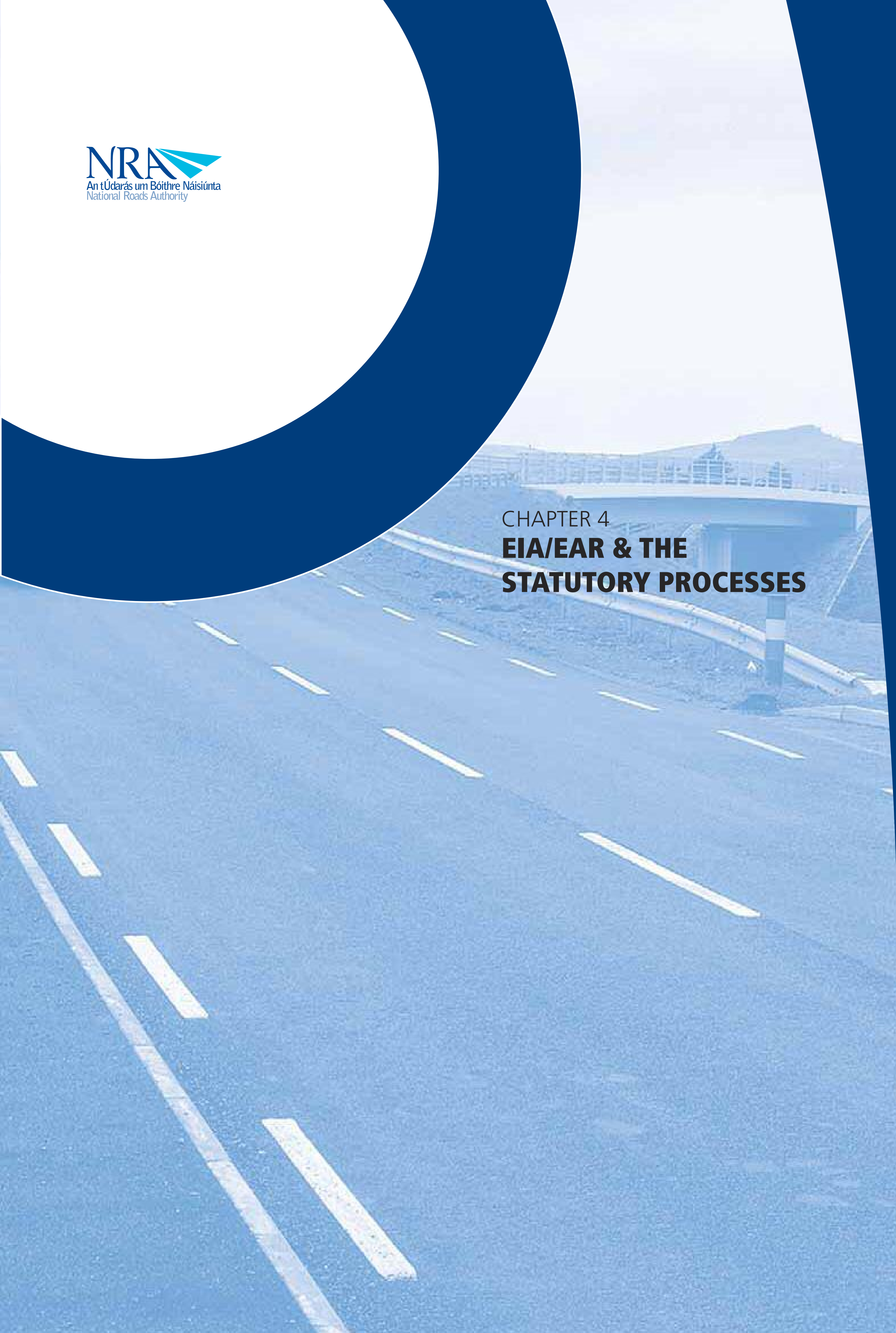

CHAPTER 4

EIA/EAR & THE STATUTORY PROCESSES

4.0 EIA/EAR & THE STATUTORY PROCESSES

4.1 Objectives

The objective of Phase 4, EIA/EAR & The Statutory Processes is to undertake a sufficiently detailed assessment to identify if there are any significant air quality impacts related to the preferred route and its construction. Where significant impacts are identified, the EIA should identify possible mitigation measures, including avoidance that might be applied.

In preparing the Environmental Impact Statement (EIS), regard should be given to the EPA's *Guidelines on the Information to be Contained in Environmental Impact Statements* (Environmental Protection Agency, 2002) and the National Roads Authority's *Environmental Impact Assessment of National Road Schemes – A Practical Guide* (National Roads Authority, 2008).

4.2 Approach

The air quality input for the EIS should follow on from the work carried out for the Route Selection and Design Phases. The EIA scoping process undertaken during the Design Phase should be re-evaluated to ensure a robust approach to monitoring and prediction modelling is undertaken. The outcome of the air quality impact assessment will form part of the EIS.

The input to the EIS should:

- consider any changes to baseline air quality since Phase 2 - Stage 2 Project Appraisal. This should include updating any monitoring data and information about existing pollution sources, as well as any changes to the location of sensitive receptors. Any new monitoring surveys, carried out specifically for the EIS, should also be reported;
- recalculate the Index of Overall Change in Exposure for the existing route and the preferred route if predicted traffic flows or road alignments have changed or new sensitive receptors have been identified;
- determine the changes in pollutant concentrations alongside roads with a significant change in traffic at a sufficient number of sensitive receptor locations. The study should specifically consider receptors at all road links were a greater than 5% change in flows or speeds is predicted for the "Do-Something" option. Predictions should be carried out for the current (baseline), opening and design years;
- compare the predicted pollutant concentrations with the air quality standards described in Appendix 1. An assessment with regard to the $PM_{2.5}$ limit values is also required;
- consider the wider-scale impacts of the preferred route by calculating the change in total emissions of nitrogen oxides (NO_x) and carbon dioxide (CO_2) for the current (baseline), opening and design years;
- provide any additional information required to complete an assessment of impacts on any ecologically sensitive habitats;
- assess the potential impacts of construction works and
- identify any mitigation measures to be implemented during both the construction and operational phases.

4.2.1 Baseline air quality

It is important to accurately define baseline air quality conditions for the EIS. Information collated for the Route Selection and Design Phases should be reviewed and the requirement to undertake any additional monitoring to support the EIS should be reassessed. The Authority considers that additional monitoring surveys for nitrogen dioxide, PM_{10} and $PM_{2.5}$ are likely to be required for the EIS, unless there are adequate data already available, and/or it can be confidently demonstrated that the pollutant concentrations are well below the air quality standards/limit values[10]. Again, it is important to reiterate that a minimum of three months monitoring is strongly recommended (see Appendix 2).

It should be noted that where detailed dispersion modelling is required (see below) monitoring data will be required to verify the predicted concentrations. Further guidance on monitoring is provided in Appendix 2.

4.2.2 Predictions using a screening model

In the first instance, predictions can be carried out using the method described in the DMRB. A detailed description of the approach is provided in Appendix 4. However, as previously stated in Section 1.1, at the time of preparing this document the UK Highways Agency was undertaking a major revision to the DMRB model. This revision will take account of the new emissions factors published by the UK Department for Transport and the revised NO_x:NO_2 calculator published by the UK Department for Environment, Food and Rural Affairs (Defra), and will allow the calculations to be performed within a GIS platform. It is expected that the revised DMRB model will be available in mid-2011. If necessary, these Guidelines will be further updated to reflect the revised DMRB model. While use of the current DMRB model is not discouraged, practitioners should be aware that it does not use the most up-to-date emissions factors and they should apply professional judgment to determine whether a more detailed dispersion model should be used. **In all cases, local verification of the DMRB model will be a critical aspect of the study.**

The DMRB model requires a number of inputs to be provided, including the traffic flow, speed, vehicle mix, and the background pollutant concentration for the year of interest. Existing pollutant concentrations may be derived from the output of the baseline assessment described above. For the purpose of the EIS, it should be assumed that pollutant concentrations will decline in future years, as a result of various initiatives to reduce vehicle emissions both in Europe and in Ireland. The spreadsheet tool that was previously available to adjust measured background concentrations to a future year has now been replaced in the UK by the use of mapped concentrations for each year up until 2020. To assist users of these Guidelines, a series of adjustment factors that can be applied in Ireland have been prepared and are set out in Appendix 5. This Appendix also contains factors that can be used to adjust measured roadside nitrogen dioxide concentrations to a future year.

The predicted concentrations should be compared with the air quality standards and limit values. If concentrations are predicted to exceed or approach (defined as greater than 90%) the standards/limit values for the preferred route option, then a detailed dispersion modelling study will be required for that pollutant.

[10] Well below can be taken to be <75% of the relevant standard.

4.2.3 Detailed Dispersion Modelling

If concentrations exceeding 90% of the air quality standards/limit values are predicted during a screening model assessment for the EIS, then a detailed dispersion modelling study should be carried out for the particular pollutant in question. In situations where sensitive receptors exist within 50m of a complex road layout (e.g. grade separated junctions, hills etc) detailed dispersion modelling should also be undertaken.

An approach for detailed dispersion modelling is provided in Appendix 4. Verification of the model output against monitoring data is a critical component of this approach.

4.2.4 Modelling Uncertainties

The modelling studies completed for the EIS should provide a robust assessment of the potential impacts of the proposed scheme. It should not normally be necessary to quantify the modelling uncertainties for individual scheme assessments, but it is important that the EIS should address the uncertainties associated with the data inputs and show what steps have been taken to minimise these uncertainties.

There are many components that contribute to the uncertainty of modelling predictions, including the traffic data; the vehicle emissions; the meteorology; and, of course, the assumptions that the model makes to interpret the dispersion of pollutant emissions in a real-world situation. An important stage in the process is model verification, in which the model output is compared with empirical measurements. The level of confidence in the verification process is necessarily enhanced when data from an automatic analyser have been used. Because of verification, there is usually an increased confidence in the prediction of base year concentrations.

Predicting pollutant concentrations in a future year will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future and it is necessary to rely on a series of projections as to what will happen to background pollutant concentrations and to vehicle emissions. These are based on emission factors which also take into account projections of the fleet mix in each year.

Recently, however, a disparity between the road transport emission projections and measured annual mean concentrations of NO_x and NO_2 has been identified across the UK and in Ireland. Similar disparities have also been reported from a number of European countries. Whilst the emission projections suggest that both annual mean NO_x and NO_2 concentrations should have fallen over the past 6 to 8 years, NO_x concentrations at Irish monitoring sites appear to have been increasing at roadside (traffic) sites, with NO_2 concentration slightly increasing or flattening off at both roadside and background sites (see Appendix 6)

The precise reason for this disparity is not known, but is thought to be related to the actual on-road performance of diesel vehicles when compared to the calculations based on the EURO standards. It may therefore be expected that NO_x and NO_2 concentrations will not fall as quickly in future years as the current projections indicate. However, at this stage, there is no robust evidence upon which to carry out any revised predictions.

The implication is that the absolute NO_2 concentrations predicted in future years may be higher than expected. The potential for this should be considered in the EIS, particularly if concentrations are predicted to be close to the standards. Any potential for under-prediction can, to some extent, be offset by the inclusion of worst-case assumptions into the modelling assessment.

4.2.5 Impacts at National/International Level

The assessment of the national/international level impacts of the preferred route should focus on the change in emissions of nitrogen oxides and carbon dioxide in the current (baseline), opening and design years. In carrying out this assessment, it is important that all roads within the affected network are included and that road links should be selected to accurately reflect speeds and flows along different sections of the network. The DMRB 'regional' approach can be used to estimate total emissions from the road network. A description of the approach is provided in Appendix 7. The wider-scale impacts should be assessed principally by comparing the incremental change in emissions between the Do-Minimum and Do-Something options. Comparison should also be made with current baseline emissions. An example layout is provided in Table 2 below.

As stated in Section 1.1, at the time of preparing this document the UK Highways Agency was undertaking a major revision to the DMRB model. This revision will take account of the new emissions factors published by the UK Department for Transport, and it is anticipated that the DMRB "regional approach" will be extended to include $PM_{2.5}$. It is expected that the revised DMRB model will be available in mid-2011. If necessary, these Guidelines will be further updated to reflect the revised DMRB regional model.

Table 2: Example layout for comparison of route network emissions for the wider scale impact

	NO_x (t/a)	CO_2 (kt/a)
Baseline 2010	1667	116
Do minimum 2015	1127	123
Do something 2015	1205	130
Do minimum 2025	929	125
Do something 2025	1022	136
Increment in 2015 [a]	78	7
% change in 2015	6.9%	6%
Increment in 2025	93	10
% change in 2025	10.0%	8%

[a] Increment due to the scheme in the specified year

The NRA's *Environmental Impact Assessment of National Road Schemes – A Practical Guide* (Rev. 1, National Roads Authority, 2008), notes that climate change and transboundary pollution issues are largely outside the scope of an EIS for individual road schemes. These issues and mitigation measures are the subject of specific policies and strategies set out in the relevant Government's National Climate Change Strategy (NCCS) and the *National Programme for Ireland for the Progressive Reduction of National Emissions of Transboundary Air Pollutants by*

2010. However, the EIS should indicate whether the scheme would impact positively or negatively on carbon dioxide and nitrogen oxides (NO_x) emissions.

4.2.6 Construction Impacts

The impact of both dust and vehicle emissions during the construction phase should be considered within the EIS. Dust emissions can lead to elevated PM_{10} and $PM_{2.5}$ concentrations and may also cause dust soiling. The impacts of dust emissions should be assessed by estimating the area over which there is a risk of significant impacts. Guidelines for assessing these impacts are provided in Appendix 8.

The significance of impacts due to vehicle emissions during the construction phase will be dependant on the number of additional vehicle movements, the proportion of HGVs and the proximity of sensitive receptors to site access routes. If construction traffic would lead to a significant change (> 10%) in AADT flows near to sensitive receptors, then concentrations of nitrogen dioxide, PM_{10} and $PM_{2.5}$ should be predicted using the approach described previously.

Where the location of any designated habitats (see para. 2.2.6) is within 200 m of any construction works, then this should be clearly identified within the EIS, and consideration given to the need for additional mitigation measures to reduce dust emissions.

4.2.7 Sensitive ecosystems

If the scheme is predicted to cause an increase in nitrogen oxides concentrations greater than 2 $\mu g/m^3$ and the concentrations predicted are very close to or exceed the standard (i.e., above 90% of the standard) then the sensitivity of the relevant species should be assessed by the project ecologist. If any of the designated sites are sensitive to nitrogen deposition, then the incremental nitrogen deposition rate should be calculated for the preferred route, both with and without the scheme. The incremental nitrogen deposition rates should then be compared with published critical loads for that habitat. A more detailed description of the approach is provided in Appendix 9.

4.3 Mitigation

Mitigation measures for both operation and construction of the preferred route should be considered. In terms of operation, mitigation measures to reduce air quality are generally limited. Where significant impacts are identified, the possible realignment of the Preferred Option should be considered, if possible without compromising any other locations or parts of the scheme. Where it is not possible to amend the alignment, then other measures should be considered. It is beyond the scope of this guidance to consider these in detail. The impacts of various mitigation measures to improve air quality near roads have been investigated at a European level (CEDR Air Quality Group, 2005), and this guidance provides useful background information.

Mitigation during the construction phase should also be considered within the EIS. Any impacts associated with the construction works will be of a temporary nature. Measures to mitigate the emissions of dust due to construction activities should include, where appropriate and practicable: wind breaks and barriers, frequent cleaning and watering of the construction site and associated access roads, control of vehicle access, vehicle speed restrictions, covering of piles, use of gravel at site exit points to remove caked on dirt from tyres and tracks, washing of equipment at the end of each work day and prevention of on-site burning. Where appropriate and practicable, hard surface roads should be wet swept to remove any deposited materials; un-surfaced roads should be restricted to essential site traffic only; and wheel-washing facilities should be located at all exits from the construction site. Public roads in close proximity to the construction site may contain temporary traffic controls including speed reduction. Construction phased activities occurring near sensitive areas should receive a higher level of preventative planning. Sensitive areas may include hospitals, schools, day-care centres, playgrounds, retirement homes, sensitive ecological sites and areas where local inhabitants exercise outdoors in designated areas such as public parks.

Readers are referred to the *Control of dust from construction and demolition activities* (BRE, 2003) and the *Best Practice Guidance: The control of dust and emissions from demolition and construction* (GLA, 2006) for more information on this matter.

4.4 Contents of the Air Quality Input to the EIS

The air quality input should include:

- an update on any changes to the location of sensitive receptors or local emissions sources following preparation of the Route Selection Study;
- any additional monitoring data that will have become available following preparation of the Route Selection Study or Design Report. If monitoring has been carried out, then precise details of the methodology (see Appendix 2), period and annualised concentrations and comparisons with the relevant standards/limit values should be provided;
- a table showing the recalculated Index of Overall Change in Exposure for the existing route and the preferred route option, if applicable. This should include information about the number of properties within 50m of each link considered;
- a description of the model methodology. This should include a description of the model used (including version number), a justification for the model selection, the source of any input data such as background concentrations, traffic data[11] and meteorological data and the methodology used to verify any detailed dispersion modelling (see Appendix 4);
- a suitably scaled map showing the locations of the receptors used in the air quality modelling and the preferred route; see section 3.3.5 on Production of drawings for an EIS in the NRA EIS Guidelines;
- predicted nitrogen dioxide, PM_{10} and $PM_{2.5}$ concentrations for the existing route and the preferred route in the current (baseline), opening and design years at representative relevant sensitive locations;
- a discussion of the modelling results, including comparison with the air quality standards/limit values and any local monitoring data;
- an assessment of the significance of the predicted concentrations using the criteria set out in Appendix 10, taking account of the modelling uncertainties as described in section 4.2.4;
- proposed mitigation measures, where appropriate;

[11] It is important that the traffic data be either reproduced in the Air Quality Chapter of the EIS, or a specific reference provided as to where they can be found (in the format that was used for the assessment).

- a table presenting total emissions of NO_x and CO_2 for the existing route and the preferred route in the current (baseline), opening and design years to indicate whether the scheme will impact positively or negatively with respect to pollutants which contribute to climate change and acidification;
- discussion of any impacts during the construction phase and proposed mitigation measures, as required and
- where dealing with European sites, reference to the results included in the Natura Impact Statement prepared for the purpose of Appropriate Assessment.

CHAPTER 5

REFERENCES AND OTHER SOURCES OF INFORMATION

5. REFERENCES AND OTHER SOURCES OF INFORMATION

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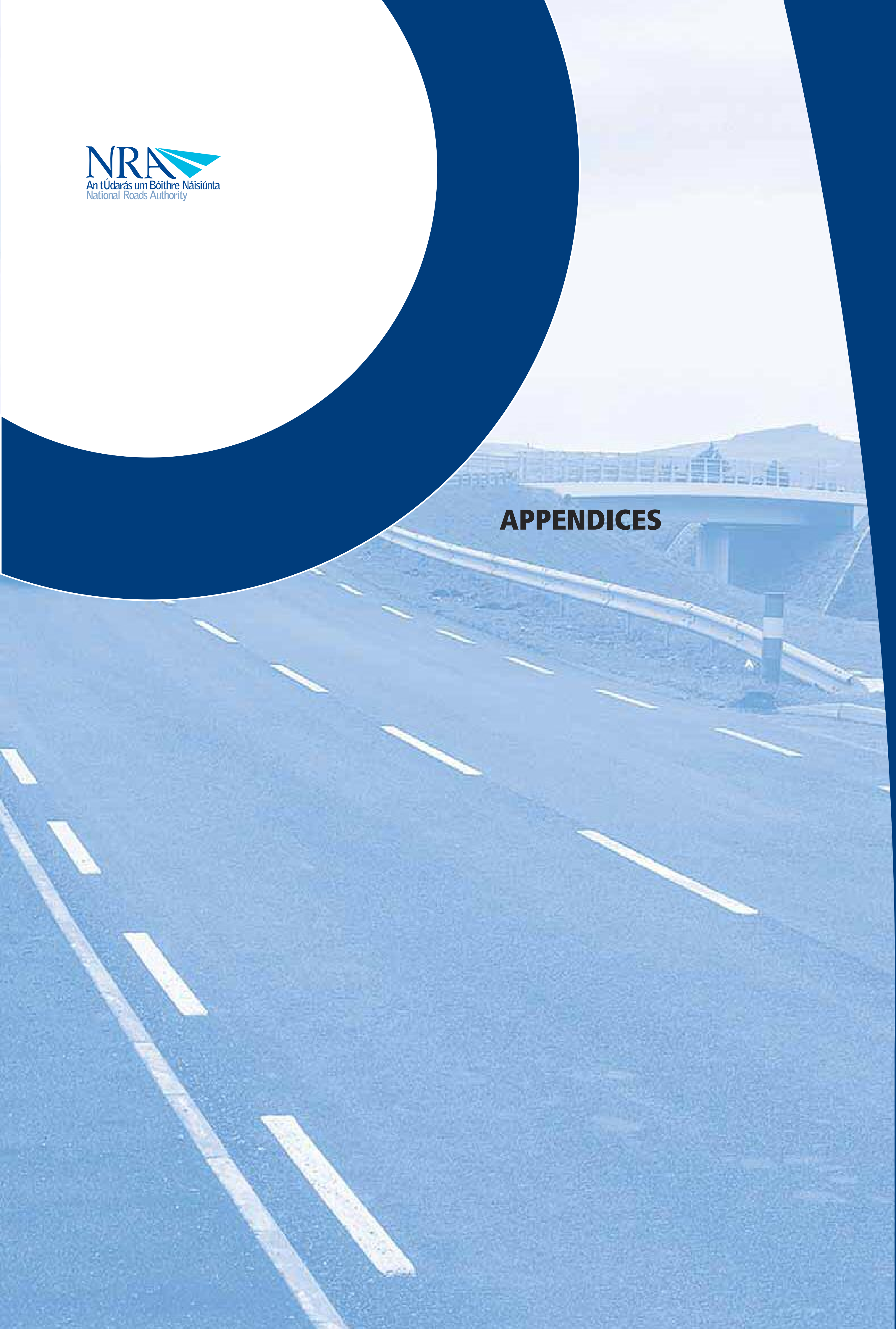


APPENDICES

APPENDIX 1: AIR QUALITY STANDARDS

Air Quality Strategy Regulations

Extract from S.I. No. 180 of 2011, Air Quality Standards Regulations 2011.

The Air Quality Standards Regulations (AQSR) came into effect in April 2011 and specify limit values for benzene, carbon monoxide, lead, nitrogen dioxide and oxides of nitrogen, particulate matter (PM_{10}) and sulphur dioxide. Only the standards related to nitrogen dioxide, oxides of nitrogen, PM_{10} and $PM_{2.5}$ are relevant for the assessment of national road schemes.

Box A1.1: Relevant Air Quality Standards

Pollutant	Averaging Period	Limit Value
Nitrogen Dioxide (NO_2) Protection of Human Health	1 Hour	200 $\mu g/m^3$ not to be exceeded more than 18 times a calendar year by 2010
	Annual Average	40 $\mu g/m^3$ by 2010
Nitrogen Oxides (NO_x) Protection of Vegetation	Annual Average	30 $\mu g/m^3$
Particulate Matter (PM_{10}) (Stage 1 2005)	24 Hour	50 $\mu g/m^3$ not to be exceeded more than 35 times a year by 2005
	Annual Average	40 $\mu g/m^3$ by 2005

Box A1.2: Relevant Limit Values for $PM_{2.5}$

Time Period	Obligation	To be achieved by
Annual mean	Limit value of 25 $\mu g/m^3$	2015
Annual mean	Stage 2 indicative Limit value of 20 $\mu g/m^3$	2020

APPENDIX 2: BACKGROUND CONCENTRATIONS AND MONITORING

A2.1 Introduction

Air quality monitoring data form an important part of each stage of the road scheme assessment. They are used to describe the existing air quality conditions, and to provide information on background concentrations for input to air quality models. They will also be required for the verification of the DMRB model and any detailed dispersion models if these are used for the preparation of the EIS.

For the Route Selection and Design Phases, data should, where possible, be collected from previous studies or reports. For the **Environmental Impact Assessment**, it may be necessary to carry out air quality monitoring at one or more locations along the existing and/or preferred route, depending upon the availability of existing data and the complexity of the scheme.

Sources of air quality monitoring data and important issues related to any additional monitoring campaigns are discussed in the following sections.

The pollutants of most concern in relation to emissions from road traffic are nitrogen dioxide, and Particulate Matter. The Route Selection and Design Phases should focus upon nitrogen dioxide and PM_{10}, although it may prove useful to collate any $PM_{2.5}$ data at the same time. The EIA/EAR and The Statutory Process Phase should also consider $PM_{2.5}$

A2.2 Sources of monitoring data

Wherever possible, use should be made of existing air quality data. These may have been collected as part of national or local government programmes, or as part of air quality assessments related to other development schemes.

The Environmental Protection Agency (EPA) publishes annual reports on *Air Quality in Ireland* that provide statistical summaries of monitoring data. The EPA also provides access to real-time monitoring data. These reports and data can be accessed via the EPA website at www.epa.ie.

In all cases, regard should be given to the QA/QC procedures that have been applied to the operation of the monitoring site. Where the monitoring stations have been operated or are reported by the EPA, then it may be assumed that adequate procedures have been applied. Where data are derived from monitoring studies conducted by other parties, then details of the QA/QC procedures should be obtained and described within the assessment report. If no details are available, this should be clearly stated.

Concentrations of nitrogen dioxide may also be measured using passive diffusion tubes. These provide a simple, cost-effective means of monitoring at a number of locations across an area, and can provide useful information on spatial distributions. Such diffusion tube surveys may usefully supplement measurements carried out with continuous analysers in order to provide both high quality NO_x and NO_2 measurements, and an indication of the spatial variation. Where diffusion tubes are used, it is **essential** that the data are adjusted for 'bias'. This is dependant on the laboratory that prepared the tubes, and the method of preparation that was used. Suitable bias adjustment factors may be derived locally (by collocating tubes with an automatic analyser) or default factors may be obtained from the following website http://laqm1.defra.gov.uk/review/tools/no2/baf.php,for some of the laboratories that may be used. The assessment report should explicitly state what bias adjustment factors have been applied.

Passive diffusive samplers are also available to measure nitric oxide (NO) concentrations. This is potentially useful as it allows NO_x concentrations ($NO + NO_2$) to be determined, which is advantageous for model verification. However, the performance of these tubes is not fully understood and caution should be applied to their application in studies unless local intercomparison exercises are carried out.

Monitoring for PM_{10} and $PM_{2.5}$

It is more difficult to measure concentrations of PM10 and PM2.5 than nitrogen oxides and nitrogen dioxide and there are currently no suitable screening methods available. The air quality standards and limit values for PM_{10} and $PM_{2.5}$ are based on the European reference samplers defined in EN12341 and EN14907 respectively (CEN 1998, 2005). These are gravimetric samplers that require filters to be exposed on a daily basis. The PM mass is then determined by weighing the filters in a laboratory.

Monitoring concentrations of PM in ambient air is not straightforward, due to the variable nature and composition of the particles. The analysers cannot be calibrated in the traditional sense (as there are no reference standards) and there can be significant problems with the loss of semi-volatile components such as ammonium nitrate and the absorption and retention of water vapour. The method that is selected for the collection and determination of PM mass has an influence on the PM concentration that is subsequently reported,

There is a wide range of methods that may be used to determine concentrations of PM_{10} and $PM_{2.5,}$ including manual gravimetric samplers and continuous analysers. Historically, monitoring of PM_{10} concentrations has been widely carried out using the TEOM (Tapered Element Oscillating Microbalance) analyser, applying a default correction factor of 1.3 to account for the loss of the semi-volatile component in order to approximate a concentration that is "reference sampler equivalent".

In 2006, Defra and the devolved administrations published the results of a study to determine the equivalence of a range of instruments in common use in the UK (Harrison et al, 2006). An important conclusion of this study was that the TEOM analyser did not meet the equivalence criteria for PM_{10}, regardless of any correction factor that is applied. A number of other PM_{10} samplers and analysers were found to meet the equivalence criteria employed in that study, either directly, or after a suitable slope/and or intercept correction is applied; only one $PM_{2.5}$ instrument (the Filter Dynamics Measurement System - FDMS) was tested and found to meet the equivalence criteria directly. The results of this study are summarised in Table A2.1 below.

Table A2.1 Summary of UK Equivalence Tests, 2006.

Instrument	Outcome of Test
TEOM (PM_{10})	Fails the equivalence criteria
FDMS "Model B" (PM_{10})[1]	Meets the equivalence criteria
FDMS "Model B" ($PM_{2.5}$)[1]	Meets the equivalence criteria
Partisol 2025 (PM_{10})[2]	Meets the equivalence criteria
OPSIS SM200 (PM_{10})[3]	Beta - Meets the equivalence criteria Mass - Meets the equivalence criteria with correction for slope and intercept
Met-One BAM (unheated) (PM_{10})	Meets the equivalence criteria with correction for slope

Notes:
1. The "Model B" FDMS is no longer available. The UK networks currently use the "Model B/C" FDMS which is a hybrid instrument incorporating the "Model B" drier. The "Model C" FDMS is undergoing equivalence trials.
2. The Partisol 2025 was operated with PTFE-coated glass fibre filters.

A series of UK equivalence tests is ongoing, coordinated by Defra and the devolved administrations, but with the field trials funded by the instrument manufacturers; this is being carried out as a joint TUV/MCERTS programme. As part of this study, the dual channel (PM_{10} and $PM_{2.5}$) beta-attenuation analyser manufactured by FAI Instruments (Model SWAM 5a) has achieved both TUV and MCERTS certification which effectively means it is equivalent for use in the UK; it is expected that the $PM_{2.5}$ Smart BAM will achieve MCERTS certification in 2010 (Harrison, pers comm).

Although the TEOM does not meet the equivalence criteria, a new approach to correcting TEOM data has been introduced involving the Volatile Correction Model (VCM) developed by King's College, London. The approach is based on the assumption that the volatile component of PM_{10} lost during the heated sampling with a standard TEOM is consistent across a defined geographical area, such that measurements of this component at one location may be used to correct measurements elsewhere. Thus, it is assumed that the volatile component is constant across a region, with the implication that local sources do not contribute to volatile PM. The approach uses the FDMS "purge measurement" as an indicator of the volatile component that will have been lost by the TEOM. PM10 concentrations measured by a TEOM may be corrected to a concentration that is essentially equivalent to the European reference sampler using the following equation:

TEOMVCM PM_{10} = TEOM PM_{10} + (1.87 x Regional FDMS PM_{10} purge)

A VCM web portal (http://laqm1.defra.gov.uk/review/tools/vcm.php) is available which allows users to download geographically-specific correction factors to apply to TEOM PM_{10} measurements, but this only applies to UK sites. However, the above equation can be applied manually to hour-by-hour measured concentrations using a spreadsheet. It recommended that purge measurements are derived from FDMS analysers within the same Zone as the TEOM site.

A list of FDMS analysers currently measuring PM_{10} concentrations in the EPA network is summarised below:

- Ringsend (Zone A)
- Rathmines (Zone A)
- Bray (Zone C)
- Celbridge (Zone C)
- Ennis (Zone C)
- Longford (Zone D)

Wherever possible, the NRA encourages the use of instruments to measure PM concentrations that meet the equivalence criteria, but recognises that the issue is most critical where levels are close to the standards. It is not possible to define precisely what "close to" means, but as an approximate guide it is likely to be in the range of 30 to 40 days of PM_{10} exceedence (as measured by the TEOM multiplied by 1.3). Where non-equivalent methods are used, a thorough justification, and interpretation of the data should be provided.

QA/QC procedures are particularly important for PM monitoring and especially so where gravimetric samplers and subsequent laboratory weighing is used. Guidance on QA/QC procedures for PM monitoring is given in Annex 1 to LAQM.TG(09) (Defra, 2009).

A2.3 Short-term monitoring

Unless data are obtained from fixed monitoring stations, it is unlikely that the period of monitoring will extend over a full calendar year. Whilst data from short-term monitoring campaigns are useful, and unavoidable where a specific programme of monitoring is commissioned to support the EIS, care needs to be taken when comparing these data with the standards, which are expressed in terms of the calendar year.

Where data from short-term monitoring campaigns are used, the results may be adjusted to an equivalent annual mean concentration by comparison with fixed monitoring stations. An example of how to carry out this adjustment is provided in Box A2.1.

Box A2.1: Approach to the estimation of annual mean nitrogen dioxide concentrations from short-term monitoring data

Example

It is only possible to carry out a monitoring survey at site **S** for 6 months between June and November 2010. The measured mean concentration **M** for this period is 38.0 µg/m^3. How can this be used to estimate the annual mean for this location?

NB: This result could come from a chemiluminesence monitor or from a bias-adjusted diffusion tube.

Adjustment to estimate annual mean

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

1. Identify the closest fixed monitoring sites. Ideally these should be background sites to avoid any very local effects. [These sites could be up to 100 miles away depending on what is available.]
2. Obtain the annual means, **Am**, for the previous calendar year for these sites, 2009 in this example.
3. Work out the period means for these sites, **Pm**, for the period of interest, in this case June to November 2010.
4. Calculate the ratio, **R**, of the annual mean to the period mean (Am / Pm) for each of the sites.
5. Calculate the average of these ratios, **Ra**. This is then the adjustment factor.
6. Multiply the measured period mean concentration **M** by this adjustment factor **Ra** to give the estimate of the annual mean for 2009.

Short-term monitoring campaigns may serve two purposes within the EIS. These are to describe existing background concentrations and to provide suitable data for model verification, where a detailed dispersion model is used (see Appendix 4). In the design of short-term monitoring campaigns to support the EIS, the following issues should be taken into consideration:

- Monitoring locations should be carefully selected. To provide data on background pollutant concentrations, the monitoring sites should be along the proposed route corridor and unaffected by any immediate local pollution sources. To support model verification work, monitoring should also be carried out at a roadside location so that the traffic increment to pollutant concentrations can be identified;
- Monitoring should ideally be carried out for a period of six months, including both summer and winter periods. However, for practical reasons, the monitoring period may be shorter, but, wherever possible, should extend for at least 3 months and should not be less than 1 month (see Box A2.2), and
- Appropriate QA/QC methods should be applied for calibration and verification, and should be documented within the EIS.

A2.4 Reporting monitoring data

When reporting monitoring data the following information should be recorded:

- site name;
- site location (including height of sampling inlet, site description and six-figure grid reference);
- site type (e.g. kerbside (0-1m), roadside (1-15m), urban background, suburban, rural etc.);
- monitoring method (e.g. chemiluminescence, diffusion tube, TEOM, FDMS, gravimetric sampler etc.);
- details of QA/QC procedures (if data are derived from a monitoring site not within the EPA network) and any adjustments applied e.g. to PM instruments or to nitrogen dioxide diffusion tubes to account for laboratory "bias";
- monitoring period;
- details of any adjustments applied to short-term data;
- concentration units ($\mu g/m^3$ or mg/m^3), and
- data capture statistics.

Box A2.2: Influence of the length of the sampling period on the estimated annual mean concentration

Figures A2.1(a) to A2.1(d) below describe box and whisker plots for the range of values (expressed as a percentage of the annual mean) for 1, 4 and 16-week sample periods started on any day in the year (>75% of values required for a valid period mean). The monitoring data represent both urban traffic and suburban background locations.

The box shows the inter-quartiles, i.e. 50% of the values lie in this range. The whiskers show the range of the data, except for outliers, which are shown as individual dots.

Fig A2.2(a) Nitrogen Dioxide at Coleraine (urban traffic) monitoring site, 2001 – annual mean 39.3 $\mu g/m^3$

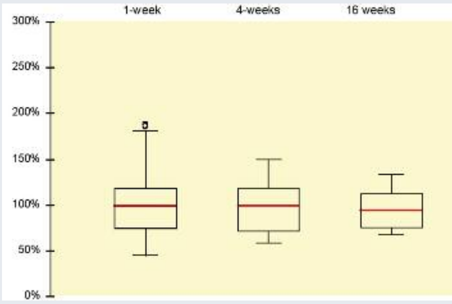


Fig A2.2(b) Nitrogen Dioxide at Ballyfermot (suburban background) monitoring site, 2003 – annual mean 26.9 $\mu g/m^3$.

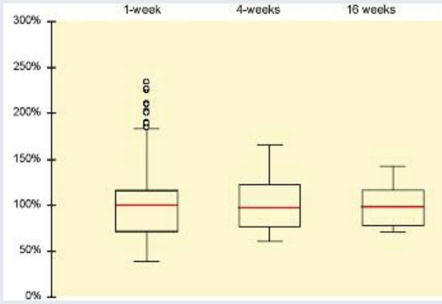


Fig A2.2(c) PM10 at Coleraine (urban traffic) monitoring site, 2001 – annual mean 26.6 $\mu g/m^3$

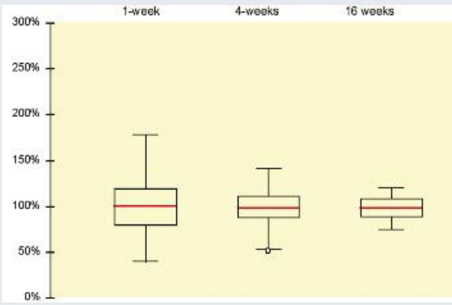
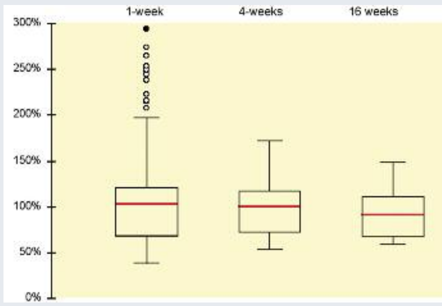


Fig A2.2(d) PM10 at Heatherton Park (suburban background) monitoring site, 2002 – annual mean 21.3 $\mu g/m^3$.



It may be concluded that a 1-week sampling period would give a very poor representation of the annual mean for both nitrogen dioxide and PM_{10} concentrations. A 4-week sampling period might be expected to be within -40% to +60% of the true annual mean; a 16-week sampling period reduces this uncertainty to about -30% to +40%.

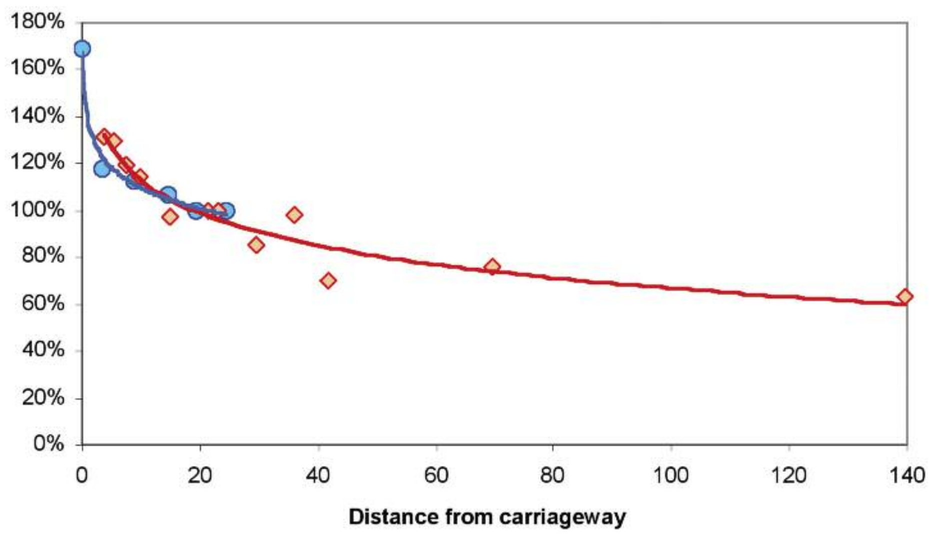
APPENDIX 3: CALCULATION OF INDEX OF OVERALL CHANGE IN EXPOSURE

A3.1 Introduction

Calculation of the Index of Overall Change in Exposure allows a comparison of the overall impact on people of each of the Route Options to be carried out. The Index is based on identifying the number of sensitive receptor locations (e.g. residential properties) within 50m of the carriageway for all road links with a significant change in traffic for each of the Route Options. Fifty metres represents the distance within which detectable impacts of road traffic might be found, while a significant change can be considered to be an increase or decrease in traffic flow (AADT) of 5% or more. The number of properties is then multiplied by the predicted change in the emission rate along that link , and then summed across all links[12] for that Route Option.

Justification for the 50m distance criteria is drawn from the two reports published by the UK Air Quality Expert Group (AQEG). Figures A.3.1 and A.3.2 have been taken from these reports and demonstrate that both nitrogen dioxide and PM_{10} concentrations decline rapidly with increasing distance from the carriageway, such that levels beyond 50m distance are unlikely to be distinguishable from the background in most situations[13] .

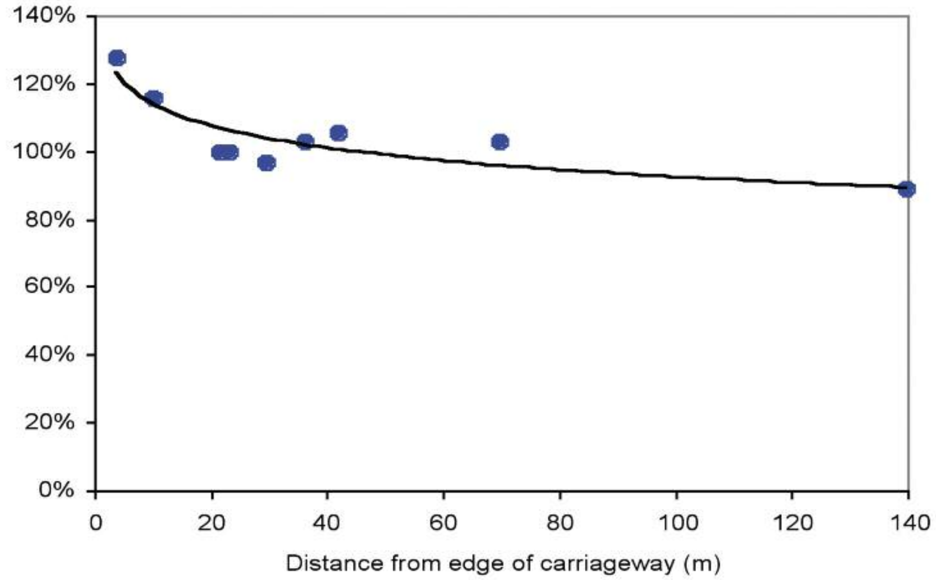
Fig A.3.1: NO^2 concentrations measured on a transect away from a busy central London road (red) and a motorway (blue), normalised to 100% at about 20m distance from the edge of the carriageway. The data points have been fitted using a logarithmic relationship. Source: *AQEG(2004) Nitrogen Dioxide in the United KIngdom*



[12] The Index of Overall Exposure calculates the change in NO_x emissions, which is intended to reflect the likely change in exposure to NO_2 concentrations.

[13] Exceptions may occur in areas with very low background concentrations and extremely high traffic flows. In such circumstances, an assessment of local scale pollutant concentrations should be carried out at receptor locations, as described in Section 3.

Figure A.3.2: PM_{10} gravimetric concentrations measured on transects away from the M25 motorway, normalised to 100% at about 20m from the edge of the carriageway. The data points have been fitted using a logarithmic relationship. Source: *AQEG(2005) Particulate Matter in the United Kingdom*



The various steps required to calculate the overall change in exposure are summarised in Box A3.1.

Box A3.1: Summary of steps to calculate the Overall Change in Exposure

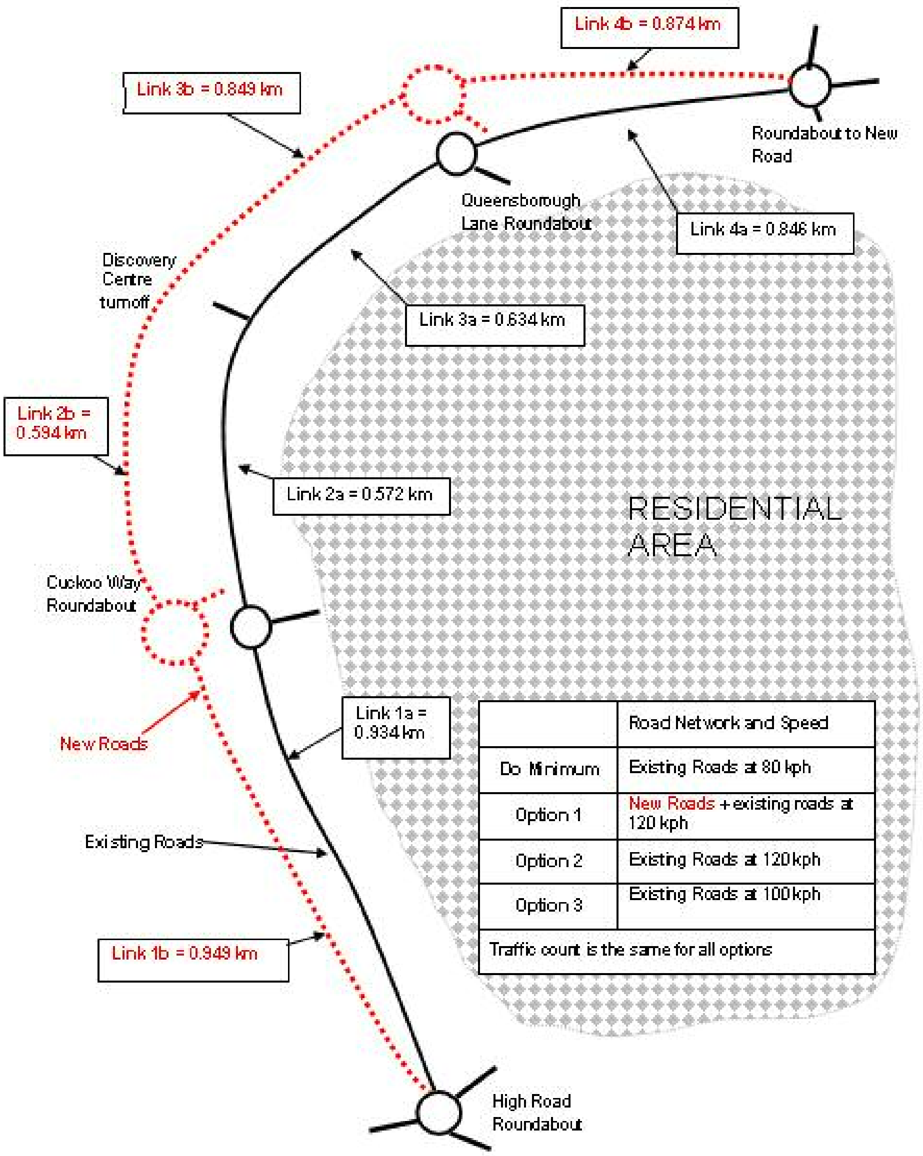
Step	Actions
1	**Collate basic traffic information** for each link. This should cover traffic flows (for the opening year), composition and speeds, as well as link lengths.
2	**Define the study area.** As a minimum, this should include the proposed and existing road, and any other roads with 'significant' changes in emissions (determined as road links with ±5% change in emissions from step 2). To ensure a balanced comparison between the Route Options, the same study area should be used for the existing route and each Route Option, even if changes are less than 5% for some roads with some Options.
3	**Calculate total emissions for each link** based on link length, vehicle flow, %HDV (HGV + buses + OGV) and average speed using the 'Regional Impact Assessment' function in the DMRB spreadsheet. Careful consideration should be given to average speeds used in the assessment, particularly where the scheme is expected to change speeds. Total emissions from the whole route network should also be recorded.
4	**Calculate the difference between do-minimum and do-something emissions from each link.** Where a new section of road is proposed, an emission of zero should be assumed for the do-minimum situation. A negative value will represent a decrease in emissions with the scheme, a positive value an increase.
5	**Count the number of sensitive locations within 50m of the carriageway of each of the links** Where a property falls within 50m of two or more links, it should be counted as part of the total number of properties for both links (i.e. the property should be 'double counted').
6	**Calculate the change in emission rate (kg/km/yr) for each link being considered in the study area.** This can be calculated by dividing the calculated change in emissions (kg/yr) by the link length (km).
7	**Multiply the change in emission rate from each link by the number of properties within 50m**. Retain the sign, -ve for a decrease in emissions and +ve for an increase.
Step	Actions
8	**Add together the total numbers for each link** to determine an overall exposure index for each Route Option.
9	**Compare the exposure index for each of the Route Options.** A negative score indicates that there would be an overall reduction in exposure to pollution, i.e. a benefit, a positive score indicates an increase in exposure to pollution, i.e. adverse impact. The Route Option with the lowest exposure index would be the preferred option from an air quality perspective.

A3.2 Worked Example

An example of the calculation of Overall Exposure Change for the Route Corridor Selection is provided below. The example shown is based on NO_x; the same procedure should also be carried out for PM_{10} emissions.

The scheme is to upgrade an existing bypass to safely accommodate traffic travelling at a faster speed. The current speed is 80 kph. Option 1 involves realigning the road, to reduce the arc in the road to allow vehicles to travel at 120 kph, whilst Options 2 and 3 involve upgrading the existing road to either 100 or 120 kph standard. Further details of the options are provided in Figure A3.3.

Figure A3.3 Input Data for Worked Example



Step 1: Collate basic information about each link. This should cover traffic flows, composition and speeds, as well as link lengths. The information on link length should be entered into a spreadsheet like that shown in Tables A3.1 to A3.3. The details will be entered in columns 'a' and 'c'.

Table A3.1: Option 1

Option 1								
a	b	c	d	e	f	g	h	i
			NO_x emissions (kg/yr)					
Link name	Properties within 50m	Link Length (km)	Do-minimum	Do-Something	Change in emissions (kg/yr)	Change in emissions (%)	Change in NO_x emission rate (kg/km/yr)	NO_x Index
1b	35	0.949	0	6,266	6,266	>+10	6603	231105
2b	4	0.594	0	3,909	3,909	>+10	6580	26320
3b	3	0.649	0	4,265	4,265	>+10	6572	19715
4b	11	0.874	0	5,971	5,971	>+10	6832	75149
1a	40	0.934	4,388	0	-4,388	>-10	-4698	-187902
2a	17	0.572	2,701	0	-2,701	>-10	-4721	-80264
3a	40	0.634	2,988	0	-2,988	>-10	-4713	-188523
4a	15	0.846	4,161	0	-4,161	>-10	-4918	-73769
TOTAL			**14,237**	**20,410**				**-178169**

Table A3.2: Option 2

Option 2								
a	b	c	d	e	f	g	h	i
			NO_x emissions (kg/yr)					
Link name	Properties within 50m	Link Length (km)	Do-minimum	Do-Something	Change in emissions (kg/yr)	Change in emissions (%)	Change in NO_x emission rate (kg/km/yr)	NO_x Index
1a	40	0.934	4,388	6,167	1,779	+40.5	1905	76208
2a	17	0.572	2,701	3,764	1,063	+39.4	1859	31595
3a	40	0.634	2,988	4,166	1,178	+39.4	1859	74343
4a	15	0.846	4,161	5,780	1,619	+39.9	1914	28707
TOTAL			**14237**	**19877**				**210854**

Table A3.3: Option 3

Option 3								
a	b	c	d	e	f	g	h	i
			NO_x emissions (kg/yr)					
Link name	Properties within 50m	Link Length (km)	Do-minimum	Do-Something	Change in emissions (kg/yr)	Change in emissions (%)	Change in NO_x emission rate (kg/km/yr)	NO_x Index
1a	40	0.934	4,388	5,136	748	+17.0	801	32047
2a	17	0.572	2,701	3,152	451	+16.6	789	13409
3a	40	0.634	2,988	3,488	500	+16.7	788	31533
4a	15	0.846	4,161	4,850	690	+16.6	815	12227
TOTAL			**14237**	**16626**				**89215**

Step 2: Calculate total emissions for each link. Calculate total emissions for each link using the DMRB total emissions spreadsheet, adding the results to columns 'd' (do-minimum) and 'e' (do-something)

In this example, the only changes in traffic flow, composition and speed are those associated with the links that form the scheme itself. No changes affect the rest of the network, so only links 1 to 4 need to be included.

Step 3: Calculate the difference between do-minimum and do-something emissions from each link. 'f' = 'e'-'d' 'g' = 'f' as a % of 'e'

With Option 1 (Table A3.1), a new section of road is introduced, in a different location to the existing road. The assessment of Option 1 therefore needs to consider both the existing and proposed sections of road (see Table A3.1). Where a new section of road is introduced, emissions are zero in the do-minimum; where an existing section of road is decommissioned, then the do-something emissions are zero *(in most cases existing section of road would continue to be used)*. In the case of Options 2 and 3, the assessment is more straightforward, as shown in Tables A3.2 and A3.3. Emissions increase in the do-something, as a result of the increased speeds.

e.g. Option 2 Link 1 – do-minimum emissions (Kg/yr) = 4,388
do-something emissions (Kg/yr) = 6,167
change in emissions (Kg/yr) = 6,167 – 4,388 = 1,779 = +40.5%

Step 4: Define the study area.
The study area should cover all links with a change in emissions of more than +/- 10%. These links can be identified from column 'g'. In this example all the links need to be included.

Step 5: Count the number of sensitive locations within 50m of the centreline of each of the links. Add to column 'b'

An individual property can be counted against more than one link, especially near to junctions. This gives an element of double counting, but allows for the impacts of the changes on both roads as they will affect the property. This does not apply in this example.

Step 6: Calculate the change in emission rate (kg/km/yr) for each link. 'h' ='f'/'c'

e.g. Option 2 Link 1 – change in emissions = 1779 Kg/yr
link length = 0.934 km
change in emission rate = 1779/0.934 = 1905 kg/km/yr

Step 7: Multiply the change in emission rate for each link by the number of properties within 50m. 'i' = 'b' * 'h'

e.g. Option 2 Link 1 change in emission rate = 1905 kg/km/yr
number of properties within 50m = 40
NO_x Index Score = 40 * 1905 = 76208
(result based on unrounded numbers)

N.B. If there is a reduction in emissions then this Index Score would be negative.

Step 8: Add together total numbers for each link to determine an overall exposure index for each option.

Option 2 Exposure Index = 76,208 + 31,595 + 74,343 + 28,707
= 210,854

Step 9: Compare the exposure indices for each of the route options

The Index of Overall Change in Exposure is summarised in Table A3.4 below. The negative score for Option 1 indicates that there would be a reduction in Overall Exposure with the scheme. This would be as a result of moving the road further from properties. Options 2 and 3 have positive Index scores, indicating that they would lead to increases in exposure to pollution, as a result of increasing speeds, which would increase emissions. The higher Index Score for option 2 shows that increasing the speed to 120 kph would have a greater negative impact than increasing the speed to 100 kph (Option 2).

Table A3.4: Summary of Index of Overall Exposure for each Route Option

Option	NO_x Exposure Index	Better or Worse
1	-178169	Better
2	210854	Worse
3	89215	Worse

APPENDIX 4: APPROACH TO DISPERSION MODELLING

A4.1 Introduction

This Appendix provides a description of the various approaches that may be taken for dispersion modelling studies. It is not intended to be prescriptive, but sets out the general principles that should be followed. Reference to important background information and sources of data is set out in the initial sections. More specific information relating to the use of the DMRB Screening Model and detailed dispersion models is then provided. As stated previously in these Guidelines, it is important that the version number and/or date of the selected model is always clearly stated.

A4.2 Background Information

The NO_x:NO_2 Relationship

Nitrogen oxides, NO_x (NO + NO_2), are predominantly emitted from road vehicle exhausts in the form of nitric oxide (NO) which is then transformed to nitrogen dioxide (NO_2) via a series of complex chemical processes in the atmosphere. The dominant pathway for NO_2 formation is via the reaction of NO with ozone (O_3).

However, there has been an increasing proportion of direct (or primary) NO_2 emitted from vehicle exhausts, often referred to as "f-NO_2". These increased primary emissions are associated with the greater uptake of diesel cars, and the use of certain types of regenerative particle traps on some heavy duty vehicles.

An empirical approach to calculating NO_2 from NO_x concentrations at roadside sites was developed by Defra in 2002, then updated in 2007, and was referenced in the original version of these Guidelines. However, it was always accepted that such an empirically-derived relationship was not best suited to the prediction of NO_2 concentrations in future years as the proportion of f-NO_2 was expected to continue to increase.

In 2009, Defra published a revised approach for predicting NO_2 from NO_x concentrations at roadside sides, which takes account of the difference between fresh emissions of NO_x and background NO_x, the concentration of O_3, and the different proportions of primary NO_2 emissions in different years. The approach has been incorporated into a simple spreadsheet calculator which allows the calculation of NO_2 from NO_x and vice versa; the calculator can be downloaded from the internet at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php.

The calculator was designed for local authorities in the UK, and provides default input data for the regional background concentrations of O_3, NO_x and NO_2 via a "local authority selection tab". For practitioners in Ireland, there are two approaches that can be taken:

- Specify the regional background concentrations from a local monitoring site. This would probably be a rural site. It is important to ensure the O_3, NO_x and NO_2 concentrations must be provided from the same monitoring site for the same year; or
- Assume that regional concentrations in Ireland are characterised by a local authority in

Northern Ireland (Craigavon is recommended, see Appendix 11). This approach has the advantage that concentrations in future years will be automatically calculated within the model. In this respect, it should be noted that the gradient of regional background NO_x, NO_2 and O_3 concentrations is relatively small across the geographic domain of the United Kingdom.

Other approaches for NO_x to NO_2 conversion may be used, and may be preferred in some cases, depending on the dispersion model that is being used. For example, the Generic Reaction Series, or other chemical reaction schemes may be used, but the precise method applied should always be explicitly stated, along with assumptions made for f-NO_2 proportions and future year O_3 concentrations. It should be noted that the "Derwent-Middleton" equation is no longer considered a suitable approach.

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

The standards for nitrogen dioxide are expressed in terms of both the annual mean and the number of hours above 200 $\mu g/m^3$. It is not straightforward to predict exceedences of the 1-hour standard and all models are inevitably poorer at predicting short-term peaks than they are at predicting annual mean concentrations.

However, empirical data[14] suggest that the hourly mean standard is unlikely to be exceeded at roadside locations unless the annual mean is above 60 $\mu g/m^3$.

Relationship between the annual mean and 24-hour mean PM10 standard

The standards for PM_{10} are expressed as the annual mean and the number of days above 50 $\mu g/m^3$. Dispersion models are inherently less accurate at predicting exceedences of the 24-hour mean PM_{10} standard than for the annual mean standard. An empirical relationship between the annual mean concentration and the number of days >50 $\mu g/m^3$ PM_{10} has been derived in LAQM.TG(09) and takes the form:

No. 24-hour mean exceedences = -18.5 + 0.00145 x annual mean^3 + (206/annual mean)

Emissions Factor Toolkit

Vehicle emission factors are available from a number of sources. Emission factors have been developed for the UK National Atmospheric Emissions Inventory (NAEI). These factors have been incorporated into an Emissions Factor Toolkit (EFT version 4.2) which allows users to calculate emissions rates in terms of grams per vehicle-kilometre for all years up until 2025[15]. The EFT takes into account UK fleet composition for different road types, European emission standards from pre-Euro to Euro VI and scaling factors to reflect improvements in fuel quality, retrofitting, and technology conversions. The EFT now also includes emission factors for $PM_{2.5}$, and an allowance for PM (both PM10 and $PM_{2.5}$) emissions associated with brake and tyre wear. The toolkit allows users to calculate vehicle emissions for multiple road links based on vehicle fleet composition, traffic speeds and road type.

[14] Cook (2008) Analysis of the relationship between 1-hour and annual mean nitrogen dioxide concentrations at UK roadside and kerbside monitoring sites. Available at http://laqm2.defra.gov.uk/supportguidance/

[15] The EFT was commissioned by the Department for Environment, Food and Rural Affairs in the UK to support local authorities undertaking review and assessment studies. The EFT spreadsheet may be downloaded from http://laqm1.defra.gov.uk/review/tools/emissions.php

Non-exhaust emissions of particulate matter

The road traffic contribution to concentrations of Particulate Matter (both PM_{10} and $PM_{2.5}$) comprises several components:

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

Brake and tyre wear emissions make a substantial contribution to road traffic PM emissions, particularly for PM_{10}. The Emissions Factor Toolkit (see above) includes an allowance for brake and tyre wear emissions for both PM_{10} and $PM_{2.5}$, based on the UK National Atmospheric Emissions Inventory. Whilst the resuspension component is also widely considered to be important, at this stage there are no robust data upon which to base PM emission rates.

It is important to note that the current version of the DMRB model does not account for brake and tyre wear PM emissions. Where predicted concentrations are well below[16] the standard/limit value this is unlikely to be a significant issue; in all other circumstances brake and tyre wear emissions should be taken into account using appropriate emission factors and detailed dispersion modelling.

Model Verification

Models selected for use in the assessment of national road schemes should be fit for purpose and should have some form of published validation assessment available, preferably within the peer-reviewed press. However, the validation reports prepared by the model developers are unlikely to be specific to the assessment area being considered and a comparison between modelled concentrations and local monitoring data should be carried out. This process is referred to as model verification and should be carried out for all dispersion modelling studies for the EIS.

Discrepancies between modelled and measured concentrations may arise for a number of reasons, depending on the model being used, for example:

- uncertainties in traffic data (flows, speeds, vehicle mix);
- emission factors assumed for each vehicle type;
- assumptions regarding background concentrations;
- meteorological data;
- model input parameters (e.g. roughness length, minimum Monin-Obukhov length etc.) and
- model parameters that are fixed, e.g. initial dispersion, but which may in practice vary according to local conditions.

In all cases, every attempt should be made to minimise any discrepancies. This may involve further scrutiny of the model input assumptions, or the parameterisation of the model itself. Where discrepancies remain, the model should be adjusted to account for any systematic errors. The EIS should provide full details of the model verification process and explicitly define any adjustment factors that have been used. Further guidance on model verification is provided in Appendix 3 of LAQM.TG(09).

[16] Well below can be taken to be <75% of the relevant standard

A4.3 Model Input Data

All dispersion models require a variety of input data to be provided. The quality of these input data largely determines the output of the model and it is important that due consideration is given to the sources and accuracy of these data. The specific requirements for input data and the manner in which they are treated are dependent upon the model being used, but some issues and considerations are common and are discussed below.

Background pollutant concentrations: Dispersion models only directly account for those sources that are explicitly included within the model (for example, the local road network). It is therefore usually necessary to account for emissions arising from other sources by including the local background contribution. This local background may represent a significant or dominant proportion of the total pollutant concentration and it is thus important that careful consideration is given to background levels and how they may change in future years.

Information on local background concentrations may be derived from the baseline survey completed for the Route Selection Report or the EIS and is further discussed in Appendix 2. For the purpose of the road scheme assessment, it should be assumed that pollutant concentrations will decline in future years as a result of various initiatives to reduce emissions both in Europe and Ireland. An approach to adjusting current year background pollutant concentrations to a future year is set out in Appendix 5.

Receptor locations: Selected receptors should include relevant locations where the impact of the scheme is expected to be greatest because of significant changes in traffic conditions. The specific receptor locations should be described in detail, providing grid references (6 figures), distances from the road and height. As pollutant concentrations decline rapidly with increasing distance from the road, receptors within 20 metres of the road centreline should be measured as accurately as possible, preferably to the nearest 1 metre. Wherever possible, the use of GIS systems to record and display data is strongly encouraged. The assessment should also take account of receptors where there is an expected improvement to air quality due to the scheme, for example, where traffic is relieved on an existing road.

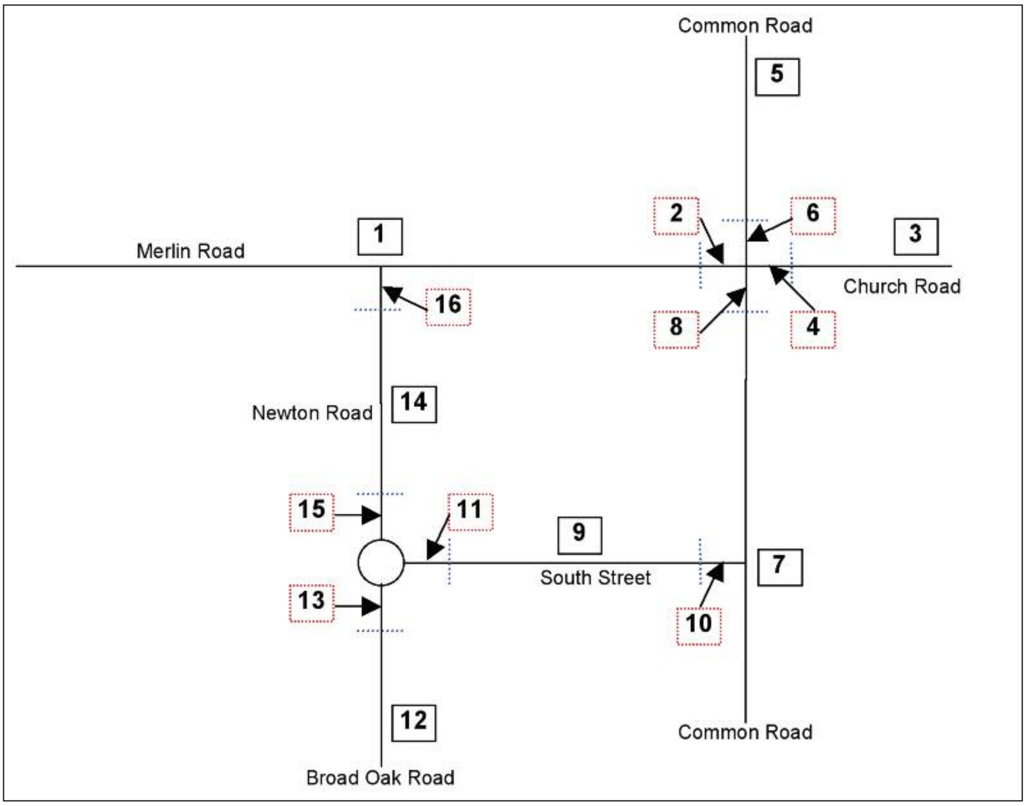
Junctions and congested traffic: Consideration should be given to sections of road where emissions may be higher, for example, due to congested traffic or road junctions. There is no widely-accepted approach to doing this, but one simple method is to reduce the traffic speed close to junctions or in congested areas e.g. for modelling traffic emissions at junctions, an annual average traffic speed of between 20 and 40 kph should be assumed from a point 50 metres from the yield/stop line to the yield/stop line itself. This will model the slowing of vehicles approaching the junction[17] . Where schemes involve the modification of traffic movements at junctions, the use of micro-simulation traffic models (and associated emissions models) should be potentially considered and close liaison between traffic engineers and the air quality specialist is encouraged.

Road links: The road network should be divided into separate links, describing sections of road where traffic conditions are homogenous (in terms of traffic composition, speed, and flow). Care should be taken to assign an appropriate number of road links particularly where there are sensitive receptors in close proximity to the road. An example of how links may be represented

[17] This approach will only provide an approximation, as the emission rates are defined as a function of the average speed across a defined driving cycle In addition, this approach cannot directly account for accelerating and decelerating vehicles.

is set out in Figure A4.1 below. Further examples of how complex junctions should be treated can be found in paragraph 3.23 of the DMRB Volume 11.

Figure A4.1: An example of how links can be represented. Circles represent receptors and squares the links.



Road Link		AADT	%HCV	Speed (kph)
Merlin Road	1	20,000	15.1	85
	2	20,000	15.1	30
Church Way	3	15,000	11.6	80
	4	15,000	11.6	30
Common Road	5	7,900	5.2	50
	6	7,900	5.2	30
	7	9,300	7.4	50
	8	9,300	7.4	30
South Street	9	6,300	2.2	50
	10	6,300	2.2	30
	11	6,300	2.2	40
Broad Oak Road	12	5,100	7	60
	13	5,100	16	40
Newton Road	14	4,300	15	50
	15	4,300	12	40
	16	4,300	5	30

The links near junctions extend 50 m back from the junction.

A4.4 DMRB Screening Model

The Design Manual for Roads and Bridges (DMRB) screening model provides a simple and straightforward means of predicting pollutant concentrations associated with road traffic emissions. The method is not intended to provide accurate predictions of air quality, but it is a suitable approach in circumstances where the predicted environmental concentrations (i.e. ambient background + predicted concentration) lie sufficiently below the air quality standards (taken to be <90% of the standard), and where there are no complex or unusual features (e.g. Grade Separated Junctions, road links with gradients >2.5%) of the scheme.

The approach is therefore suited to the **Route Selection** and the **Environmental Impact Assessment Phases** provided that the above criteria are met. Where predicted concentrations approach or exceed the air quality standards/limit values, or where there are any complex or unusual features of the scheme, a detailed air quality modelling assessment must be carried out.

However, as previously stated in Section 1.1, at the time of preparing this document the UK Highways Agency was undertaking a major revision to the DMRB model. This revision will take account of the new emissions factors published by the UK Department for Transport and the revised NO_x:NO_2 calculator published by Defra and will allow the calculations to be performed in GIS. It is expected that the revised DMRB model will be available in mid-2011. If necessary, these Guidelines will be further updated to reflect the revised DMRB model. While use of the current DMRB model is not discouraged, practitioners should be aware that it does not use the most up-to-date emissions factors and they should apply professional judgment to determine whether a more detailed model should be used. Local verification of the DMRB model should always be undertaken for the EIS.

The DMRB spreadsheet can be downloaded from the UK Highways Agency website[18]. Users are advised to read the instructions for spreadsheet operation contained within paragraphs 3.30 to 3.37 of DMRB Volume 11, Section 3, Part 1 which may also be downloaded[19]. Users should always specify which version of the spreadsheet they are using.

Inputs to the DMRB model – Local impact assessment

The specific input requirements for a local impact assessment are described below:

Background pollutant concentrations: The DMRB model requires the input of annual mean background pollutant concentrations. The approach described in Section A4.3 above should be followed.

Receptor locations: Selected receptors should include relevant locations where the impact of the scheme is expected to be greatest because of significant changes in traffic conditions. The assessment should also take account of receptors where there is an expected improvement to air quality due to the scheme. As set out above (Section A4.3), consideration should also be given to junctions or areas of congested traffic.

[18] http://www.standardsforhighways.co.uk/guidance/air-quality.htm
[19] http://www.standardsforhighways.co.uk/dmrb/index.htm

Road network: The assessment should include all roads expected to make a significant contribution to air quality. In practice, it should not be necessary to include any road more than 100 metres away from a sensitive receptor.

Road type and Traffic data: The DMRB spreadsheet allows selection of three broad categories of road (category A = Motorways and 'A' roads; category B = other urban roads; category C = other roads; category D = detailed breakdown of vehicle categories). This classification is used to derive the vehicle composition in each category and is based on categories within the UK National Atmospheric Emissions Inventory (NAEI). Wherever possible, category D should be selected, which allows the user to input precise details of the traffic composition. The model also requires annual average speed as an input parameter, which may have a significant impact on the predicted results. Wherever possible, actual or expected speeds should be used rather than simply choosing the speed limit for the road.

Road links: the road network should be divided into separate links, as described in Section A4.3 above.

Output of the DMRB Model

The DMRB model predicts annual mean concentrations of NO_x and PM_{10}. It is important to ensure that the approach set out in A4.2 above should be used to calculate annual mean NO_2 concentrations from the predicted annual mean NO_x values, rather than the NO_2 concentrations predicted directly by the current version of DMRB. The model also predicts the number of days with PM_{10} concentrations above 50 $\mu g/m^3$ based on the relationship described in Section A4.3.

It is currently not possible to directly predict concentrations of $PM_{2.5}$ using the DMRB model, as there current version does not include $PM_{2.5}$ emission factors, and so an interim approach is recommended. The Airborne Particles Expert Group (APEG, 1999) suggested a $PM_{2.5}$ to PM_{10} ratio of 0.8 for non-catalyst petrol vehicles and 0.9 for all other vehicles. The current DMRB database shows that non-catalyst petrol vehicles comprised only 4% of the UK vehicle fleet in 2008[20], gradually declining in years thereafter. It is not practicable to apply different $PM_{2.5}$ ratios to different vehicle types, but given the small number of non-catalyst petrol vehicles on the road, this is unlikely to introduce any significant error. A worst-case approach should be taken, assuming a 0.9 ratio for all vehicles is applied. To estimate $PM_{2.5}$ concentrations, the predicted road PM_{10} contribution should be factored by 0.9 and then added to the background $PM_{2.5}$ concentration.

A4.2 Detailed Dispersion Models

Where predicted environmental concentrations from the DMRB screening model exceed 90% of the relevant air quality standard, or where there are complex or unusual features of the scheme, a detailed dispersion modelling assessment should normally be carried out. It should be noted that it will usually only be necessary to carry out detailed dispersion modelling in the immediate area of the complex feature, such as a specific junction, and not for the scheme as a whole, although many practitioners may find it simpler to use a single approach for the scheme assessment.

[20] This includes the predicted fraction of the fleet with failed catalysts.

In addition, for situations where background pollutant levels are very low and it can be demonstrated that a number of worst-case assumptions have been included within the assessment, it may be sufficient to rely on the outcome of the screening model, provided concentrations are well within the standards. In such circumstances (i.e., where the DMRB is used in complex situations with low backgrounds) an upper limit of 75% of the relevant standard is recommended.

The use of a detailed dispersion model will allow the specific characteristics of the scheme to be more accurately represented, for example, the traffic composition, diurnal patterns in flow, local meteorological conditions, topography etc.

There are a range of dispersion models that can be used for the assessment of road schemes and it is not within the scope of this document to advise on the selection of one model or another. However, "new-generation" models that rely on an improved understanding of the boundary layer meteorology are now in common use and are strongly preferred above those models that are based on the more simple Pasquill parameterisations.

The choice of the model is largely dependent upon the road scheme under evaluation, but the following issues need to be taken into consideration:

- road links and receptors – is the model capable of handling all of the receptors and links in the route network?
- terrain – some models are capable of inputting digitised terrain data, but predictions made using this function should be treated with caution and should always be compared with model runs assuming flat terrain;
- bridges and cuttings – some models allow the type of road to be defined, such as bridges, cuttings, embankments, grade separated junctions etc.;
- street canyons – pollutant dispersion is restricted within street canyons. Some models allow canyons to be explicitly considered;
- photochemistry – some models rely on empirical relationships between NO_x and NO_2, whilst others include chemical reaction schemes, and
- compatibility with the air quality standards/limit values – the model should be capable of predicting pollutant concentrations with averaging periods that are directly comparable with the standards.

A justification for the selection of a particular dispersion model should always be provided, setting out, for example, how the features and capabilities of the model are suited to the scheme in question.

It is important to note that a detailed dispersion model will normally only provide improved results over the DMRB method if more detailed and accurate input data are used. Sources of error in dispersion modelling can arise from a number of areas, including the emissions activity data, emissions factors, meteorological data and the model set up parameters. The aim should be to minimise these errors as much as possible, particularly at locations where there are sensitive receptors close by.

Specific issues that may need to be considered in detailed dispersion modelling studies are set out below:

Emission factors: As set out in A4.2 above, vehicle emissions may be derived using the Emission Factor Toolkit (EFT). A disadvantage of the EFT is that is based on the UK fleet composition, which may differ from that in Ireland. Emissions factors may also be derived from the COPERT 4 model developed by Corinair[21]. The model includes speed-dependent emissions equations for a wide range of vehicle types. Whilst this potentially offers a more accurate approach to the estimation of emission rates, it does require the user to provide detailed information of fleet mix, including age of the vehicles, and speeds for each year of assessment. If this detailed information is not available, COPERT 4 may offer little advantage over the EFT approach.

Emissions activity data: Includes traffic flows, speeds and vehicle composition assumed for each of the road links. Traffic data used for dispersion modelling are frequently derived from transport models which may only forecast peak hour flows and speeds, which then need to be adjusted to provide the required input data for the dispersion model. It is important that the approach used for such adjustments is described, or adequately referenced. Where there are any doubts regarding specific traffic data provided by the model, it may be useful to carry out manual counts to confirm the assumptions.

Road geometry and receptor locations: The distance from the road centre line to the receptors is critical to the determination of the predicted concentrations, especially close to the road (see Figures A3.1 and A3.2). Care therefore needs to be taken where road links are represented as straight lines to ensure distances to receptors are correct.

Users may prefer to identify specific receptor locations in the model, or use a regular Cartesian grid if concentration isopleths are to be generated. In all cases, it is recommended that specific receptors are included for all sensitive locations and for any all locations where monitoring data are used for subsequent verification. Where a receptor grid is used, spacing should generally be less than 25 metres and should be to a higher resolution (5 to 10 metres) for any receptors within 50 metres of the road. Some models include "intelligent gridding" in order to place a line of receptors at specified distances from the road edge.

It is also necessary to specify the height of the receptors above the ground. This is usually taken to be 1.5 m. Where modelling for specific monitoring locations, so as to verify the model, the actual height of the intake should be used, for instance, diffusion tubes are often 3 m above the ground.

Complex topography: Some models allow complex topographical features (such as hills and valleys) to be included by the use of digital terrain files. However, it is not normally necessary to consider such effects where the gradient in slope is less than 10%. Additional considerations are:

- is the modelling domain sufficiently extensive to justify the inclusion of terrain effects? Where single route corridors are under evaluation, significant effects are unlikely to extend

[21] COPERT 4 (1999) EMEP CORINAIR Emissions Guidebook, August 2007.

more than several hundred metres from the line of the carriageway. In addition, the resolution of the terrain file (e.g. 100 metres) may not be sufficient to reflect terrain changes over such small distances, and

- what level of detail does the model use for terrain modelling? Some models interpolate terrain files to a lower resolution to reduce model run times.

Street canyons: Models designed for the treatment of street canyons aim to calculate the zone of recirculation of wind flow. Wind direction and speed data are used to determine where, and how large this recirculation zone is. Pollutant concentrations within this recirculation zone are considered to be homogenous by many models such as OSPM.

There is no strict definition of a "street canyon" but it can be considered as a relatively narrow road with buildings on both sides, where the height of the buildings is greater than the width of the road. Street canyons are normally confined to urban areas, and are unlikely to be considered in most national road scheme assessments.

Meteorological data: Most detailed dispersion models require the user to input a suitable meteorological dataset. These data are available from an increasing number of sources including the Irish Meteorological Office. In most cases, the user should select the nearest meteorological site to the study area, but account should be taken of any local effects that may make the data unsuitable, for example, coastal effects, complex topography etc. Wherever possible, the year of meteorological data should correspond with the year of monitoring data that is used for the subsequent model verification. Various studies have demonstrated that year-to-year variations in local meteorology affect predicted annual mean concentrations by no more than about 15%.

It is important that full details of the meteorological data used are reported. This includes the location of the meteorological recording site and its relation to the study area (e.g. it is located 10km away to the south east).

Assessment of individual traffic lanes: In certain circumstances it may prove beneficial to assess separate lanes of traffic (moving in different directions). This can be particularly useful where, for example, the characteristics of traffic on one side of the carriageway are different to those on the other, or where there are wide roads with physically separated lanes (such as dual-carriageways).

Road gradients: Roads with gradients can affect pollutant emissions, particularly from HDVs. It is not normally necessary to consider any changes in emissions from passenger cars and LDVs. Emission factors associated HDVs on gradients have been published in the COPERT 4 model, and an approach to dealing with gradients is set out in LAQM.TG(09) (A2.19 – A2.30).

It is not normally necessary to consider gradient effects where the number of HDVs ascending and descending the hill are approximately equal and the gradient is less than 2.5%.

Cold starts: Under circumstances where road links may be associated with a significant proportion of vehicles running with cold engines, it will be necessary to account for the excess emissions associated with these "cold start" movements. Such considerations are only likely to apply within urban or suburban areas and in most circumstances are unlikely to affect assessments for national road schemes,

Cold start models based on the TRAMAQ EXEMPT model are available to download at http://laqm1.defra.gov.uk/review/tools/emissions.php. Guidance on the use of these spreadsheet tools can be found in LAQM.TG(09), A2.31-A2.36.

Sensitivity Testing: Detailed dispersion models require parameterisation of a number of factors, such as the Monin-Obukhov length, the surface roughness and the emissions source height. These parameters tend to have a much smaller impact on predicted concentrations than, for example, variations in the emissions activity data, but users may wish to carry out sensitivity tests using a range of parameters at a limited number of receptor locations, especially where concentrations are close to or above a standard. In all cases the parameters used should be clearly set out in the EIS.

APPENDIX 5: FUTURE YEAR PROJECTIONS OF MONITORING DATA

A5.1 Introduction

In many cases it will be necessary to consider how measured pollutant concentrations may change in future years. In the previous version of the Guidelines, reference was made to the Year Adjustment Calculator published by Defra. This calculator is no longer available and has been replaced by 1x1km background maps for each year. These maps do not cover Ireland and it is therefore necessary to adopt a modified approach.

The Year Adjustment Calculator was based on averaging the mapped background concentrations across the UK and then deriving correction factors for each future year based on forecast changes in pollutant emissions. In order to provide correction factors for measured background concentrations in Ireland, the 1x1km mapped concentrations have been averaged for each year across Northern Ireland. This is likely to improve the accuracy of the future predictions as compared to the previous method. In addition, correction factors that can be applied to measured $PM_{2.5}$ concentrations are also now included.

The above approach cannot be used to adjust measured roadside NO_2 concentrations due to the differing proportions of primary NO_2 emissions that were assumed in each year. Year adjustment factors for roadside NO_2 concentrations are based on those published in LAQM.TG(09) and have been calculated separately based on the average of approximately 7,000 road links across the UK taking into account the changes in traffic activity and emissions factors for NO_x and primary NO_2 (f-NO_2)[22].

A5.2 Approach

To adjust measured background annual mean concentrations of either NO_x or NO_2, PM_{10} or $PM_{2.5}$ forwards to a future year, the correction factors shown in Boxes A5.1 to A5,4 should be used. In years beyond 2020, it should be assumed that there will be no further reduction in pollutant concentrations.

[22] f-NO_2 is the fraction of the NO_x emissions present as NO_2.

Box A5.1: Correction factors to estimate annual average NO_x concentrations in future years from measured data at background sites

Year	Correction factor to be applied
2008	1.000
2009	0.929
2010	0.858
2011	0.823
2012	0.787
2013	0.752
2014	0.716
2015	0.681
2016	0.653
2017	0.626
2018	0.599
2019	0.572
2020	0.544

Example

Correction of measured background NO_x concentrations: The measured NOx concentration at a background site in 2009 is 55.2 $\mu g/m^3$. The corrected concentration for 2012 would then be 55.2 x (0.787/0.929) = 45.0 $\mu g/m^3$

Box A5.2: Correction factors to estimate annual average NO_2 concentrations in future years from measured data at background sites

Year	Correction factor to be applied
2009	1.000
2009	0.932
2010	0.864
2011	0.829
2012	0.795
2013	0.761
2014	0.726
2015	0.692
2016	0.665
2017	0.638
2018	0.610
2019	0.583
2020	0.556

Example
Correction of measured background NO_2 concentrations: The measured NO_2 concentration at a background site in 2009 is 35.2 μg/m^3. The corrected concentration for 2012 would then be 35.2 x (0.795/0.932) = 30.0 μg/m^3

Box A5.3: Correction factors to estimate annual average PM_{10} concentrations in future years from measured data at background sites

Year	Correction factor to be applied
2009	1.000
2009	0.981
2010	0.962
2011	0.955
2012	0.948
2013	0.940
2014	0.933
2015	0.926
2016	0.921
2017	0.916
2018	0.910
2019	0.905
2020	0.900

Example
Correction of measured background PM_{10} concentrations: The measured PM10 concentration at a background site in 2009 is 22.5 μg/m^3. The corrected concentration for 2012 would then be 22.5 x (0.948/0.981) = 21.7 μg/m3

Note: It is no longer necessary to take direct account of the different contributions of primary and secondary PM_{10} in future years, as this has already been included in the background maps for each year, and consequently within the above correction factors.

Box A5.4: Correction factors to estimate annual average $PM_{2.5}$ concentrations in future years from measured data at background sites

Year	Correction factor to be applied
2009	1.000
2009	0.973
2010	0.945
2011	0.935
2012	0.924
2013	0.914
2014	0.903
2015	0.893
2016	0.885
2017	0.878
2018	0.870
2019	0.862
2020	0.855

Example
Correction of measured background $PM_{2.5}$ concentrations: The measured $PM_{2.5}$ concentration at a background site in 2009 is 16.2 µg/m3. The corrected concentration for 2012 would then be 16.2 x (0.924/0.973) = 15.4 µg/m^3

To adjust measured roadside annual mean concentrations of NO_2 forwards to a future year, the correction factors in Box A5.5 should be used

Box A5.5: Correction factors to estimate annual average NO concentrations in future years from measured data at roadside sites

Year	Correction factor to be applied
2009	1.000
2009	0.965
2010	0.921
2011	0.886
2012	0.850
2013	0.816
2014	0.781
2015	0.745
2016	0.716
2017	0.684
2018	0.653
2019	0.624
2020	0.582

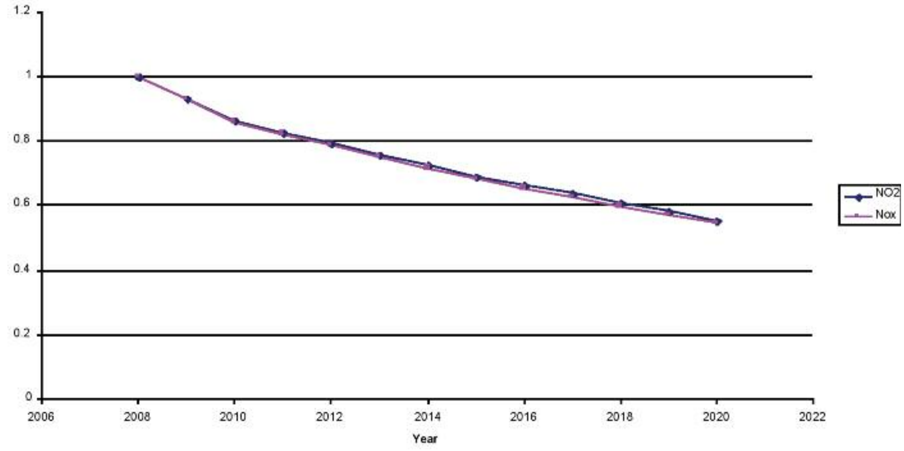
Example
Correction of measured roadside NO_2 concentrations: The measured NO_2 concentration at a roadside site in 2009 is 59.2 µg/m3. The corrected concentration for 2012 would then be 59.2 x (0.850/0.965) = 52.1 µg/m3

Roadside locations are typically within 1 to 5 metres of the kerbside, but may extend up to 15 metres depending upon the configuration and traffic flow.

APPENDIX 6: TRENDS IN NO_x AND NO_2 CONCENTRATIONS

The “year adjustment factors” described in Appendix 5 indicate that concentrations of both NO_x and NO_2 are forecast to decline sharply in future years up to 2020, principally as a result of more stringent emissions standards for vehicles. The year adjustment factors set out in Boxes A5.1 and A5.2 are illustrated in Figure A6.1 below.

Figure A6.1: Forecast reductions in background NO_x and NO_2 concentrations relative to a 2008 base year



However, analyses of historical monitoring data across the UK have identified a disparity between the measured concentrations and the predicted decline in concentrations associated with the emissions forecasts. Similar disparities have also been reported from a number of other European member states, including Ireland, as set out below.

Measured NO_x and NO_2 concentrations at monitoring sites in the EPA network with more than 5 years data have been examined to inform these Guidelines. The following sites were considered:

- Rathmines (Urban Background)
- Ballyfermot (Suburban Background)
- Glashaboy (Rural Background)
- Killkit (Rural Background)
- Colleraine St (Urban Traffic)
- Winetavern St (Urban Traffic)
- Old Station Road (Urban Traffic)

There are inevitably differences between individual sites. For ease of comparison, the data are plotted in Figures A6.2 and A6.3 as averages across background and roadside (traffic) sites separately. At traffic sites, NOx concentrations appear to have been increasing, particularly over the period since 2004, whilst at background sites there is only evidence of a very weak downward trend. For NO_2, concentrations have increased slightly at traffic sites and remained constant at background sites.

Figure A6.2: Trends in annual mean NO_x concentrations averaged across 4 background and 3 traffic sites (2002 – 2009)

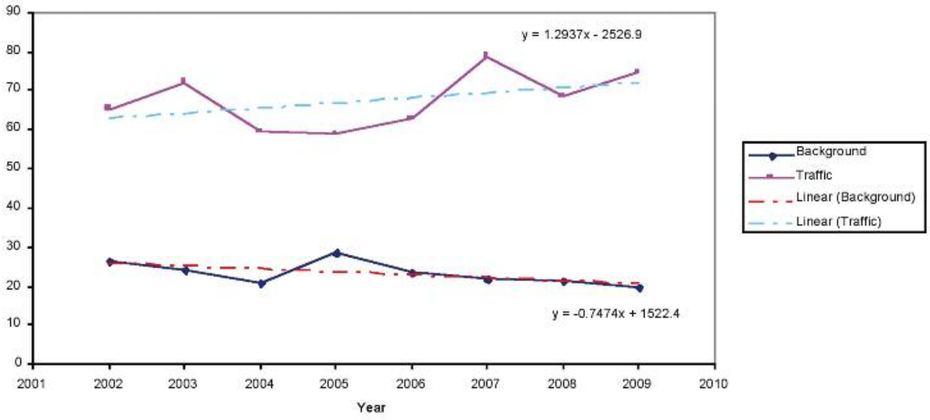
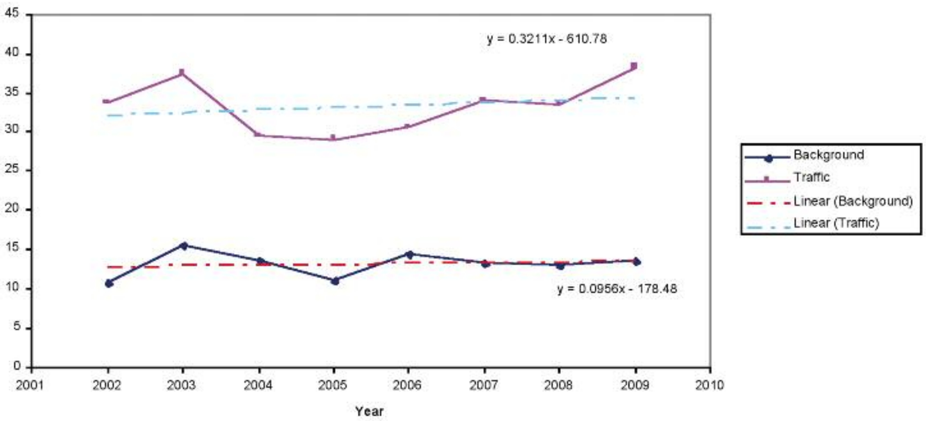


Figure A6.3: Trends in annual mean NO_2 concentrations averaged across 4 background and 3 traffic sites (2002 – 2009)



Overall, there is no evidence of a consistent downward trend in either NO_x or NO_2 concentrations that would be suggested by the emissions inventory estimates.

The precise reason for this disparity is not fully understood, but is thought to be related to the actual on-road performance of diesel road vehicles when compared with the calculations based on the Euro standards. Some preliminary studies have indicated that NO_x emissions from petrol-engined vehicles have declined as expected, but that emissions from diesel-engined cars under urban driving conditions have not declined substantially, up to and including Euro 5; there is limited evidence from UK data that the same pattern may occur under high speed (motorway) driving conditions[23].

This disparity in the historical data highlights potential uncertainties for future-year projections of NO_x and NO_2 concentrations and for the emissions factors that are included in the DMRB model and the Emissions Factor Toolkit. These preliminary findings would suggest that the Euro standards will deliver only marginal, if any, reductions in NO_x and NO_2 concentrations until the

[23] It is important to note that the analysis of data from the Irish networks only includes traffic sites in urban environments.

Euro 6 emissions standards begin, as is currently forecast, to play a major role (circa post-2015). However, at this stage there is no robust evidence upon which any revised road traffic emissions projections can be based.

APPENDIX 7 IMPACTS AT NATIONAL/INTERNATIONAL LEVEL

A7.1 DMRB 'Regional Impact' Assessment

The Design Manual for Roads and Bridges (DMRB) spreadsheet model provides a straightforward means of calculating total pollutant emissions across the route network.

The DMRB spreadsheet can be downloaded from the Highways Agency website[24]. Users are advised to read the instructions for spreadsheet operation contained within paragraph 3.33 of DMRB Volume 11, Section 3, Part 1 which may also be downloaded[25]. As set out in Section 1, at the time of preparing these revised Guidelines, the UK Highways Agency was undertaking a major revision to the Design Manual for Roads and Bridges (DMRB) model to take account of the new emissions factors published by the UK Department for Transport. It is expected that the revised DMRB model will be available in mid-2011. If necessary, these Guidelines will be further updated to reflect the new DMRB model.

The data inputs for the wider-scale assessment using the DMRB model are effectively the same as those required for the local scale assessment (described in Appendix 4). The following issues should be carefully considered:

- all roads within the affected network should be included in the assessment, and
- the network should be divided into road links at a suitable level of detail to accurately reflect speeds and flows along different sections.

[24] http://www.highways.gov.uk/business/238.aspx
[25] http://www.archive2.official-documents.co.uk/document/deps/ha/dmrb/index.htm

APPENDIX 8: ASSESSMENT OF CONSTRUCTION IMPACTS

It is very difficult to accurately quantify dust emissions arising from construction activities. It is thus not possible to easily predict changes to dust soiling rates or PM_{10} concentrations. A semi-quantitative approach is recommended to determine the likelihood of a significant impact, which should be combined with an assessment of the proposed mitigation measures. The distance criteria set out in Box A8.1 can be used to assist this semi-quantitative assessment.

Box A8.1: Assessment Criteria for the Impact of Dust Emissions from Construction Activities, with Standard Mitigation in Place

Source		Potential Distance for Significant Effects (Distance from source)		
Scale	**Description**	**Soiling**	**PM_{10} a**	**Vegetation effects**
Major	Large construction sites, with high use of haul routes	100 m	25 m	25 m
Moderate	Moderate sized construction sites, with moderate use of haul routes	50 m	15 m	15 m
Minor	Minor construction sites, with limited use of haul routes	25 m	10 m	10 m

[a] Significance based on the 2005 standard, which allows 35 daily exceedences/year of 50 µg/m³

APPENDIX 9: IMPACTS UPON SENSITIVE ECOSYSTEMS

A9.1 Introduction

Readers are referred, *inter alia*, to the NRA's *Guidelines for Assessment of Ecological Impacts of National Road Schemes* (Rev. 2, National Roads Authority, 2009) and to *Appropriate Assessment of Plans and Projects in Ireland – Guidance for Planning Authorities* (Department of the Environment, Heritage and Local Government, 2010) for details regarding the regime governing the legal protection of designated conservation areas.

The Ecologist will be undertaking the assessment of impacts on sensitive ecological sites, and the Air Quality specialist should therefore liaise with the Ecologist to assist in this process from an Air Quality perspective.

The NRA requires the Air Quality Specialist to liaise with the Ecologist on all schemes where there is a designated conservation area, including a European site, within 2 km of the route corridor. However, as the potential impact of a scheme is limited to a local-scale assessment, detailed consideration need only be given to roads where there is a significant change to traffic flows (>5%) and the designated site lies within 200 m of the road centre line.

A9.2 Route Selection

Where there is a significant change to traffic flows (>5%) and the designated site lies within 200 m of the road centre line, the assessment at the Route Selection stage will involve a calculation of nitrogen oxides (NO_x) concentrations and nitrogen deposition.

The calculation of NO_x concentrations may be carried out using the DMRB screening approach described in Appendix 4. Concentrations should be predicted at 10 m intervals within the designated site in a transect up to 200 m from the road, for both the current year and the opening year, with and without the scheme. Predicted concentrations should be compared with the air quality standard for the protection of vegetation (30 $\mu g/m^3$) and the incremental change due to the proposed scheme identified.

Where the scheme is expected to cause an increase in concentrations of more than 2 $\mu g/m^3$ and the predicted concentrations (including the background) are close to (within 10% of), or exceed the standard, then the sensitivity of the habitat to NO_x should be assessed by the project Ecologist.

The process described above is repeated, but for the calculation of nitrogen dioxide concentrations. The dry deposition of nitrogen (from nitrogen dioxide) may then be calculated assuming a deposition velocity of 0.001 m/s using the following:

$$1\ \mu g/m^3\ NO_2 = 0.1\ kg\ N\ ha^{-1}\ yr^{-1}$$

The road contribution to dry deposition should then be calculated and compared with the published critical loads for the selected habitat (see Table A9.1). The change in deposition due to the scheme should be assessed in relation to the relevant critical load by the project Ecologist.

Table A9.1: UNECE (2003) Critical Loads for Nitrogen

Ecosystem type	Kg(N)/ha/yr	Reliability and indication of exceedence effects
Forest habitats		
Temperate and boreal	10-20	# Changes in soil processes, ground vegetation, mychorrhiza, increased risk of nutrient imbalances and susceptibility to parasites
Heathland, scrub and tundra habitats		
Tundra	5-10 [a]	# Changes in biomass, physiological effects, changes in species composition in moss layer, decrease in lichens
Arctic, alpine and subalpine scrub habitats	5-15 a	(#) Decline in lichens, mosses and evergreen shrubs
Northern wet heath • 'U' Calluna dominated wet heath (upland moorland) • 'L' *Erica tetralix* dominated wet heath	10-20 10-25 [a,b]	(#) Decreased heather dominance, decline in lichens and mosses (#) Transition heather to grass
Dry heaths	10-20 [a,b]	## Transition heather to grass, decline in lichens
Grassland and tall forb habitats		
Sub-Atlantic semi-dry calcareous grassland	15-25	## Increase tall grasses, decline in diversity, increased mineralization, N leaching
Non-Mediterranean dry acid and neutral closed grassland	10-20	# Increase in graminoids, decline typical species
Inland dune pioneer grasslands	10-20	(#) Decrease in lichens, increase biomass
Inland dune siliceous grasslands	20-30	(#) Increase in tall grasses, decrease in diversity
Mountain hay meadows	10-20	(#) Increase in nitrophilous graminoids, changes in diversity
Moist and wet oligotrophic grasslandsMoist and wet oligotrophic grasslands • *Molinia caerulea* meadows • Heath (*Juncus*) meadows and humic (*Nardus stricta*) swards	15-25 10-20	(#) Increase in tall graminoids, decreased diversity, decrease of bryophytes # Increase in tall graminoids, decreased diversity, decrease of bryophytes
Alpine and subalpine grasslands	10-15	(#) Increase in nitrophilous graminoids, biodiversity change
Moss and lichen dominated mountain summits	5-10	# Effects upon bryophytes or lichens
Mire, bog and fen habitats		
Raised and blanket bogs	5-10 [a,c]	## Change in species composition, N saturation of Sphagnum
Poor fens	10-20	# Increase sedges and vascular plants, negative effects on peat mosses
Rich fens	15-35	(#) Increase tall graminoids, decrease diversity, decrease of characteristic mosses
Mountain rich fens	15-25	(#) Increase vascular plants, decrease bryophytes

Ecosystem type	Kg(N)/ha/yr	Reliability and indication of exceedance effects
Inland and surface water habitats		
Permanent oligotrophic waters • Softwater lakes • Dune slack pools	5-10 10-20	## Isoetid species negatively affected (#) Increased biomass and rate of succession
Coastal habitat		
Shifting coastal dunes	10-20	(#) Biomass increase, increase N leaching
Coastal stable dune grassland	10-20	# Increase tall grasses, decrease prostrate plants, increased N leaching
Coastal dune heaths	10-20	(#) Increased plant production, increase N leaching, accelerated succession
Moist to wet dune slacks	10-25	(#) Increased biomass, tall graminoids
Marine habitats		
Pioneer and low-mid salt marshes	30-40	(#) Increased late-successional species, increase productivity

Reliability key: ## reliable, # quite reliable, (#) expert judgement

a Use towards high end of range at phosphorus limitation, and towards lower end if phosphorus is not limiting

b Use towards high end of range when sod cutting has been practiced, use towards lower end of range with low intensity management

c Use towards high end of range with high precipitation and towards low end of range with low precipitation

A9.3 Environmental Impact Assessment

Depending upon the outcome of the assessment carried out during the Route Selection Phase, a more detailed assessment may be required for the EIS. A more detailed assessment will be carried out as part of the overall ecological assessment.

In particular, where potential problems have been identified, then it is highly likely that local air quality monitoring will be required to support the EIS in order to more accurately determine background concentrations.

APPENDIX 10: Significance criteria

In terms of significance criteria, all sensitive locations for human exposure and for ecosystems are judged to be of 'high sensitivity'.

Criteria to assist in judging the nature of air quality impacts associated with National Road Schemes, and the significance of these impacts were published in the 2006 Guidelines. These criteria have now been updated, based on an approach developed by the Institute of Air Quality Management (IAQM, 2009), and incorporated into Environmental Protection UK's guidance document on planning and air quality (EPUK, 2010). The approach involves three distinct stages: the application of descriptors for magnitude of change; the description of the impact at each sensitive receptor; and then the assessment of overall significance of the scheme.

The definition of ***impact magnitude*** is solely related to the degree of change in pollutant concentrations, expressed in microgrammes per cubic metre, but originally determined as a percentage of the air quality standard or limit value. ***Impact description*** takes account of the impact magnitude and of the absolute concentrations and how they relate to the air quality standards or limit values. The descriptors for the magnitude of change due to the scheme are set out in Box A10.1, while Boxes A10.2 and A10.3 set out the impact descriptors. These boxes have been designed to assist with describing air quality impacts at each specific receptor. They apply to the pollutants relevant to the scheme under consideration and the standards/limit values against which they are being assessed.

Box A10.1: Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations.

Magnitude of Change	Annual Mean NO2/PM_{10}	No. days with PM10 concentration greater than 50 $\mu g/m^3$	Annual Mean $PM_{2.5}$
Large	Increase/decrease ≥4 $\mu g/m^3$	Increase/decrease >4 days	Increase/decrease ≥2.5 $\mu g/m^3$
Medium	Increase/decrease 2 - <4 $\mu g/m^3$	Increase/decrease 3 or 4 days	Increase/decrease 1.25 - <2.5 $\mu g/m^3$
Small	Increase/decrease 0.4 - <2 $\mu g/m^3$	Increase/decrease 1 or 2 days	Increase/decrease 0.25 - <1.25 $\mu g/m^3$
Imperceptible	Increase/decrease <0.4 $\mu g/m^3$	Increase/decrease <1 day	Increase/decrease <0.25 $\mu g/m^3$

Box A10.2: Air Quality Impact Descriptors for Changes to Annual Mean Nitrogen Dioxide and PM_{10} and $PM_{2.5}$ Concentrations at a Receptor

Absolute Concentration in Relation to Objective/Limit Value	Change in Concentration [a]		
	Small	Medium	Large
Increase with Scheme			
Above Objective/Limit Value With Scheme (≥40 µg/m³ of NO_2 or PM_{10}) (≥25µg/m³ of $PM_{2.5}$)	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective/Limit Value With Scheme (36-<40 µg/m³ of NO_2 or PM_{10}) (22.5-<25µg/m³ of $PM_{2.5}$)	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value With Scheme (30-<36 µg/m³ of NO_2 or PM10) (18.75-<22.5 µg/m³ of $PM_{2.5}$)	Negligible	Slight Adverse	Slight Adverse
Well Below Objective/Limit Value With Scheme (<30 µg/m³ of NO_2 or PM_{10}) (<18.75µg/m³ of $PM_{2.5}$)	Negligible	Negligible	Slight Adverse
Decrease with Scheme			
Above Objective/Limit Value Without Scheme (≥40 µg/m³ of NO_2 or PM_{10}) (≥25µg/m³ of $PM_{2.5}$)	Slight Beneficial	Moderate Beneficial	Substantial Beneficial
Just Below Objective/Limit Value Without Scheme (36-<40 µg/m³ of NO_2 or PM_{10}) (22.5-<25µg/m³ of $PM_{2.5}$)	Slight Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective/Limit Value Without Scheme (30-<36 µg/m³ of NO_2 or PM_{10}) (18.75-<22.5 µg/m³ of $PM_{2.5}$)	Negligible	Slight Beneficial	Slight Beneficial
Well Below Objective/Limit Value Without Scheme (<30 µg/m³ of NO2 or PM_{10}) (<18.75µg/m³ of $PM_{2.5}$)	Negligible	Negligible	Slight Beneficial

[a] Where the Impact Magnitude is Imperceptible, then the Impact Description is Negligible.

Box A10.3 Air Quality Impact Descriptors for Changes to Number of Days with PM_{10} Concentration Greater than 50 µg/m³ at a Receptor

Absolute Concentration in Relation to Objective/Limit Value	Change in Concentration [a]		
	Small	**Medium**	**Large**
Increase with Scheme			
Above Objective/Limit Value With Scheme (≥35 days)	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective/Limit Value With Scheme (32-<35 days)	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value With Scheme (26-<32 days)	Negligible	Slight Adverse	Slight Adverse
Well Below Objective/Limit Value With Scheme (<26 days)	Negligible	Negligible	Slight Adverse
Decrease with Scheme			
Above Objective/Limit Value Without Scheme (≥35 days)	Slight Beneficial	Moderate Beneficial	Substantial Beneficial
Just Below Objective/Limit Value Without Scheme (32-<35 days)	Slight Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective/Limit Value Without Scheme (26-<32 days)	Negligible	Slight Beneficial	Slight Beneficial
Well Below Objective/Limit Value Without Scheme (<26 days)	Negligible	Negligible	Slight Beneficial

[b] Where the Impact Magnitude is Imperceptible, then the Impact Description is Negligible.

The IAQM guidance is that the assessment of significance should be based on professional judgement, with the overall air quality impact of the scheme described as either, 'insignificant', 'minor', 'moderate' or 'major'. In drawing these conclusions, the factors set out in Box A10.4 should be taken into account. The experience of the air quality specialist in making this professional judgment should be clearly set out in line with the requirements specified in Section 1.4 of these Guidelines.

Box A10.4 Factors Taken into Account in Determining Air Quality Significance

Factors
Number of people affected by increases and/or decreases in concentrations and a judgement on the overall balance.
The number of people exposed to levels above the objective or limit value, where new exposure is being introduced.
The magnitude of the changes and the descriptions of the impacts at the receptors i.e. using the findings based on Boxes A8.1, A8.2 and A8.3.
Whether or not an exceedence of a standard or limit value is predicted to arise in the study area where none existed before or an exceedence area is substantially increased.
Whether or not the study area exceeds a standard or limit value and this exceedence is removed or the exceedence area is reduced.
Uncertainty, including the extent to which worst-case assumptions have been made
The extent to which a standard or limit value is exceeded, e.g. an annual mean NO_2 of 41 $\mu g/m^3$ should attract less significance than an annual mean of 51 $\mu g/m^3$

APPENDIX 11: DERIVATION OF REGIONAL BACKGROUND CONCENTRATIONS FOR THE NO_x:NO_2 MODEL

A11.1 Introduction

A new approach to calculating NO_2 from NO_x concentrations is set out in Section A4.2. The approach has been incorporated into an Excel spreadsheet calculator that allows the calculation of NO_2 from NO_x and vice versa.

The approach requires the user to input regional background concentrations of O_3, NOx and NO_2, adjusted, if necessary, to the assessment year. Whist these values can be derived from local monitoring stations, it is critical that the concentrations for each pollutant are obtained from the same monitoring site, in the same year. There is also no straightforward way to forecast future concentrations of O_3.

To overcome this limitation, use is made of regional background concentrations of O_3, NO_x and NO_2 that have been mapped across the UK on a 5 x 5 km grid basis for each year up until 2020. These mapped values have been averaged for individual UK local authority areas. In the UK, users of the NO_x:NO_2 converter can thus assign default regional background concentrations by simply selecting the appropriate local authority area from a drop-down menu.

A recommendation for how this simple approach might be used in Ireland is set out below.

A11.2 Adaption of the Approach for Ireland

The 2009 estimated O_3, NOx and NO_2 concentrations for all local authorities in Northern Ireland are shown in Table A11.1. The average values across Northern Ireland were 66.5 $\mu g/m^3$ (O_3), 5.1 $\mu g/m^3$ NOx and 3.9 $\mu g/m^3$ NO_2. These average values are reasonably well represented by Craigavon and it is recommended that users of the calculator select this local authority to assign the default regional background concentrations when using the calculator.

Table A11.1 Regional background pollutant concentrations assigned to local authorities in Northern Ireland, µg/m^3 (2009).

Local Authority	O_3	NO_x	NO_2
Fermanagh	67.4	3.6	2.9
Omagh	67.2	3.9	3.0
Dungannon	67.0	4.2	3.3
Strabane	67.3	3.7	2.9
Derry	66.7	4.6	3.6
Limavady	67.2	3.9	3.1
Armagh	67.0	4.4	3.4
Newry and Mourne	66.9	4.4	3.4
Banbridge	66.7	4.8	3.7
Down	66.9	4.5	3.4
Lisburn	65.9	6.1	4.6
Craigavon	66.5	5.1	3.8
Cookstown [a]	**67.1**	**4.1**	**3.2**
Magherafelt	67.0	4.2	3.3
Coleraine	67.1	4.1	3.2
Ballymena	66.9	4.6	3.4
Moyle	67.5	3.7	2.8
Larne	67.0	4.5	3.4
Carrickfergus	65.8	6.3	4.7
Newtownabbey	65.4	6.9	5.1
Belfast	62.4	12.0	8.6
North Down	64.9	7.7	5.7
Ards	66.6	4.9	3.7
Castlereagh	65.0	7.5	5.6
Ballymoney	67.2	4.1	3.1
Average	**66.5**	**5.1**	**3.9**

[a] Concentrations for this local authority most closely represent the Northern Ireland average.