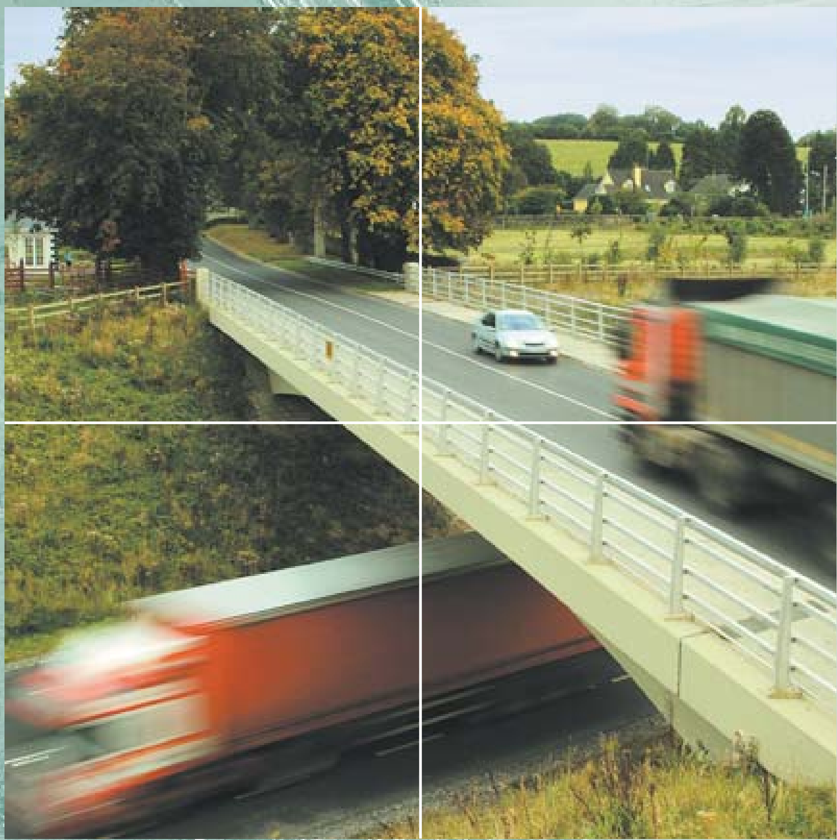

NATIONAL ROADS AUTHORITY

Draft Guidelines for the Treatment of Noise and Vibration in National Road Schemes

NRA
National Roads Authority
An tÚdarás um Bóithre Náisiúnta

Contents

ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

1.1 Background

The purpose of this document is to provide guidance on the treatment of noise and vibration during the planning and design of national road schemes. The guidelines are not mandatory but are recommended to achieve appropriate consistency and standards in respect of noise and vibration input into the Constraints Study, Route Corridor Selection and the Environmental Impact Statement.

There are currently no Irish standards governing the assessment of noise and/or vibration associated with either new or existing roads.

Road traffic noise is considered in Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 *relating* to the *assessment* and *managemen*t of *environmental noise*. This Directive deals mainly with strategic noise mapping and noise management action plans, although it does touch upon noise indicators and prediction methodologies. Furthermore, the Directive does place certain obligations upon Member States, in particular Article 5 paragraph 4, which states:

> "No later than 18 July 2005, Member States shall communicate information to the Commission on any relevant limit values in force within their territories or under preparation …… for road-traffic noise, rail-traffic noise, aircraft noise around airports and noise on industrial activity sites, together with explanations about the implementation of the limit values."

Article 77 of the Roads Act (1993) deals with noise. It outlines the powers of the Minister to make regulations in respect of noise limits, measurement and mitigation. No specific guidance in respect of noise is contained within the Roads Act.

1.2 National Roads Project Management Guidelines

The procedures followed by the National Roads Authority and local authorities in the planning, design and implementation of road schemes are specified in the Roads Act (1993) and the National Roads Project Management Guidelines (NRPMG).

The Roads Act requires the preparation of an Environmental Impact Statement for certain types of road schemes and, following a period of public consultation, submission of the EIS to An Bord Pleanala for consideration.

Public consultation is catered for at a number of stages in the planning process and, as a matter of practice, is generally engaged in as early as is deemed practicable. There are a number of stages to the planning and consultation process as set out in the Authority's NRPMG.

The NRPMG (2000) were prepared to allow a phased approach to developing a major road scheme. For the purposes of this guidance note, three phases of the guidelines are considered: the Constraints Study, Route Corridor Selection and the Environmental Impact Statement. The aim of this guidance note is to provide advice as to the scope of activities as they pertain to each of these three different phases. The activities during each phase of project planning will differ and hence the subsequent input feeding into the Constraints Study, Route Corridor Selection process and the Environmental Impact Statement will also differ.

The noise and vibration input into each of the three phases should not be treated in isolation. The findings arising out of each phase should set the foundation for the next activity and collectively should assist in the final design of the road scheme. The noise and vibration input into the Constraints Study and Route Corridor Selection should concentrate on the avoidance of impacts. The Environmental Impact Statement should describe any further steps taken to avoid impacts and should thereafter consider further mitigation of noise and vibration as necessary.

Noise impacts should be seen in conjunction with engineering constraints and other impacts such as those on the natural environment, socio-economic factors, visual amenity etc. Each Route Corridor Selection process in the country will have unique features and Constraints may vary. In some cases the optimum route from a noise perspective may not be the overall optimum route when other impacts are evaluated. However, noise aspects should receive detailed consideration and indeed in some cases they may constitute one of the most important factors to be addressed during Route Corridor Selection and subsequent design of the road scheme.

1.3 Requirements for an Acoustic Engineer

The assessment of noise for the purposes of these guidelines requires expertise, experience, independence and objectivity. The acoustic engineer 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 acoustic engineer must be capable of assisting with the detailed design of such measures and should have a thorough knowledge of suitable techniques and products. The acoustic engineer should have a knowledge of the relevant standards and legislation that apply to the subject; be familiar with the relevant standards and criteria for evaluation and classification of significance and impacts; be able to interpret the specialised documentation of the construction sector, in so far as it is relevant to matters relating to noise and/or vibration; and be able to clearly and comprehensively present the findings.

The Authority encourages Acoustic Engineers to be able to demonstrate that they have the necessary knowledge and skill through reference to suitable qualifications and/or experience.

The Authority acknowledges that, given the large amount of survey work that is required in support of a noise impact study, it is not reasonable to require that all such work be undertaken by a qualified Acoustic Engineer meeting the above requirements. However, such a person must oversee all aspects of the study and must attend site at appropriate intervals throughout the course of the project.

CHAPTER 2

DESIGN GOALS

2.1 The Purpose of Design Goals

Noise and vibration design goals are required in order to ensure that the current roads programme proceeds on a path of sustainable development. Achieving sustainable development in practice requires that economic growth supports social progress and respects the environment, that social policy underpins economic performance and that environmental policy is cost effective. In devising design goals for national roads the Authority has balanced environmental and economic considerations. With this in mind, the Authority acknowledges that it may be appropriate to adopt different design goals. In addition, there are different design goals for the construction phase of road schemes.

2.2 Noise and Vibration Fundamentals

Given the complexity of the subject, it is appropriate to provide a brief overview of some of the fundamentals relating to noise and vibration.

2.2.1 Noise

Noise is typically defined as "unwanted sound", sound being the human sensation of pressure fluctuations in the air. Sound levels are expressed in decibels (dB) on a logarithmic scale, where 0dB is nominally the "threshold of hearing" and 120dB is nominally the "threshold of pain". Depending upon the circumstances and characteristics of the sound in question, a change in level of 3dB is just perceptible, whereas an increase of 10dB is perceived as a subjective doubling of loudness.

The frequency of sound is the rate at which a sound wave oscillates, and is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. A mechanism known as "A-weighting" has been adopted in order to account for this non-linearity of the human ear. Sound levels expressed using "A-weighting" are typically denoted dB(A). An indication of the level of some common sounds on the dB(A) scale is presented in Figure 1.

The parameter most commonly used for the assessment of noise impact is L_{Aeq}, which is defined as being the A-weighted equivalent continuous steady sound level during the sample period and effectively represents an average value.

The noise level associated with a stream of traffic is not constant but varies from moment to moment. In order to assess the overall noise level produced by traffic, another single-figure index designated $L_{10(18hour)}$ has been employed in the UK and Ireland to date. This measurement parameter is defined as the arithmetic mean of the A-weighted noise levels exceeded for 10% of the time in each of the 18 1-hour periods between 6am and midnight. The established prediction and measurement techniques for this parameter are well developed.

The sources of noise from a traffic stream can be separated into two components. The first is generated by the vehicles themselves and is a function of type, number and speed. The second is related to the road structure – its design, construction, and materials – and is due to the interaction of vehicle tyres with the road surface. The latter component tends to be dominant under freeflow conditions at moderate to high speeds.

2.2.2 Vibration

Vibration may be defined as regularly repeated movement of a physical object about a fixed point. The magnitude of vibration is expressed in terms of Peak Particle Velocity (PPV) expressed in millimetres per second (mm/s).

As a vehicle travels along a road, vibration can be generated in the road and subsequently propagate towards nearby buildings. Such vibration is generated by the interaction of a vehicle's wheels and the road surface and by direct transmission through the air of low frequency energy waves. Some of these waves arise as a function of the size, shape and speed of the vehicle, and others from pressure fluctuations due to engine, exhaust and other noises generated by the vehicle.

2.3 Selection of Design Goals for New Road Schemes

2.3.1 Operational Noise

To date, best practice in Ireland has involved a design goal of 68dB(A) $L_{10(18hour)}$ based on UK guidance[1]. However, this de facto standard has not been enshrined in any form of policy document. The Authority intends to establish design goals having regard to EU Directive 2002/49/EC and the scale of the current road building programme.

At present most EU member states impose traffic noise limits based on an energy average in terms of L_{Aeq}. Only the UK and Portugal employ statistical indicators. Furthermore, there is a move in the EU towards the use of L_{den}, an indicator that is a composite of long term L_{Aeq} values for day, evening and night (termed L_{day}, $L_{evening}$ and L_{night}). The Authority considers that traffic noise limits in Ireland should be based on these preferred EU indicators and in particular L_{den} and L_{night}, these being the indicators specifically referenced in the EU Directive.

Current EU daytime limits typically range from 55 to 65dB L_{Aeq} and night-time limits typically range from 45 to 55dB L_{Aeq}. Most of the limits are given in terms of free field values.

The Authority considers it appropriate to set design goals for Ireland as follows:

- day-evening-night 60dB L_{den} (free field)
- night (23:00hrs to 07:00hrs) 50dB L_{night} (free field)

These design goals represent more onerous limit values than those that have typically been employed in Ireland to date.

These Design Goals are applicable to new road schemes only. In EIS terms, this means that they are to be applied to existing receptors in respect of both the year of opening and the design year (i.e. 15 years after projected year of opening).

Following confirmation of the EIS the issue of noise mitigation for new receptors is a matter for the Planning Authority within the planning legislation.

[1] *The Noise Insulation Regulations 1975*, UK Department of the Environment, S.I. No. 1763 of 1975

The Authority acknowledges that it may not always be sustainable to achieve these design goals. In such circumstances, nevertheless, a structured approach should be taken in order to ameliorate as far as practicable road traffic noise through the consideration of measures such as alignment changes, barrier type (e.g. earth mounds), low noise road surfaces etc.

Directive 2002/49/EC states that mitigation measures should be considered or enforced when limit values are exceeded, but that such limit values may vary depending upon the type of noise and the surrounding environment. It also notes that limit values may be different for existing situations compared with new situations.

Noise mitigation measures are deemed necessary whenever the following three conditions are satisfied:

(a) the combined expected maximum traffic noise level, i.e. the relevant noise level, from the proposed road scheme together with other traffic in the vicinity is greater than the design goal, and;

(a) the relevant noise level is at least 1dB more than the expected traffic noise level without the proposed road scheme in place, and;

(a) the contribution to the increase in the relevant noise level from the proposed road scheme is at least 1dB.

These conditions will ensure that mitigation measures arising out of this process are based upon the impact of the scheme under consideration.

2.3.2 Construction Noise

There is no published Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities should control construction activities by imposing limits on the hours of operation and consider at their discretion noise limits.

The Authority considers that the noise levels in Table 1 are typically deemed acceptable. Note that these values are indicative only; it may be appropriate to apply more stringent limits in areas where pre-existing noise levels are low.

Days & Times	$L_{Aeq\ (1hr)}$ dB	L_{Amax} dB
Monday to Friday 07:00 to 19:00hrs	70	80
Monday to Friday 19:00 to 22:00hrs	60[2]	65[2]
Saturday 08:00 to 16:30hrs	65	75
Sundays and Bank Holidays 08:00 to 16:30hrs	60[2]	65[2]

Table 1: Maximum Permissible Noise Levels At The Façade of Dwellings During Construction

[2] Construction activity at these times, other than that required in respect of emergency works, will normally require the explicit permission of the relevant local authority.

2.3.3 Operational Vibration

It has been found that ground vibrations produced by road traffic are unlikely to cause perceptible structural vibration in properties located near to well-maintained and smooth road surfaces. The Authority does not therefore consider it necessary to set limits for vibration during the operational phase of a road scheme.

2.3.4 Construction Vibration

There is no published Irish guidance relating to vibration during construction activities. Common practice in Ireland has been to use guidance from internationally recognised standards. Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. In both instances, the magnitude of vibration is expressed in terms of Peak Particle Velocity (PPV) in millimetres per second (mm/s).

In the case of nominally continuous sources of vibration such as traffic, vibration is perceptible at around 0.5mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short duration. For example, blasting and piling, two of the primary sources of vibration during construction, are typically tolerated at vibration levels up to 12mm/s and 2.5mm/s respectively. This guidance is applicable to the daytime only; it is unreasonable to expect people to be tolerant of such activities during the night-time.

Guidance relevant to acceptable vibration at the foundation of buildings is contained within:

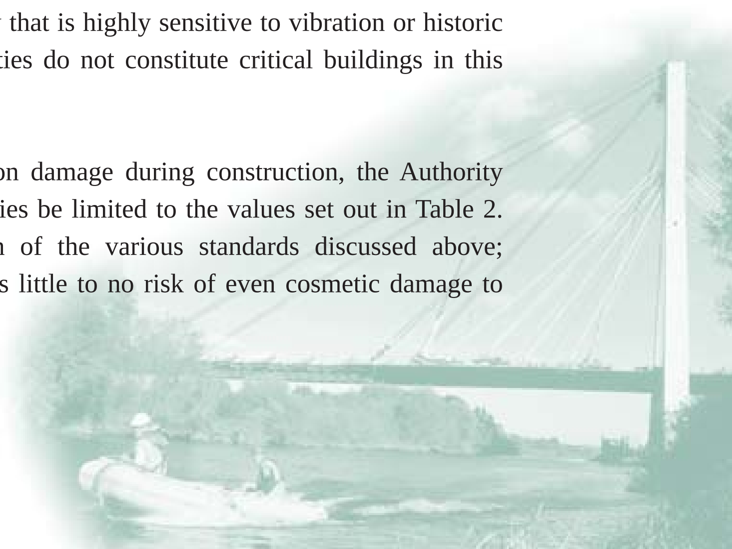
- Building Research Establishment (BRE) Digest 353 (July 1990): *Damage to structures from ground-borne vibration,* and;

- British Standard BS 7385 (1993): *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration.*

The BRE digest refers to the German Standard DIN 4150, which provides limits below which there is very unlikely to be any cosmetic damage to buildings. For structures that are of great intrinsic value and are particularly sensitive to vibration, transient vibration should not exceed 3mm/s at low frequencies. Allowable levels increase to 8mm/s at 50Hz and 10mm/s at 100Hz and above.

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15mm/s at low frequencies rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above. These guidelines relate to relatively modern buildings and should be reduced to 50% or less for more critical buildings. Critical buildings would include premises with machinery that is highly sensitive to vibration or historic buildings that may be in poor repair. Residential properties do not constitute critical buildings in this context.

In order to ensure that there is no potential for vibration damage during construction, the Authority recommends that vibration from road construction activities be limited to the values set out in Table 2. These values have been derived through consideration of the various standards discussed above; compliance with this guidance should ensure that there is little to no risk of even cosmetic damage to



Allowable vibration velocity (Peak Particle Velocity) at the closest part of any sensitive property to the source of vibration, at a frequency of		
Less than 10Hz	10 to 50Hz	50 to 100Hz (and above)
8 mm/s	12.5 mm/s	20 mm/s

buildings.

Table 2: Allowable Vibration During Road Construction in Order to Minimise the Risk of Building Damage

CHAPTER 3

NOISE LEVEL PREDICTIONS

3.1 Operational Noise

Traffic noise levels expressed in terms of the parameter $L_{10(18hour)}$ may be calculated using the methodology set out in Calculation of Road Traffic Noise (CRTN)[3] . However, the design goals set out in section 2.3.1 of this document are expressed in terms of long term L_{Aeq} values designated L_{den} and L_{night}.

Traffic noise levels expressed in terms of L_{Aeq} may be calculated using Road *Traffic Noise: new French method including meteorological effects* (NMPB96). This document deals solely with propagation of noise, whereas emission levels are taken from *Guide de Bruit des Transports Terrestres – Prévision des Niveaux Sonares*. NMPB96 is put forward in Directive 2002/49/EC as the "recommended interim computation method" for "Member States that have no national computation methods". Notwithstanding this, NMPB96 has a number of shortcomings as identified in a study[4] undertaken by the UK Transport Research Laboratory (TRL) on behalf of the UK Department of Environment, Food and Rural Affairs (DEFRA). These shortcomings, as they pertain to Ireland, may be summarised as follows:

1. The input source data is out of date.

2. In order to obtain reliable results, it is considered that source data pertinent to current Irish traffic conditions would be required.

3. Software packages currently used for modelling in accordance with CRTN cannot be adapted to NMPB96. New packages or calculation modules would be required.

4. Meteorological information required for the purposes of establishing long term noise values is not readily available for the whole of Ireland.

5. The standard error in prediction is not known.

6. The method has not been used previously in Ireland.

Given that these same shortcomings apply in respect of the UK, it is understood that the relevant UK authorities have decided to comply with the mapping requirements of Directive 2002/49/EC by predicting noise levels in accordance with CRTN. These predicted levels are then to be converted to appropriate EU indices using "end corrections" derived by the TRL. The Authority concurs with this approach, believing it to be the most reliable method of assessing traffic noise levels.

In summary, traffic noise levels should be predicted using the methodology set out in CRTN, giving results in the form of $L_{10(18hour)}$ values. These should then be converted to L_{den} and L_{night} values in accordance with the procedures detailed in the TRL study. These conversion procedures are summarised in Appendix 1. The derived values for L_{den} and L_{night} should be rounded to the nearest whole number, with 0.5 being rounded up.

It is important to note that, whilst the design goals have been established in terms of the L_{den} indicator, the calculation procedures are rooted in the $L_{10(18hour)}$ indicator.

3 *Calculation of Road Traffic Noise, Department of Transport Welsh Office, HMSO, 1988*

4 *Converting the UK traffic noise index LA10,18h to EU indices for noise mapping*, Abbott & Nelson, TRL Limited, 2002

3.2 Construction Noise

Where it is deemed necessary to predict noise levels associated with construction activities (see section 6.0), this should be done in accordance with BS5228: Part 1[5]. This standard sets out sound power levels for plant items normally encountered on construction sites, which in turn enables the prediction of noise levels at selected locations.

5 BS5228: *Noise and vibration control on construction and open sites, Part 1: Code of practice for basic information and procedures for noise and vibration control, 1997*

CHAPTER 4
CONSTRAINTS STUDY

4.1 Objectives

The NRPMG state that the purpose of the Constraints Study is to gather "as much information regarding the project as possible. This data collection should be focused on determining what constraints (physical, procedural, legal, environmental etc.) exist that could affect the design of the scheme, delay progress, and influence the costs. Large-scale maps (OS Discovery Series Maps, or equivalent) of the corridor should be prepared to determine the extent of the study area and all known physical constraints within the area should be identified and recorded. The first part of this data collection should be based on deskbound research searches. Once a basic large-scale map of the study area is prepared a First Public Consultation for the scheme should be carried out."

The specific objective of the noise input to the Constraints Study is to identify any receptors that may be deemed to be particularly sensitive to noise and/or vibration.

4.2 Approach

The primary aspect of the noise input to the Constraints Study is a site inspection, although it is likely that large-scale OS maps will be of benefit in planning and conducting the inspection. The appraisal should include an examination of the area or areas through which the route might potentially pass.

Receptors that are, or have the potential to be, particularly sensitive to noise and/or vibration should be identified. Examples of such receptors are schools, hospitals, places of worship, heritage buildings, special habitats, amenity areas in common use and designated quiet areas.

The characteristics of the prevailing noise climate should also be noted, along with any significant sources of noise. Opportunities for noise mitigation, e.g. as a result of favourable topography, should also be noted. A detailed discussion of mitigation is presented in section 6.6.

The Authority considers that noise measurements or prediction calculations are not normally required in support of a Constraints Study. However, there may occasionally be circumstances under which some additional information of this kind may be beneficial. For example, if noise levels in the vicinity of existing roads are high, it may be deemed necessary to quantify these levels in order to establish whether or not the construction of a new road might serve to reduce noise exposure of sensitive locations in the vicinity.

4.3 Contents of the Noise Input to the Constraints Study

The noise input should include:

- a listing of any receptors deemed sensitive or potentially sensitive to noise and/or vibration;
- a general description of the prevailing noise climate;
- a listing of any significant sources of noise in the study area;
- a discussion of opportunities for mitigation;
- where practicable, a suitably scaled map (e.g. 1:100,000) showing the locations of sensitive receptors and significant noise sources.

CHAPTER 5
ROUTE CORRIDOR SELECTION

5.1 Objectives

The work undertaken as part of the Constraints Study is used by the project engineers responsible to refine the broad corridor into a small number of route corridor options. The NRPMG state that the purpose of Route Corridor Selection is to "carry out a detailed technical evaluation of the scheme corridor. The route selection process involves…. [the] identification and investigation of Route Options, assessment of Environmental Impacts for each option…". This evaluation in turn leads to the production of a Route Corridor Selection Report.

The route selection process typically involves, for each route corridor option:

- traffic surveys;
- identification and investigation of corridor options;
- impacts on land holdings severance;
- broad assessment of environmental impacts of each option, and;
- preparation of a budget/cost estimate.

Depending upon circumstances, it may also involve noise measurements and/or the preparation of prediction calculations.

The identification of the environmental impacts of the various options will include, among other things, assessment of potential impacts on local communities and homes, archaeology, flora and fauna, surface water and groundwater, and socio-economic impacts. Noise is one aspect that is considered and the assessment of noise forms part of the Route Corridor Selection Report.

5.2 Approach

There are three elements to the noise element of Route Corridor Selection. These elements consist of an assessment of potential impact based upon property counts, consideration of likely changes in traffic flow and a review of the need for and difficulties associated with noise mitigation measures. Once these three elements have received detailed consideration, route options should be ranked with respect to noise.

5.3 Assessment of Potential Impact Based on Receptor Counts

All receptors within 300m of each route option should be identified and put into one of four "bands". These bands are defined by their distance to either side of the centre line of each route option. Band 1 is from 0 to 50m of the centre line, Band 2 is from 50 to 100m, Band 3 is from 100 to 200m and Band 4 is from 200 to 300m. For this purpose, a receptor is defined as being any dwelling house, hotel, hostel, health building, educational establishment, place of worship, entertainment venue or any other facility or area of high amenity which benefits from or requires the absence of high noise levels. Whilst property counts can be conducted in large part using drawings or aerial photographs, an inspection should be conducted along each route option in order for there to be no doubt as to the function of any particular building or amenity area.

The total number of receptors in each band is multiplied by an arbitrary rating factor. The rating factor is 4 for Band 1, 3 for Band 2, 2 for Band 3 and 1 for Band 4. The resultant values are summed to give a single number for each route option, termed the Potential Impact Rating (PIR). The PIR values may be used to assess the **potential** impact of each route option, the larger the PIR the greater the potential impact.

An example of this process for a single route option is shown in Table 3.

Band	No of Receptors in Band	Rating Factor	A x B
1	30	4	120
2	25	3	75
3	80	2	160
4	20	1	20
	Potential Impact Rating		**375**

Table 3: Example of Calculation of Potential Impact Rating (PIR) Based on Receptor Counts

The PIR of Route 1 in the example is 375. It would have a greater potential impact than a route with a PIR of 200 and a lesser potential impact than a route with a PIR of 550.

Note that this stage of the process only permits ranking of route options in order of potential noise impacts. In order to accurately assess the likely impact of each route option other factors such as "cut and fill", traffic flow and mitigation measures should be considered.

5.4 Assessment of Changes in Traffic Flow

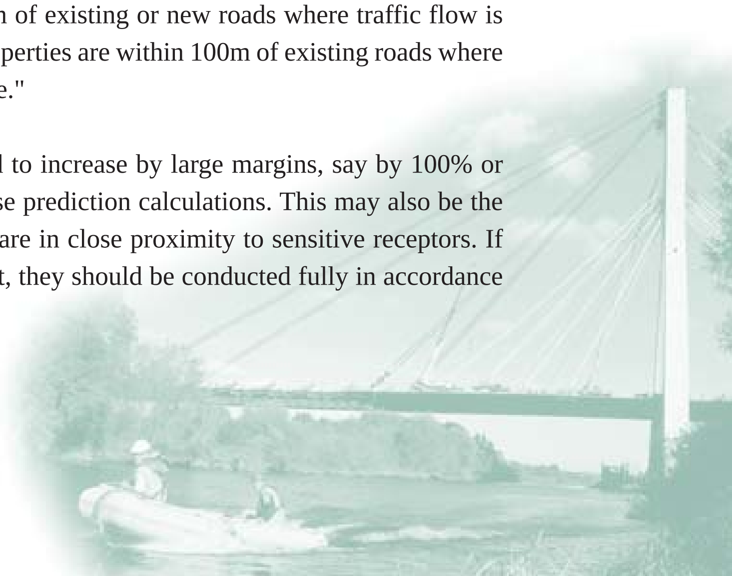
It is envisaged that indicative traffic flow data will be made available at this stage of the scheme appraisal. This data should be considered for each route option. An estimate should be made of the number of receptors in the vicinity of roads where traffic flows are likely to increase or decrease by 25% or more. Consideration should also be given to new roads that are introducing traffic flow where none presently exists.

It will be acceptable to provide approximate numbers for receptors based on maps and/or aerial photography.

The results of this appraisal should be presented in the form of a simple statement for each option, for example:

> "For Route 1, some 250 properties are within 300m of existing or new roads where traffic flow is expected to increase by 25% or more. Some 100 properties are within 100m of existing roads where traffic flow is expected to decrease by 25% or more."

If there are any locations where traffic flows are expected to increase by large margins, say by 100% or more, it may be deemed prudent to prepare indicative noise prediction calculations. This may also be the case when new roads with moderate to high traffic flows are in close proximity to sensitive receptors. If noise predictions are undertaken at this stage of the project, they should be conducted fully in accordance with the guidance set out in section 3.0.



5.5 Assessment of the Likely Need for Mitigation Measures

For each route option, consideration should be given to what opportunities exist for the provision of noise mitigation measures, should they be deemed necessary. This should incorporate a review of topography and opportunities for judicious use of subsoil/soil excavated as part of the construction process.

Particular attention should be paid to those options where space may be limited in order to avoid a situation where it is not possible to achieve the noise design goals.

A detailed discussion of mitigation is presented in section 6.6

5.6 Ranking of Route Options

The final stage in preparing the noise input to the Route Corridor Selection is to rank the route options in order of "preference". The assessment should start with the PIR's for each option and then consider all mitigating circumstances arising out of the review of traffic flow and need for mitigation measures.

It is possible that the route with highest PIR may present significant opportunities for mitigation; it may even lead to major benefits in the vicinity of existing roads where projected traffic flows show a decrease.

Those conducting the assessment should exercise discretion and call upon experience of previous schemes in order to arrive at a final ranking order.

5.7 Contents of the Noise Input to the Route Corridor Selection

The noise input should include:

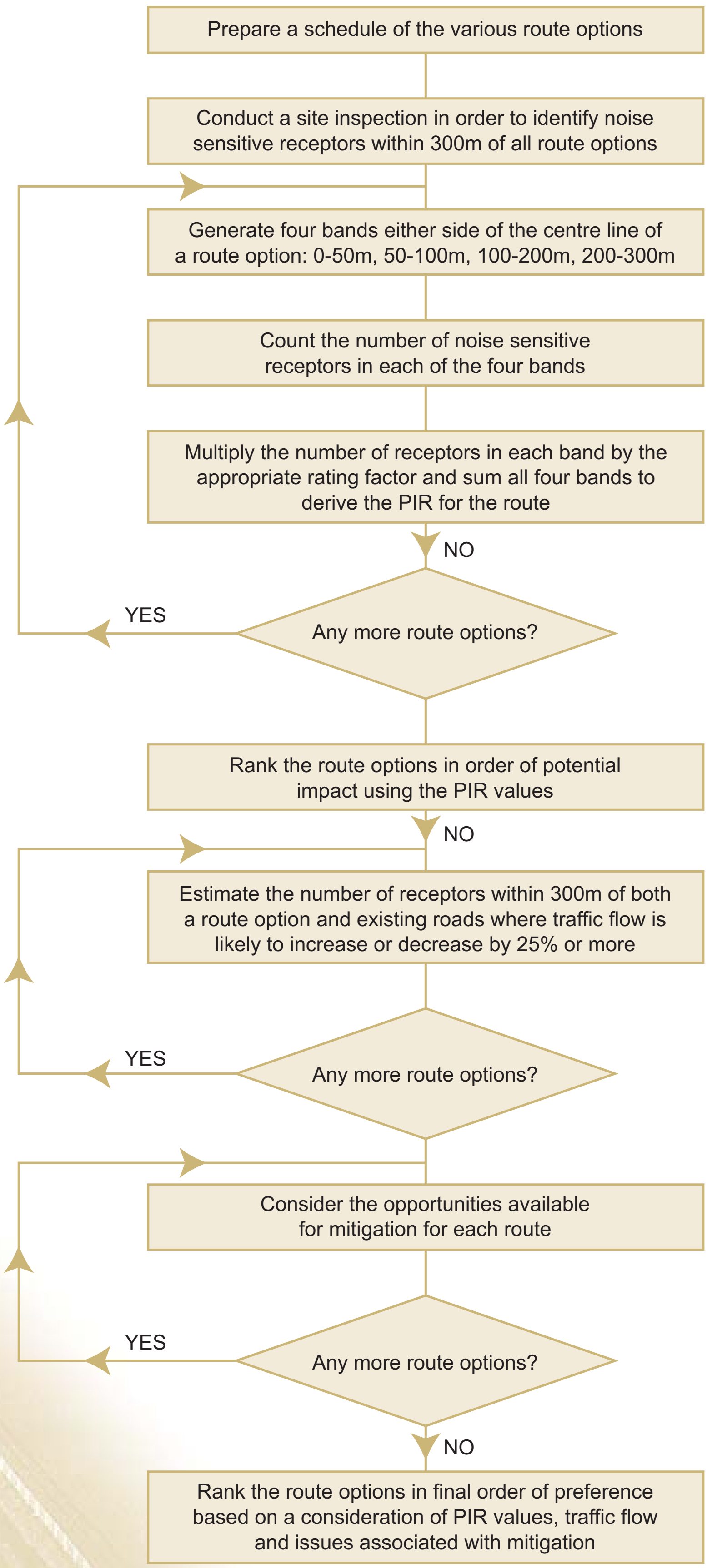
- an *Introduction*, which introduces the study areas and refers to the findings of the Constraints Study;
- a statement of *Methodology*, which outlines the methods used in the noise study and refers to any relevant legislation, standards and guidance documents followed during the assessment process;
- a description of each of the *Route Options* (although this may be included in another section of the Route Corridor Selection report);
- details of an Assessment of *Potential Impact* using calculated values for PIR, presented in tabular form;
- a discussion of *Changes in Traffic Flow*;
- a discussion of possible *Mitigation Measures*;
- a *Conclusion*, which draws together the various threads of the appraisal and compares the relative impact of each route option with a view to ranking in order of preference.

Note that the issue of vibration need not receive consideration at this stage unless there are any special circumstances.

Chart 1 (overleaf) illustrates the procedure for Route Corridor Selection in the form of a flow chart.

Chart 1

Flow Chart For Route Corridor Selection



CHAPTER 6

ENVIRONMENTAL IMPACT STATEMENT

6.1 Objectives

The objective at the Environmental Impact Statement (EIS) stage is to undertake sufficient assessment to identify significant impacts on the noise climate and, where the design goals are exceeded, to mitigate accordingly.

Those preparing an EIS should have regard to the EPA publication *Guidelines on the information to be contained in Environmental Impact Statements (2002).*

6.2 Approach

The noise input to the EIS follows on from the work undertaken as part of the Constraints Study and Route Corridor Selection. There should already be an awareness of the primary issues associated with the final route selection, which will permit accurate scoping of the detailed noise study that is required in support of an EIS. A full EIS noise study should involve at least the following:

- a series of noise surveys to quantify the prevailing noise climate along the proposed routes;
- preparation and calibration of a suitable traffic noise prediction model;
- prediction of Do Minimum and Do Something noise levels for opening and design years;
- comparison of predicted Do Something noise levels with the design goals and three conditions that must be satisfied before mitigation measures are deemed necessary;
- specification and assessment of road traffic noise mitigation measures, where required;
- assessment/review of construction impacts and mitigation measures;
- assessment/review of vibration.

6.3 Noise Surveys

Noise surveys should be conducted in order to quantify the existing noise environment in the vicinity of noise-sensitive locations that may be affected by the proposed scheme.

The noise surveys should be conducted generally in accordance with the guidance set out in ISO1996-1: 1982: Part 1[6], although the specific guidance set out below takes precedence in the event of any conflict.

6.3.1 Selection of Measurement Locations

It is necessary to select a sufficient number of locations to establish a clear picture of noise level variation along the entire length of the scheme. Furthermore, measurement periods and methodology will have to be such that the results are sufficiently accurate to permit validation of the noise model.

[6] ISO1996-1: 1982: Acoustics -- *Description and measurement of environmental noise -- Part 1: Basic quantities and procedures*

The Authority considers that the optimum means of meeting these requirements is to conduct both attended measurements over short periods and unattended (i.e. automated) measurements over longer periods, e.g. 24 hours.

As a general guideline, there should be one unattended measurement location for every 2km of scheme.

If the unattended measurements are conducted over a continuous 24 hour period, it should be possible to conduct attended measurements at six locations over the same period in accordance with the protocol set out in section 6.3.3. All six of these locations should be within approximately 1km of the unattended measurement location and one of them should be contiguous with it for validation purposes.

If, however, a scheme includes straight sections of road with similar characteristics, it may be appropriate to use fewer measurement locations.

The measurement locations should ideally be positioned such that they provide results indicative of the prevailing noise climate at sensitive receptors. For the 24 hour unattended monitoring, it would be advantageous to place the microphone at a height of 4m above ground level. For the purposes of the attended measurements, the microphone should be at least 1.5m above ground level. In all instances the microphone should be sufficiently far from building facades to give results that may be considered "free field".

Measurement locations should not be situated close to localised sources of high noise levels, such as external plant.

An example of the selection process for measurement locations is shown on Figure 2.

6.3.2 Unattended Measurements

Unattended measurements over extended periods should be conducted using an environmental kit incorporating a logging sound level meter. The meter should be set up to provide data in hourly samples over a period of at least 24 hours. For ease of analysis, the samples should begin and end "on the hour", i.e. 06:00 to 07:00hrs, 07:00 to 08:00hrs etc. A range of indicators should be logged: L_{10}, L_{eq} and L_{max} are all required as a minimum. It may also be prudent to log L_{90} in order to quantify the prevailing background noise level.

The results may be used to derive $L_{10(18hour)}$ dB(A) values by taking the arithmetic mean of the 18 one-hourly values of L_{10} covering the period 06:00 to 24:00hrs.

The methodology discussed in section 3.1 may then be used to derive values for L_{day}, $L_{evening}$, L_{night} and L_{den} from $L_{10(18hour)}$.

6.3.3 Attended Measurements

Measurements should be made at each location over any three consecutive hours between 10:00 and 17:00hrs. For ease of analysis, the hourly periods during which the consecutive samples are taken should begin and end "on the hour", i.e. 10:00 to 11:00hrs, 11:00 to 12:00hrs etc. Sample periods for attended measurements should be 15 minutes and once again a range of indicators should be measured with L_{10},

L_{eq} and L_{max} being required as a minimum. $L_{10(18hour)}$ dB(A) values may be derived by subtracting 1dB(A) from the arithmetic mean of the L_{10} values measured during the three sample periods.

Example: the following results are obtained.

Measurement Period	Measured Noise Levels (dB re.2x10^{-5}Pa)		
	L_{Aeq}	L_{A90}	L_{A10}
10:10 – 10:25	66	42	70
11:12 – 11:27	67	45	71
12:15 – 12:30	67	44	69

$L_{10(18hour)}$ may be calculated as follows:

$L_{10(18hour)} = (70 + 71 + 69) \div 3 - 1 = 69dB(A)$

Note that the use of 15 minute sample periods should permit measurements to be made at a total of three locations in any given 3 hour period, provided that they are sufficiently close together. This should in turn enable six locations to be considered in any one day.

The methodology discussed in section 3.1 may then be used to derive values for L_{day}, $L_{evening}$, L_{night} and L_{den} from $L_{10(18hour)}$.

Note that values for $L_{10(18hour)}$ obtained using this approach should be treated with caution if traffic flows in the vicinity of the measurement locations are relatively low (e.g. below 300 vehicles per hour).

6.4 Preparation and Calibration of a Traffic Noise Prediction Model

The Authority considers that it will be necessary to perform calculations using a computer based noise model built using a proprietary software package for practically every road scheme requiring an EIS. This section has been prepared assuming the use of a proprietary software package implementing CRTN guidance in full.

6.4.1 Requirements for the Noise Model

The noise model should be as detailed as possible and, as a minimum, the model should contain:

- surface contours;
- details of ground cover;
- buildings in the vicinity of proposed roads and also existing roads affected by the scheme (a representative sample of buildings will be acceptable in the case of large conglomerations and long stretches of road where traffic characteristics remain consistent);
- proposed alignments for both new and proposed roads;

- standard road surface details;
- traffic volumes, speeds and percentage of HGV's;
- other significant features that may have a bearing on sound propagation, e.g. walls, crash barriers, bunds and side slopes.

It will be necessary to prepare a number of variants of the noise model in order to encompass the various scenarios requiring consideration.

The requirements for accurate assessment of the future noise environment should, in the public interest, include as an objective value for money. Modifications may be made to avail of opportunities to improve the design in light of experience on the ground provided this has no greater impact than predicted during the Environmental Impact Assessment process.

6.4.2 Calibration of the Noise Model

In order to calibrate the noise model it will be necessary to obtain traffic data that is representative of conditions during the period when the noise survey was conducted. The noise model should be used to predict the noise level associated with that traffic data at all survey locations where traffic noise is considered to be the dominant source. The results of this exercise should then be compared with the results obtained by measurement. The model is considered to be sufficiently accurate if the variance is no greater than ±3dB(A) at any location. If the variance is greater than this value, it will be necessary to establish why this is the case. It may be due to a shortcoming in the CRTN methodology, in which case the model itself is not at fault. However, it may be necessary to further refine the model in order to achieve the required degree of accuracy.

6.5 Traffic Noise Assessment

The noise model should be used to predict Do Something and Do Minimum noise levels (in terms of L_{day}, $L_{evening}$ and L_{night}) for opening and design years. The design year is defined as 15 years after the projected year of opening.

6.5.1 Receiver Locations

Predictions should be conducted for as many receiver locations as deemed necessary in order to accurately assess the likely impact of the scheme at every noise sensitive location along the proposed route. A number of locations should also be selected in the vicinity of existing roads where traffic flows are likely to change if the scheme proceeds.

The receiver locations should be positioned such that they are representative of "worst case" conditions, i.e. they reflect noise levels at façades with the greatest exposure to noise. In certain circumstances it may be necessary to use more than one receiver location for a single noise sensitive property.

Receiver locations should be at the most exposed façade of a property and should be positioned at a height of 4±0.2m above ground level, unless the only sensitive properties in the vicinity are single storey, in which case receivers should be at least 1.5m above ground level.

Finally, receiver locations should be positioned such that the predicted noise levels are representative of free field conditions. Note that some modelling packages allow you to "link" the receiver location to a façade but then remove the façade contribution from the predicted noise level in order to give a free field value.

6.5.2 Evaluation of Impact and Need for Mitigation

The predicted Do Something and Do Minimum noise levels should be assessed against the three conditions set out in Section 2.3.1. If all three conditions are satisfied at any location, then mitigation measures are required (see section 6.6).

6.6 Road Traffic Noise Mitigation Measures

If mitigation measures are deemed necessary, the first aspect that should be considered is the alignment of the scheme. Where it is possible to amend the layout of the route such that noise levels at affected receivers are reduced without compromising any other locations or any other aspect of the scheme, then this approach should be adopted in preference to any of the measures discussed below.

In circumstances where it is not possible to amend the alignment, other mitigation measures should be considered.

A low noise road surface is a potential way of controlling road traffic noise "at source". The most common variant of low noise road surface is porous asphalt, which is generally considered to offer noise level reductions of the order of 2 to 3dB(A). However, it is generally accepted that most low noise road surfaces are prone to difficulties, such as cracking in freezing conditions and poor wet weather performance. This can lead to elevated costs for ongoing maintenance. It is worth noting that a variety of new products are being introduced onto the market, hence the engineer responsible for specifying mitigation measures is encouraged to review the availability of sustainable alternative materials.

The simplest form of mitigation measure is a barrier. A barrier can take many forms, e.g. a cutting, an earth bund, a stone wall or a proprietary timber noise barrier. The closer the barrier is to the source of noise (i.e. the road), the higher the reduction in traffic noise levels. This is also true, albeit to a lesser extent, for barriers positioned close to the receiver. Likewise, higher barriers offer more attenuation than lower barriers. Proprietary barriers offer additional options, such as absorptive surfaces, that can give significant benefits.

When considering barriers, it is important to examine and state the position, length, height, surface mass (where necessary) and requirement for absorptive surfaces (where deemed appropriate).

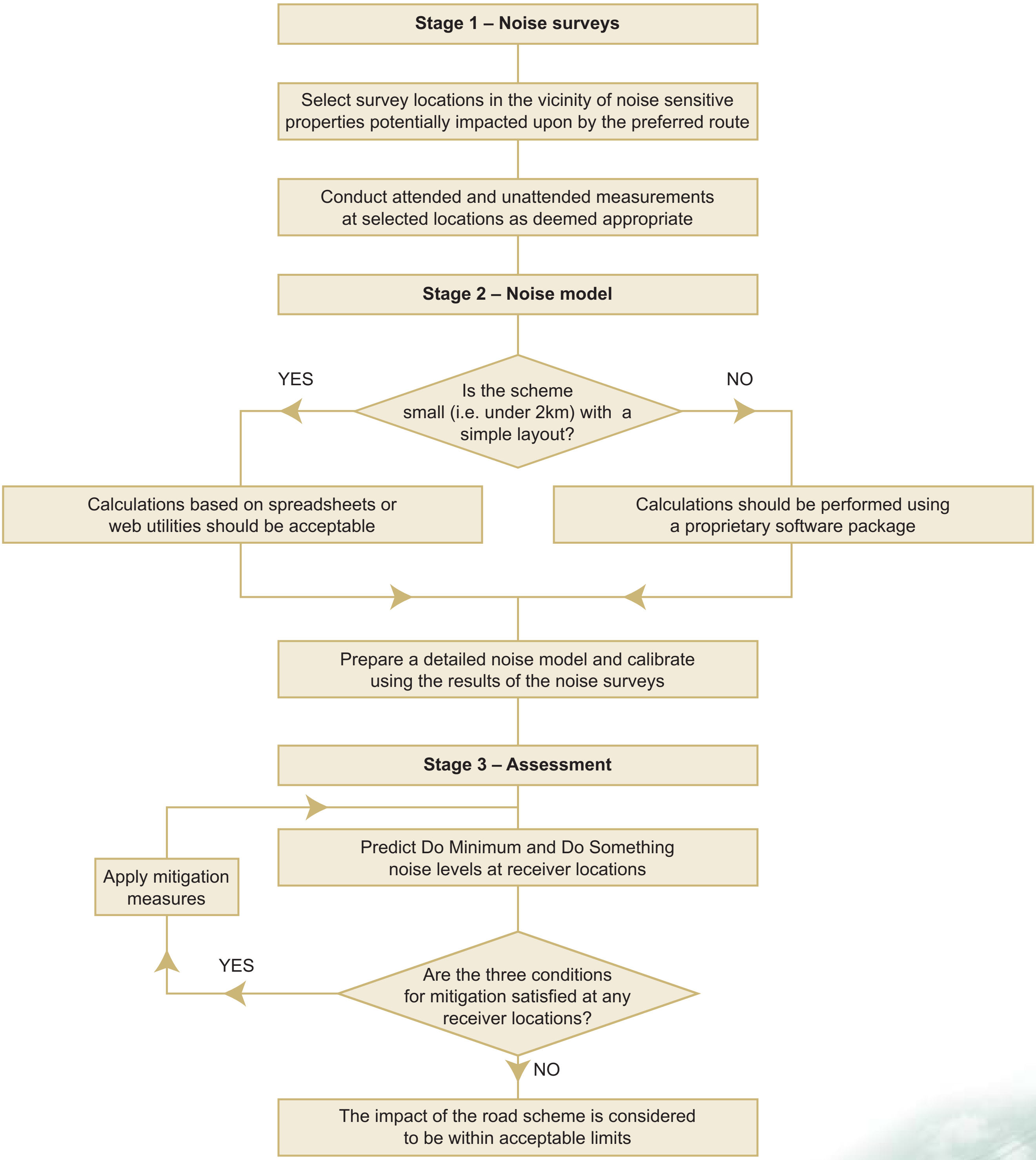
In all instances, the mitigation measures are required to reduce road traffic noise from the proposed scheme such that one or more of the three qualifying conditions is no longer satisfied. It will therefore be necessary to prepare new prediction calculations for Do Something noise levels with the mitigation measures in place.

Finally, when examining noise mitigation measures, it is important to consider indirect impacts; for example, the visual impacts of a noise barrier. Where necessary, this should be done through consultation with other members of the project team.

Chart 2 (overleaf) illustrates the procedure for the Traffic Noise Assessment in the form of a flow chart.

Chart 2

Flow Chart for the Environmental Impact Statement Traffic Noise Assessment



6.7 Construction Noise Impacts and Mitigation Measures

The Authority acknowledges that it is often not possible to conduct detailed noise assessments in respect of the construction phase of a road scheme due to the fact that the programme is not sufficiently detailed. However, due consideration should be given to the potential for high construction noise levels, particularly where work is anticipated over prolonged periods in the vicinity of noise sensitive properties. In such circumstances, it is appropriate to predict indicative construction noise levels.

Construction noise prediction calculations should be conducted in accordance with the guidance in section 3.2 and reviewed in light of the design goals in section 2.3.2.

Whether or not the engineer is in a position to predict construction noise levels, it should be possible to establish the methodology that will apply in respect of the construction contract, which will in turn enable a list of typical plant items to be drawn up. This will permit the preparation of a schedule of typical mitigation measures that may be employed. This schedule should be as thorough as possible and should consider at least the following aspects:

- noise limits;
- methods for selecting plant items;
- practicable noise control measures for plant items likely to be used;
- hours of operation;
- procedures for dealing with emergency work;
- procedures for dealing with specific activities with the potential to generate significant levels of noise, e.g. piling, blasting;
- communication with the general public.

6.8 Vibration from Road Developments

As previously noted, it has been found that ground vibrations produced by road traffic are unlikely to cause perceptible structural vibration in properties located near to well-maintained and smooth road surfaces. This aspect does not require further consideration unless there are unusual circumstances under which higher than normal traffic vibration levels may be expected.

There is of course much greater potential for generation of vibration during construction. Activities such as piling and blasting should receive careful consideration in order to ensure that the limits set out in section 2.3.4 are complied with. Certain other processes, such as excavation, earth moving and compaction also have the potential to generate significant amounts of vibration.

6.9 Contents of the Noise Input to the Environmental Impact Statement

The noise input should include:

- an *Introduction*, which should discuss the study area and refer to the findings of the Constraints Study and Route Corridor Selection;
- a statement of *Methodology*, which should outline the methods used in the noise study and refer to any relevant legislation, standards and guidance documents followed during the assessment process;
- details of the *Noise Surveys*, including a detailed description of receiver locations (and map coordinates where possible), survey periods, results and derived values for $L_{10}/L_{day}/L_{evening}/L_{night}$, comparison of results from unattended and attended locations and a discussion of the noise climate and primary contributors to noise build-up at each location;
- a listing of input data to the Noise Model and details of the Calibration exercise;
- details of the *Road Traffic Noise Assessment*, including a complete listing of predicted noise levels and (where appropriate) significance levels (Appendix 2 contains a sample table that may be incorporated into the report);
- details of *Road Traffic Noise Mitigation Measures* (if any), amended listings and a statement of likely residual impacts, i.e. the prevailing scenario after the proposed mitigation measures have taken effect as planned;
- an appraisal of *Construction Noise Impacts And Mitigation Measures*,
- an appraisal of issues relating to *Vibration*,
- a *Conclusion*, which draws together the various aspects of the assessment and summarises the net impact.

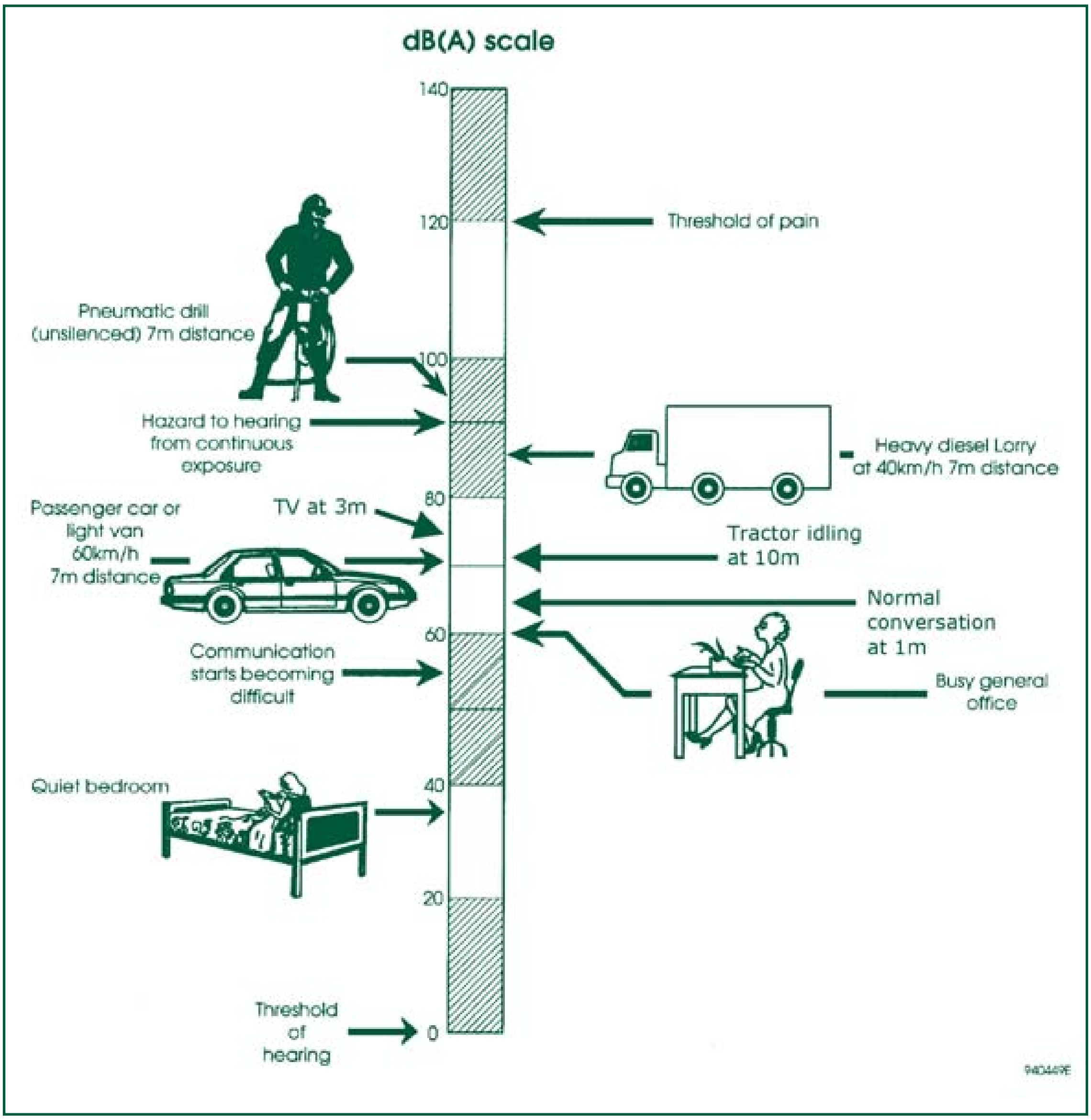


Figure 1: The Level of Typical Common Sounds on the dB(A) Scale (Based on guidance taken from: Design Manual for Roads and Bridges, Volume 11 Consolidated Edition 1993)

Description of the Proposed Scheme: 10km of motorway with one major intersection. The middle section, some 4km in length, incoporates few bends and has a constant design speed.

Selection of Unattended Measurement Locations: Assuming one unattended measurement location for every 2km of scheme, there should be five in total. However, given that there is little scheme variation along the middle 4km, only one location is required for this stretch, meaning that only four unattended locations are required in total. These are distributed as shown in the schematic below.

Selection of Attended Measurement Locations: For each unattended measurement location there are six attended locations within 1km. One of these is contiguous with the unattended location. The attended locations are distriibuted as shown in the schematic below.

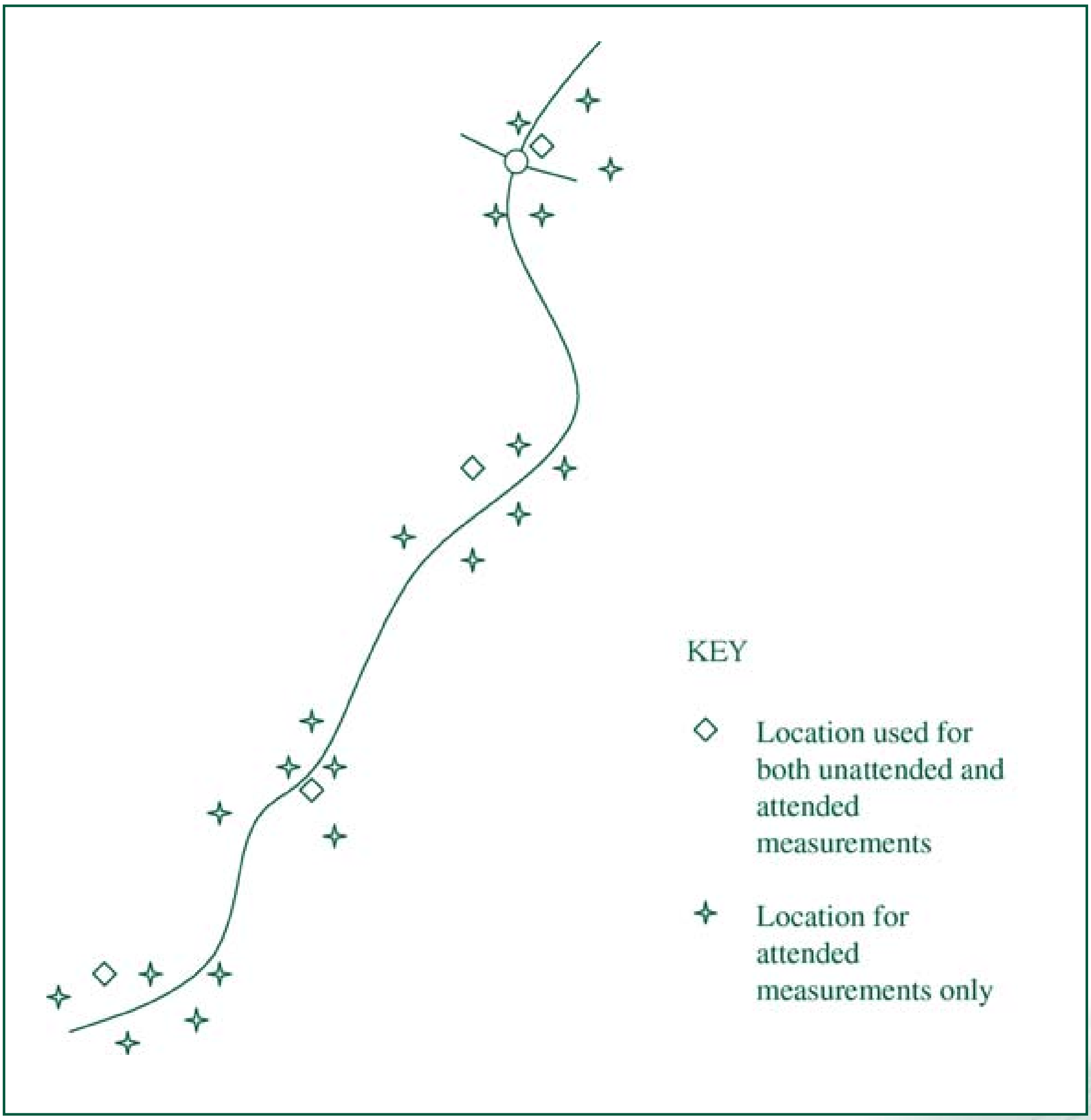


Figure 2: Example of the Selection Process for Survey Measurement Locations

CHAPTER 7
APPENDICES

APPENDIX 1
Summary of Procedures for the Conversion of $L_{10(18hour)}$ to L_{day}, $L_{evening}$ and L_{night} (Source: *TRL Limited*)

This Appendix presents three methods for converting $L_{10(18hour)}$ to L_{day}, $L_{evening}$ and L_{night}. It should be noted that the preferred method is Method 1. The evidence from both the literature survey and subsequent analysis of data collected for UK traffic conditions indicates that this form of conversion will produce acceptable errors and is robust over a wide range of conditions. Method 2 also provides a good solution where hourly traffic information is not available but where traffic data for the relevant time periods specified by the EU is available. Method 3 is potentially the least reliable of the three methods since it relies on the assumption that different road types will, on average, produce a reasonably consistent diurnal flow pattern. Clearly for roads where significant deviations from the norm occur then further errors in conversion may result.

For each of the methods specified below, where a road scheme consists of several segments it is important initially to determine the components L_{day}, $L_{evening}$, L_{night} for each segment separately. These values should then be combined to obtain the corresponding values of L_{day}, $L_{evening}$, L_{night} for the whole road scheme. Once this has been achieved, the value of Lden can be calculated from the combined component values.

Method 1

When the user has available hourly traffic data then CRTN can be used to produce values of $L_{A10(1hour)}$ which can then be converted to $L_{Aeq(1hour)}$ values using the relationship:

$$L_{Aeq(1hour)} = 0.94 \text{ x } L_{A10(1hour)} + 0.77 \text{ dB}$$

However, for non-motorway roads when hourly traffic flows are below 200 vehicles per hour during the period 24:00 to 06:00hrs, the following relationship should be used:

$$L_{Aeq(1hour)} = 0.57 \text{ x } L_{A10(1hour)} + 24.26 \text{ dB}$$

The converted values obtained for the full 24 hours can then be used to derive the values for L_{day}, $L_{evening}$, L_{night} and L_{den} as necessary.

Method 2

Where detailed hourly traffic data is not available but traffic data is known or can be estimated for the relevant time periods specified by the EU then CRTN should be used to obtain values of $L_{A10(18hour)}$ which should then be converted to L_{day}, $L_{evening}$ and L_{night} using the following relationships:

$$L_{day} = 0.99\text{x}L_{A10(18hour)} + 10\text{xlog}_{10}\left(\frac{p_{12}N_{12}V_{12}^2}{p_{18}N_{18}V_{18}^2}\right) \text{ dB}$$

$$L_{evening} = 0.99\text{x}L_{A10(18hour)} + 10\text{xlog}_{10}\left(\frac{p_4N_4V_4^2}{p_{18}N_{18}V_{18}^2}\right) +4.76 \text{ dB}$$

$$L_{night} = 0.99xL_{A10(18hour)} + 10x\log_{10}\left(\frac{p_8 N_8 V_8^2}{p_{18} N_{18} V_{18}^2}\right) +1.75 \text{ dB}$$

where $L_{A10(18hour)}$ is the averaged hourly L_{A10} level measured over the period 06:00 to midnight; pt is the percentage of heavy vehicles in the time period t hours[7]; N_t is the total traffic flow in the time period t; V_t is the mean traffic speed in the time period t.

The converted values can then be used to derive the values of L_{den} (where necessary) using the equation:

$$L_{den} = 10x\log_{10}\left(\frac{1}{24}\right)\left(12x10^{L_{day}/10} + 4x10^{(5+L_{evening})/10} + 8x10^{(10+L_{night})/10}\right)\text{dB(A)}$$

Method 3

Where detailed hourly traffic data is not available then CRTN should be used to obtain values of $L_{A10(18hour)}$ which can then be converted to L_{day}, $L_{evening}$, L_{night} or L_{den} (the latter applies only in the case of single segment roads).

For non-motorway roads:

$L_{day} = 0.95xL_{A10(18hour)} + 1.44$ dB

$L_{evening} = 0.97L_{A10(18hour)} – 2.87$ dB

$L_{night} = 0.90xL_{A10(18hour)} – 3.77$ dB

$L_{den} = 0.92xL_{A10(18hour)} + 4.20$ dB

For motorways:

$L_{day} = 0.98xL_{A10(18hour)} + 0.09$ dB

$L_{evening} = 0.89L_{A10(18hour)} + 5.08$ dB

$L_{night} = 0.87xL_{A10(18hour)} + 4.24$ dB

$L_{den} = 0.90xL_{A10(18hour)} + 9.69$ dB

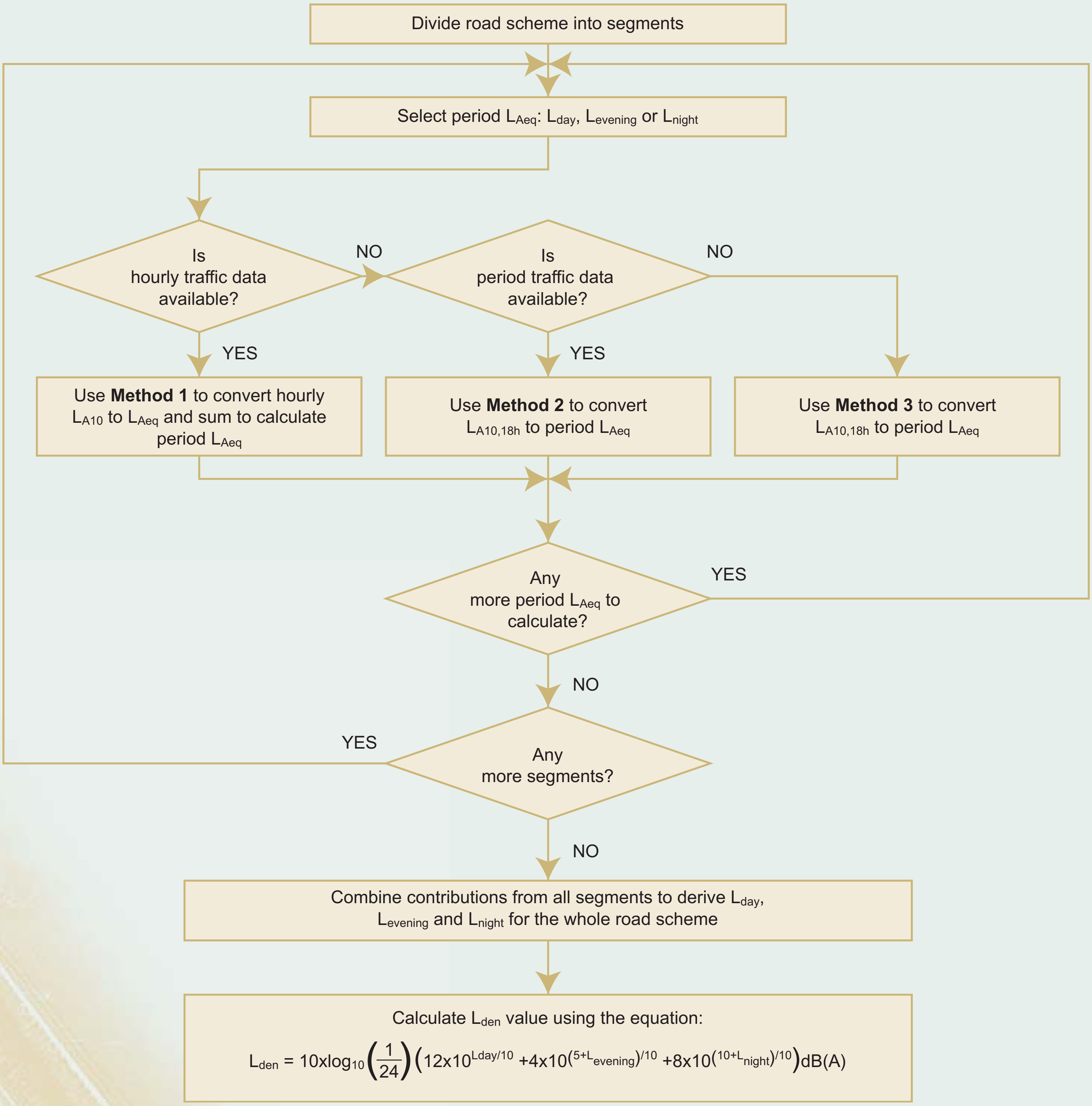
Chart 3 (overleaf) illustrates the procedure in the form of a flow chart.

[7] When the value of p_t is zero then put $p_t = 1$

Chart 3

Flow Chart For Conversion Of LA10(18hour) To EU Indices

(Source: TRL Limited)



APPENDIX 2

Sample Table for the Presentation of the Results of the Road Traffic Noise Assessment (see overleaf).

Receiver Location Reference	Opening Year				Mitigation Required?	Design Year				Mitigation Required?
	Predicted Noise Levels					Predicted Noise Levels				
	Do Minimum		Do Something			Do Minimum		Do Something		
	L_{night}	L_{den}	L_{night}	L_{den}		L_{night}	L_{den}	L_{night}	L_{den}	

Note: if mitigation measures are required, an additional table will be required in order to present the new predicted levels.

APPENDIX 3
GLOSSARY OF TERMS

A-weighting	A frequency weighting applied to measured or predicted sound levels in order to compensate for the non-linearity of human hearing.
dB (decibel)	The unit of sound pressure level, calculated as a logarithm of the intensity of sound. 0dB is the threshold of hearing, 120dB is the threshold of pain. Under normal circumstances, a change in sound level of 3dB is just perceptible. A change of 1 or 2dB is detectable only under laboratory conditions. A change of 10dB corresponds approximately to halving or doubling the loudness of sound.
Design Goal	A target limit for noise or vibration adopted during the early design stages of a project, not necessarily having a statutory basis but based on current best practice and the particular circumstances of a given scheme.
Do Minimum	Describes a scenario under which the road scheme that is under consideration does not proceed (sometimes referred to as "Do Nothing").
Do Something	Describes a scenario under which the road scheme that is under consideration proceeds.
Façade Noise Level	A noise level measured or predicted at the façade of a building, typically at distance of 1m, containing a contribution made up of reflections from the façade itself.
Free Field	Free field noise levels are measured or predicted such that there is no contribution made up of reflections from nearby building façades.
Hertz	The unit of frequency (pitch) of a sound. Formerly called cycles per second.
L_{10}	The noise level exceeded for just 10% of a sample period. $L_{10(1hour)}$ is therefore the noise level exceeded for 10% of the time over a period of one hour. $L_{10(18hour)}$ is the arithmetic average of the eighteen $L_{10(1hour)}$ values between 06:00 and 24:00hrs.
L_{90}	The noise level exceeded for 90% of a sample period; typically used as a descriptor for background noise level.
L_{max}	The instantaneous maximum sound level measured during a sample period.

$L_{eq,T}$	The equivalent continuous sound level - the sound level of a steady sound having the same energy as a fluctuating sound over a specified measuring period T. T may be as short as 1 second when used to describe a single event, or as long as 24 hours when used to describe the noise climate at a specified location. $L_{eq,T}$ can be measured directly with an integrating sound level meter.
L_{den}	The day-evening-night composite noise indicator adopted by the EU for the purposes of assessing overall annoyance.
L_{day}	The A-weighted long term average sound level as defined in ISO1996-2: 1987, determined over all the day periods of a year.
$L_{evening-}$	The A-weighted long term average sound level as defined in ISO1996-2: 1987, determined over all the evening periods of a year.
L_{night}	The A-weighted long term average sound level as defined in ISO1996-2: 1987, determined over all the night periods of a year.
PIR	Potential Impact Rating (PIR) is an arbitrary mechanism for making a preliminary judgement of the potential impact of a proposed route. It does not take account of natural or designed mitigation measures.
PPV	Peak Particle Velocity (PPV) expressed in millimetres per second (mm/s) is a vibration indicator used for the purposes of assessing potential annoyance to humans or damage to buildings.

USER COMMENT FORM

Comments on this published draft should be forwarded to: Mr. Brian Cullinane, Corporate Affairs, National Roads Authority, St. Martin's House, Dublin 4.

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