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RTA

Environmental
Noise

Management Manual



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Management Manual

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This *Environmental Noise Management Manual* was developed by Jim A Campbell and Steve Isles of the RTA Environment and Community Policy Branch.

The authors would like to acknowledge the many other contributors, both within and external to the NSW Roads and Traffic Authority. Special mention is made of the co-operative efforts made by the NSW Environment Protection Authority.

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Please read this first

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Foreword

Every one of us depends on the State's road system for access to work and recreation and for the goods and services we expect. As a result, we all contribute to the impacts of vehicles on the environment, including road traffic noise.

Among other things, policies and actions to control this noise need to address vehicle noise at the source, through traffic management, quieter vehicle standards and measures to reduce vehicle use such as land-use planning, improved public transport and telecommuting.

No single approach can solve the complex problem of road traffic noise. Having a range of options to address different problems is the best approach.

While the RTA manages the road system with local councils, other factors affecting traffic noise levels at residences and other sensitive land uses involve a number of other organisations, such as the Environment Protection Authority and Planning NSW, and the community. So solutions to the problem need to involve these organisations and the community in a partnership effort.



Road construction and maintenance works can also have significant adverse noise and vibration impacts. Management of these impacts requires meaningful community consultation and the use of best available and practical assessment and mitigation strategies.

This RTA *Environmental Noise Management Manual* is primarily intended as a guide for RTA staff, acoustic consultants and other contractors. It defines the RTA's guiding principles in managing noise and vibration from the roads it controls, and details a noise and vibration management framework for:

- New, upgraded and existing roads and transitways
- Individual vehicles, and
- Road construction and maintenance works.

The RTA *Environmental Noise Management Manual*, which has been developed in consultation with the NSW Environment Protection Authority, is also available to other organisations, individuals and the community, to encourage a partnership approach in resolving these noise and vibration issues. An electronic version is available at www.rta.nsw.gov.au.

The manual will be reviewed after 12 months of implementation. To this end, comments are welcomed from all private and public stakeholders, including State and local regulatory authorities, road development contractors, acoustic practitioners, community groups and the general public.

I commend the RTA *Environmental Noise Management Manual* to you, as it adds to the RTA's commitment to continuous improvement in the management of noise and vibration impacts.

Paul Forward

Chief Executive
Roads and Traffic Authority

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Introducing the *Environmental Noise Management Manual*

This *Environmental Noise Management Manual* has been developed to provide practical guidance to RTA staff in managing and controlling noise and vibration from vehicles, road construction and road maintenance activities and implementing the *Environmental Criteria for Road Traffic Noise*.

The guidance it provides for the management of roads also applies to the management of transitways.

More specifically, the *Environmental Noise Management Manual* will guide the work of the RTA in:

- Enforcing vehicle standards and driver education
- Managing and implementing the RTA's Noise Abatement Program for existing roads
- Managing the road traffic noise impacts of new and upgraded roads, from network analysis through to implementation, completion, operation and maintenance
- Selecting an optimum mix of road traffic noise management options
- Developing solutions for road construction and maintenance noise and vibration impacts
- Managing responses to noise and vibration complaints
- Noise and vibration impact assessment
- Advocating improved designs for noise-sensitive developments close to roads
- Commenting on traffic-generating development proposals, and
- Advocating adequate consideration of noise issues in the creation of planning instruments and in the design of Local Area Traffic Management schemes.

The *Environmental Noise Management Manual* is set out as follows:

- At the outset, there is a clear statement of the **RTA's corporate commitment and guiding principles** on noise management.
- **Part I** (*sections 1 to 5*) is an introduction to noise, noise and vibration management issues and control techniques.
- **Part II** (*sections 6 to 11*) sets out the framework for noise management, starting with the legal requirements and noise and vibration criteria, standards and guidelines (*section 6*) and then moving on to the management framework applying for different noise management situations (*sections 7 to 11*).
- **Part III** (*Practice Notes I to XI*) is a series of Practice Notes setting out supporting noise and vibration management guidelines and procedures.
- "Model" noise and vibration briefs are set out in **Appendices A to F**.

Acronyms and abbreviations

AADT	Average Annual Daily Traffic
AB	Assessed Barrier
ADR	Australian Design Rule
ANZECC	Australian and New Zealand Environment Conservation Council
BOOT	Build, Own, Operate and Transfer
CEMP	<i>Contractor's Environmental Management Plan</i>
D&C	Design and Construct
DCM	Design, Construct and Maintain
DCP	<i>Development Control Plan</i>
ECRTN	EPA <i>Environmental Criteria for Road Traffic Noise</i>
EIA	Environmental Impact Assessment
EIS	<i>Environmental Impact Statement</i>
EMS	Environmental Management System
EMP	<i>Environmental Management Plan</i>
EPA	NSW Environment Protection Authority
ETB	Effective Target Barrier
HVIS	Heavy Vehicle Inspection Scheme
LATM	Local Area Traffic Management
LEP	<i>Local Environmental Plan</i>
LTC	Local Traffic Committee
MBV	Marginal Benefit Value
MVEC	Motor Vehicle Environment Committee
NAP	RTA <i>Noise Abatement Program</i> for existing roads
NVMP	<i>Noise and Vibration Management Plan</i>
PEMP	RTA <i>Project Environmental Management Plan</i>
Planning NSW	NSW Department of Planning (formerly Dept of Urban Affairs and Planning)
PPV	Peak particle velocity
REF	<i>Review of Environmental Factors</i>
REP	<i>Regional Environmental Plan</i>
RNI	RTA Road Network Infrastructure Directorate
RTA	NSW Roads and Traffic Authority
SEPP	NSW <i>State Environmental Planning Policy</i>
TB	Target Barrier
TMC	RTA Transport Management Centre
TNB	Total Noise Benefit
TNBA	Total Noise Benefit per Unit Barrier Area
TNL	Target Noise Level



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The RTA's corporate

Commitment

and guiding principles



The RTA's corporate commitment and guiding principles to minimise noise

Corporate commitment

The RTA is committed to effectively managing the roads and traffic system under its control to minimise the noise and vibration impacts of road construction, maintenance and operation on the built and natural environment.

Guiding principles

- (1) The RTA will incorporate the assessment and mitigation of road traffic noise impacts in the road planning process, from route selection to detailed design and project completion and operation, and will continue to support the principles outlined in *Beyond the Pavement: RTA Urban and Regional Design Practice Notes*.
- (2) The RTA will continue to support the objectives of the *Environmental Criteria for Road Traffic Noise* and will work in partnership with the NSW Environment Protection Authority and other stakeholders.
- (3) The RTA will take account of maintenance requirements in the selection and design of noise treatments.
- (4) The RTA will address road traffic noise impacts on existing sensitive developments in the design of its roads and noise-control measures.
- (5) The RTA will address traffic noise impacts on sensitive developments from existing State and Federal roads through the NSW Government's Noise Abatement Program, on a prioritised basis.
- (6) The RTA will consider the broader corridor context in the selection and design of noise treatment measures for new, upgraded and existing roads.
- (7) The RTA will continue to advocate that road traffic noise should be adequately considered in the design and construction of noise-sensitive developments and traffic-generating developments and in the development of Local Area Traffic Management schemes.
- (8) The RTA will continue to manage construction noise and vibration impacts through the implementation of necessary, available, practical and cost-effective mitigation measures.
- (9) The RTA will continue to advocate the introduction of quieter vehicle standards and will work with the transport industry to achieve voluntary reductions in the use of noisy engine brakes in urban areas.
- (10) The RTA will continue to conduct and support research to improve understanding of the generation and mitigation of noise and vibration from road traffic and construction activities.
- (11) The RTA will continue to consult with the community, government departments and agencies and other stakeholders to address issues of interest and concern.

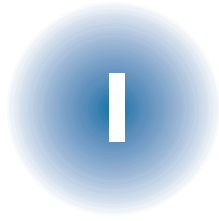


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Part I

Introduction

to noise control techniques



Section I

An introduction to noise

Sound and noise

Sound consists of fluctuations in air pressure which are detected by the ear. The human ear is able to detect these fluctuations with great sensitivity over a considerable range of both intensity and frequency.

Noise is simply unwanted sound.

Unlike industrial noise, traffic noise is rarely loud enough to cause hearing loss. Its principal effects are annoyance, the drowning out of wanted sounds such as bird calls and rustling leaves, and fatigue through sleep deprivation.

Noise energy intensity and decibels

Energy intensity is the most important factor in determining the “loudness” of a noise.

It is usually measured in decibels (dB). This is a logarithmic scale: assuming their individual noise emissions are the same, 10 compressors will be 10 dB louder than one compressor at the same location and 100 compressors will be 20 dB louder than one compressor.

Each 10 dB increase in noise levels is equivalent to a doubling of the perceived loudness.

Zero decibels is an arbitrary noise energy intensity approximately equal to the lower limit of hearing of a young adult.

In practice, when noise measurements are taken it is the sound pressure levels that are being measured. The noise energy intensity is proportional to this sound pressure measurement. Zero decibels correspond to a sound pressure of $20 \times 10^{-6} \text{ N/m}^2$ (see *Figure 1.1*).

The audible range for people is about 0–120 dB — a range of one million times the sound pressure and a million times the noise energy intensity. Above 120 dB, hearing damage will rapidly occur.

Because decibels are logarithmic units, sound levels cannot be added by ordinary arithmetic means. For example, the combined noise level from two equal sources (with twice the noise energy intensity of a single source) is 3 dB higher than the noise level from just one of these sources. Two compressors producing 75 dB each will combine to produce 78 dB, not 150 dB.

Table 1.1

If the difference between two noise sources (in dB) is —	— then add the following (in dB) to the higher noise level:
0–1	3
2–3	2
4–9	1
10 +	0

Table 1.1 (at left) presents a handy guide for adding decibels together.

There is an inverse square relationship between sound intensity and distance. So noise from a point source such as an individual vehicle will increase by 6 dB if the distance to the receiver is halved. Similarly, if the distance is doubled the noise level will fall by 6 dB.

In practice, however, factors such as the intervening ground surface, surrounding topography, wind, temperature gradients, rain, snow, fog and sound reflection will modify this inverse square law.

Road traffic noise is often best treated as a line source, comprising a number of point sources. Depending on the intervening ground surface (hard or soft), noise from such a line source will increase by between 3 dB and 4.5 dB if the distance to the receiver is halved, rather than 6 dB as described above (see Table 1.2 below).

Noise frequency and tonal and impulsive components

The audible frequency range for a young adult is generally taken to be 20–20,000 Hz. (1 Hertz (Hz) is 1 cycle per second.)

The human ear is less sensitive to low frequency sound and more sensitive to high frequency sound in the range 400– 4,000 Hz. Generally, higher frequency noise will be more annoying than lower frequency noise at the same intensity.

This has led to the development of various frequency weighting curves, which are intended to simulate this aspect of human hearing, during noise measurements.

Sound level meters have built-in electronic circuits that weight the measured noise levels to simulate the response of the human ear at various noise levels and frequencies. For the levels of sound caused by road traffic, the “A” scale frequency weighting best simulates the frequency responses of the human ear. Noise levels are recorded as “A” weighted decibels, represented by the symbol dB(A).

The controlling frequencies from a traffic noise annoyance viewpoint are generally those in the range 250–500 Hz.

Impulsive noise such as hammering is generally more annoying than more uniform noise. Tonality, caused by a concentration of energy at one frequency,

Table 1.2

Example of $L_{eq}(1 \text{ hr})$ noise levels for different traffic volumes and distances to the receiver, assuming a vehicle speed of 80 km/h and a level road with 10% heavy vehicles

Distance to assessment point over hard ground (m)	Traffic volume (vehicles per unit of time)			
	50	100	200	400
40	57 dB	60 dB	63 dB	66 dB
80	54 dB	57 dB	60 dB	63 dB
160	51 dB	54 dB	57 dB	60 dB

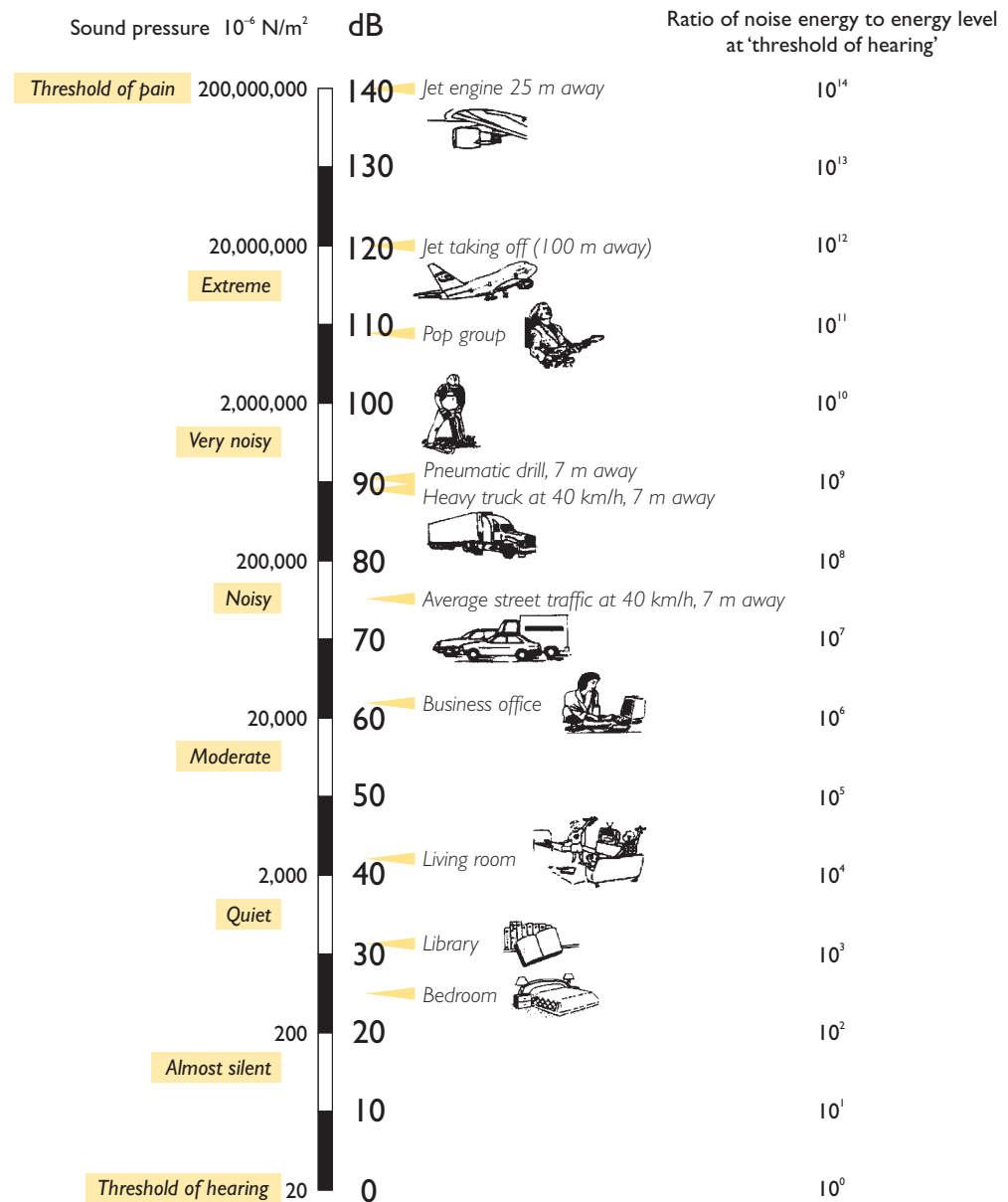


Figure 1.1. Unweighted sound levels and typical sources

also increases annoyance. Heavy vehicle exhausts and deeply grooved pavements can generate tonal and impulsive components. An upward ‘annoyance’ adjustment of 5 dB(A) is made if a construction or industrial noise source is impulsive or tonal.

Figure 1.1 illustrates the range of generally experienced (unweighted) instantaneous noise levels and some typical sources of these levels.

Noise from traffic flows

The levels and characteristics of road traffic noise depend on factors such as the composition of the traffic, vehicle speeds, vehicle ages, driver behaviours, the type of road surface, surrounding topography and the grade of the road.

For example, traffic may be continuous over a large part of a 24-hour period or it may occur mainly during peak periods. Traffic speeds may be faster during times of low volumes, such as at night, but very slow during peak periods. The traffic mix can also change, with more heavy vehicles on some main roads at night.

Each location will exhibit operating characteristics that can cause different levels of noise. For example, some roads may cause little noise disturbance during the day if traffic is travelling at low speeds. At night, even though traffic volumes are likely to be lower, high noise levels from individual faster heavy vehicles might cause disturbance.

Noise from traffic, industry, commercial activities, trains, aircraft and day-to-day domestic activities all merge together and contribute to “ambient” noise. Ambient noise studies can be useful in providing a profile of noise level changes in different areas, to determine the need for noise reduction programs. (“Ambient” noise is the general noise around us. “Background” noise is the noise level without any dominant noise source, such as a nearby vehicle, lawn mower, atypical weather noise, loud birds or insects.)

High peak noise levels

Most road traffic noise complaints relate to high noise levels caused by certain heavy or modified vehicles. When peak noise levels from noisy vehicles are superimposed over the lower background levels experienced at night, the noise impact is usually more noticeable.

The larger the difference between the background and peak noise levels, the greater the impact experienced by most people.

Noise from stop/start traffic

Intersections and other locations where steady traffic flows are interrupted can be significant traffic noise sources. Traffic management methods for major roads, such as specific turning lanes, roundabouts and the co-ordination of traffic signals, can therefore be important in reducing traffic noise.

Meteorological conditions

Varying weather conditions can influence the long-distance propagation of traffic noise, and in some cases corrections may be needed to take account of air absorption. However, in most cases the distances involved in traffic noise impact assessments are less than 300 metres from the road, and meteorological conditions have little impact on traffic noise problems over these short distances.

Intervening ground effects

Soft ground surfaces, which are covered in vegetation reduce the propagation of noise compared to hard paved surfaces. The use of roadway cuttings or shielding by other buildings reduces noise propagation.

Noise descriptors

Traffic noise is the sum of the noise produced by vehicles in a traffic stream. As such, it varies both “microscopically”, over small periods such as minutes, and “macroscopically”, over longer periods such as several hours during the course of a day.

A typical traffic noise time history is graphed in *Figure 1.2*. The microscopic fluctuations during the course of a one-hour period are apparent.

L_{10}

L_{10} is the noise level exceeded for 10% of the particular time period. In *Figure 1.2*, L_{10} is the noise level indicated by the upper horizontal line (the sum of the times shown during which the noise level exceeds this level in *Figure 1.2* is 6 minutes, 10% of 1 hour). This descriptor is used in the assessment of noise from construction activities and industry.

L_{90}

L_{90} is the noise level exceeded 90% of the time during the period of interest. It is commonly called the “background” noise level.

The L_{90} level should always be reported in any noise level measurement study, as it is the descriptor for background noise used by environmental agencies in construction and industrial noise assessment.

L_{eq}

The descriptor adopted in the *Environmental Criteria for Road Traffic Noise* (“the *ECRTN*”) is L_{eq} , the steady noise level which contains the same amount of acoustic energy as all the varying noise levels observed during a particular time period (The *ECRTN* use the terminology L_{Aeq} , to indicate they are referring to A-weighted L_{eq} noise levels). In *Figure 1.2* the lower horizontal line, at the bottom of the shaded area, represents L_{eq} .

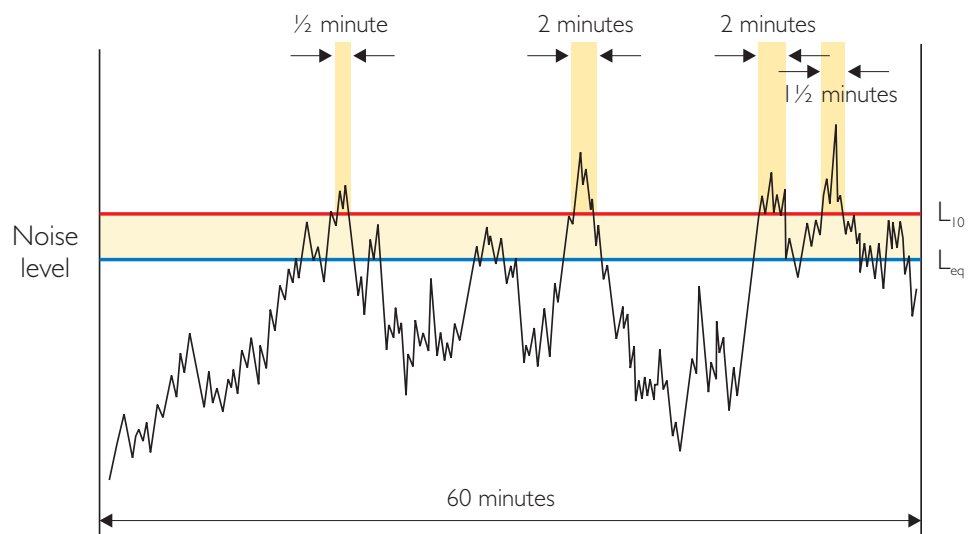


Figure 1.2. A typical traffic noise time history

Three L_{eq} measurements are most commonly used in the *ECRTN*:

- $L_{eq}(15hr)$, the L_{eq} noise level for the 15-hour period between 7 am and 10 pm.
- $L_{eq}(9hr)$, the L_{eq} noise level for the 9-hour period between 10 pm and 7 am.
- $L_{eq}(1hr)$, the highest tenth percentile hourly L_{eq} noise level between 7 am and 10 pm or between 10 pm and 7 am, whichever is relevant to the particular criterion in question.

Australian and international experience has shown that for continuous traffic flows the $L_{10}(1hr)$ and $L_{eq}(1hr)$ noise descriptors are related as follows:

$$L_{eq}(1hr) = L_{10}(1hr) - 3 \text{ dB(A)}$$

L_{max}

L_{max} is simply the maximum noise level recorded during a defined period of time.

Figure 1.3 shows an example of macroscopic fluctuations in noise levels over a one-day period, in this case primarily as a result of traffic variations. The noise descriptors shown, all for one-hour periods, are L_{max} , L_{10} , L_{eq} and L_{90} .

It may be seen that the 3 dB(A) difference between the L_{10} and L_{eq} descriptors applies throughout the day.

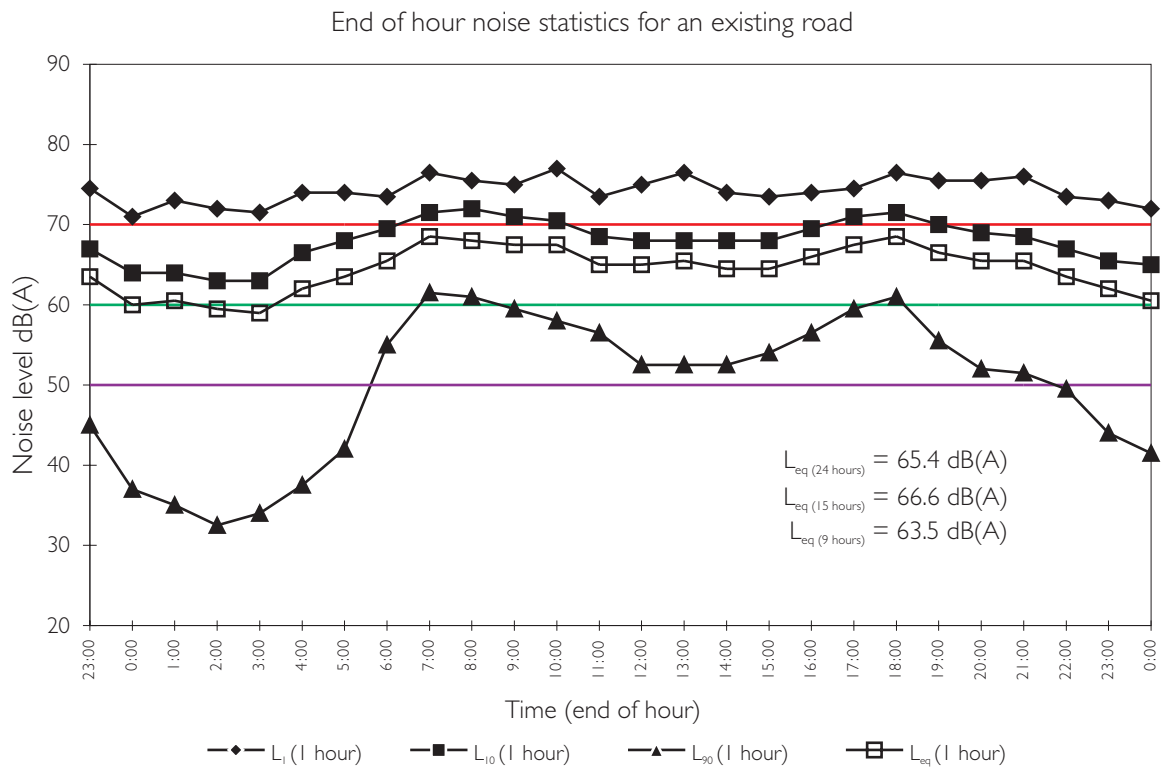


Figure 1.3. An example of monitored traffic noise descriptors over a one-day period

2

Section 2

An overview of noise management issues and techniques

The control of noise emissions at the source

The most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source, by reducing the number of vehicles and/or making the vehicles quieter.

At typical urban speeds most vehicle noise is emitted by the engine, cooling fan, transmission and exhaust.

Faulty mufflers add to the noise from both light and heavy vehicles.

For heavy vehicles poor driving practices, such as the use of noisy engine brakes near residences, is a major source of complaint. Other important heavy vehicle noise sources include rattling truck trailer bodies and trailer couplings.

At higher speeds wind-generated (aerodynamic) and tyre noise become increasingly significant, even though tyre noise has been reduced in recent years through improved tyre and tread designs, particularly for passenger cars.

Different pavement types produce different noise characteristics, and these characteristics also vary with vehicle speed. “Low noise” pavement surfaces have been developed, and research is being conducted to improve their acoustic and safety characteristics and long-term serviceability. Other factors affecting pavement noise include road joints, road markers such as rumble strips and traffic control devices such as speed humps and chicanes.

The reduction of traffic noise through source controls therefore involves a combination of:

- A reduction in traffic volumes, especially through the promotion of public transport and more efficient freight transport, including rail freight
- More stringent noise standards for new vehicles, reflecting the latest economically available technologies, supported by appropriate incentives to implement these technologies
- The progressive replacement of older, noisier vehicles

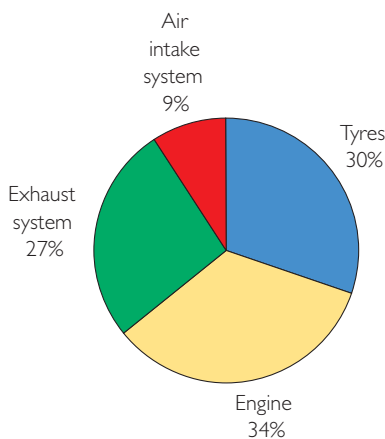


Figure 2.1.
Passenger car noise sources at speeds below 70 km/h (ARRB Research Report ARR314)

For more information on these techniques, see section 3.

For information on techniques for controlling construction and maintenance noise and vibration, see section 5.

- Measures to ensure noise-control equipment on heavy vehicles and older cars is properly maintained, supported by in-service vehicle standards and regulation
- The education of drivers, transport operators, the repair industry, after-market suppliers and the community, supported by educational material to encourage and enhance their roles in noise reduction
- The selection and design of road routes and alignments so as to reduce gradients and achieve smooth traffic flows
- The use of “low noise” pavements, improved tyre technologies, lower design speeds, speed limits and other measures to reduce aerodynamic and wheel–pavement noise emissions
- Restrictions on noisy vehicle access, such as heavy vehicle restrictions, and
- Traffic management measures to achieve smooth traffic flows and facilitate public transport, cycling and pedestrian alternatives to the use of private vehicles.

In addition to controlling traffic noise at the source, there is a need to control and manage noise emissions from plant used for road construction and maintenance activities.

The mitigation of emitted traffic noise

Even with effective vehicle controls, traffic noise will still be emitted.

Non-vehicle noise management strategies encompass:

- Land-use and transport planning, to minimise noise-sensitive land uses along transport corridors, provide buffer zones and ensure land-use developments near roads are designed to minimise traffic noise impacts
- Careful environmental assessment to identify existing and potential traffic noise problems and the most effective solutions
- New road route selection and design so as to minimise the propagation of noise from vehicles to sensitive receptors, through physical separation, vertical alignments that take advantage of the noise barrier effects of existing and new topography, road tunnels, landscaped noise moundings, noise barrier buildings and landscaped roadside noise walls, and
- Noise-mitigation treatments near and within existing noise-sensitive buildings, or their conversion for less sensitive uses.

For more information on these techniques, see section 4.

The RTA will continue to conduct research into ways of enhancing the effectiveness of noise-mitigation measures. The findings of this research will be incorporated in future revisions of this *Manual*.

Reducing noise from new roads

Traffic noise mitigation is most effective, and often achieved for the lowest cost, if it is considered right from the earliest planning stages in the road develop-

ment process. This allows noise amelioration to be incorporated into strategic transport planning, route selections and road design.

Optimum acoustic planning and design can make a significant contribution to reducing noise from new roads, both by reducing noise emissions at the source and by reducing noise levels by the time they reach sensitive receptors.

The selection of routes to provide appropriate buffer zones is a primary objective. Changes to gradients and vertical alignments (e.g. designing pavement heights to be below the natural ground level) can also considerably reduce potential traffic noise problems, eliminating or minimising the need for additional noise barriers or other mitigation measures.

All noise mitigation measures should be designed and implemented in consultation with affected communities and individuals and the EPA.

Reducing noise from existing roads

Improved traffic management, effective road maintenance and the use of lower noise pavement surface types can all assist in reducing noise from existing roads.

When these approaches are insufficient, additional noise mitigation can be achieved by erecting noise barriers (earth berms, walls, fences, etc) along the road.

Lowering the pavement elevation can also assist, but is often not feasible for upgrade projects.

In some cases, all of these approaches may still be insufficient. The options then available include upgrading of the acoustical insulation of noise-sensitive premises or the conversion of land uses to less sensitive types.

Preventing increased noise from local roads

As main roads become congested, traffic often diverts through local roads that primarily serve residential areas.

Some councils have introduced traffic management schemes to discourage through traffic from using local streets. The RTA participates with others in reviewing these schemes and their noise impacts.

Improvements to main road capacities through effective traffic management can also assist in preserving the residential amenity of local streets.

Further reading

ARRB Transport Research (1998) *Road Surface Characteristics and Condition: Effects on Road Users*, Research Report ARR314.

3

Section 3

Techniques for reducing traffic noise at the source

Quieter vehicles

The reduction of noise from individual vehicles is a major factor in reducing traffic noise. For maximum effectiveness vehicle noise management needs to include design, education and enforcement components.

Section 11 describes the noise management framework for individual vehicles and the responsibilities for implementation.

'Low noise' road surfaces

For individual vehicles road tyre noise begins to dominate power-train noise at vehicle speeds of between 30 and 50 km/h for cars and between 40 and 80 km/h for trucks. For traffic as a whole, road tyre noise appears to dominate at around 70 km/h. This means that in areas with posted speeds of 70 km/h or more, the reduction of road tyre noise can be a useful noise reduction treatment.

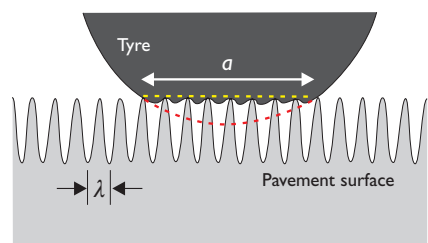
The type of road surface can have a significant impact on traffic noise generated by pavement surface/tyre interactions, as indicated in *Table 3.1*.

A rough and irregular surface causes the tyre to vibrate and emit noise. But a perfectly smooth surface creates noise as well, because air trapped between the tyre and the road cannot easily escape and the movement of this air ("air pumping") causes a hissing sound.

Fine irregularities or texture within the road surface can assist in the removal of trapped air, thus reducing air pumping, whilst simultaneously not causing deformation and vibration of the tyre.

The surface texture of a road pavement is classified into various ranges determined by the wavelength of the texture. Of particular interest for the generation of road/tyre noise is the "macrotexture" and "megatexture" of the pavement.

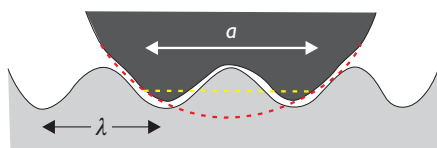
Macrotexture is defined as road surface texture with a wavelength range of 0.5 to 50 mm. *Megatexture* refers to the wavelength range 50 to 500 mm.



λ = distance between transverse waves of the pavement surface
 a = length of tyre footprint
 (vertical scale of pavement surface exaggerated)

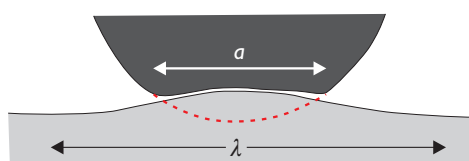
Texture ($\lambda \ll a$):

Little tyre deformation, little air pumping



Roughness ($\lambda \approx a$):

Much tyre deformation and tyre vibration



Unevenness ($\lambda \gg a$):

Little tyre deformation, much air pumping

Figure 3.1. Deformation of a tyre on a road surface containing macrotexture and megatexture (adapted from ARRB Research Report ARR314).

As well as representing defects such as ruts, potholes and major joints and major cracks, macrotexture can inadvertently exist on surfaces in otherwise good condition, often as a result of the paving or surfacing process.

Passenger car tyre/road interface noise can be reduced by:

- Minimising the macrotexture depth at wavelengths of about 10 mm and longer, and
- Maximising the macrotexture depth in the wavelength range of about 2 to 10 mm.

As truck tyre sizes are approximately twice those of car tyres, noise from truck tyres is reduced if the texture depth is maximised for wavelengths of less than 20 mm (compared with 10 mm for cars).

Table 3.1

Road surface noise corrections, relative to dense graded asphaltic concrete			
Surface type (regularly trafficked)	Noise level variation, dB(A)		
	Traffic noise	Individual vehicles pass-by noise	
		Cars	Trucks
14 mm chip seal	+ 4.0	+ 4.0	+ 4.0
Portland cement concrete: tyned and dragged	0 to + 3.0	+ 1.0 to + 3.5	- 1.0 to + 1.0
Cold overlay	+ 2.0	+ 2.0	+ 2.0
Portland cement concrete: exposed aggregate	- 0.5 to - 3.0	- 0.1	- 6.7
Stone mastic asphalt	- 2.0 to - 3.5	- 2.2	- 4.3
Open graded asphaltic concrete	0 to - 4.5	- 0.2 to - 4.2	- 4.9

The road surface correction applied depends on the road surface's porosity, macrotexture, depth and wavelength, the percentage of heavy vehicles and vehicle speeds.

While the corrections shown in *Table 3.1* may be used as a guide, variations in macrotexture wavelengths and depths, and the percentage of air voids, also need to be considered.

At speeds greater than about 80 km/h, the use of open graded asphalt rather than dense graded asphalt can reduce traffic noise caused by surface/tyre interactions by up to 4 dB(A).

In comparison, if a chip seal were used road traffic noise levels would be about 4 dB(A) higher than with dense graded asphalt.

The use of open graded asphalt, in conjunction with other amelioration methods, can therefore lead to opportunities for reducing the height and length of noise walls.

It should be noted, however, that open graded asphalt has a limited life with respect to traffic noise reduction, because of the clogging of air voids over time. Accordingly, it is recommended that in planning noise control measures the correction applied for the use of open graded asphalt should be no greater than -3 dB(A).

Modifying the road gradient

Reducing the road gradient can have a positive effect on road traffic noise levels, as acceleration noise and engine/exhaust brake noise are both reduced.

A 5% reduction in road gradient will reduce L_{eq} traffic noise levels by about 1.5 dB(A).

Reducing design speeds

On high-speed roads such as motorways, halving the average speed will lead to a reduction of up to 5–6 dB(A) in the traffic L_{eq} noise level.

Such a drastic reduction could negate part of the original purpose of the proposed roadway. However, lesser reductions in design speeds can still achieve useful reductions in noise emissions while making only small differences to total travel times.

Care should be taken to ensure that any potential noise reductions are not negated by increases in acceleration and braking noise at transitional speed zones.

Traffic management schemes and traffic calming devices

Street closures can be beneficial in diverting traffic from local roads to arterial roads.

Similarly, heavy vehicle access restrictions are an appropriate mechanism for reducing heavy vehicle noise. Heavy vehicle access restrictions adopted by local councils have included both weight and time restrictions.

Traffic calming devices such as roundabouts, speed humps, mid-block platforms and chicanes can all contribute to a reduction in traffic noise on local roads. Research has shown that roundabouts provide the greatest benefit in noise reduction on local roads.

It is important, however, for traffic calming to be planned on an area-wide basis and to consider the potential for traffic calming devices to actually increase traffic noise in some situations.

The spacing of traffic calming devices is critical. Too great an interval between these devices will encourage acceleration and braking between the devices. The aim is to provide separations that will achieve a constant speed.

Similarly, raised devices on local roads may contribute to traffic noise affecting adjacent sensitive land uses (residential, schools, hospitals and retirement villages). It is necessary to take into consideration the volume of traffic, including the percentage of heavy vehicles using the street, particularly between 10 pm and 7 am, as unladen heavy vehicles and light trucks crossing these devices can cause sleep disturbance in the early morning hours.

Contrasting pavement treatments used to highlight a particular device, such as cobblestones or rumbled pavements, can increase tyre noise.

For details on the RTA's role in Local Traffic Committees, please refer to *Practice Note X*.

Similar considerations apply to the introduction of traffic management measures on arterial routes.

For example, although a roundabout will normally reduce overall traffic noise levels, roundabouts installed on heavy vehicle arterial routes can sometimes increase community annoyance attributable to individual vehicle noise. The use of engine brakes on the approach to the roundabout may result in an increase in peak noise events from heavy vehicles.

When a Route Traffic Management Scheme is being considered, the potential for traffic to divert into parallel streets containing noise-sensitive land uses should be investigated. If the potential for diversions is significant, the noise impacts on these streets should be assessed and appropriate responses to prevent or minimise these impacts implemented.

Further reading

ARRB Transport Research (1998) *Road Surface Characteristics and Condition: Effects on Road Users*, Research Report ARR314

EPA (1999) *Environmental Criteria for Road Traffic Noise*

Karachlis N, Pontifix G and Samuels S E (1996) *The Acoustical Attributes of Some Traffic Calming Devices*, Proceedings, Roads 96 Conference, Part 6

Renzo Tonin & Associates (1996) *Traffic Calming Devices: Part 1, Effects on Attitudinal Behaviour and Roadside Noise Levels and Part 2, Community Attitudinal Survey, Background, Methodology and Data Analysis*

WSROC (1993) *Towards Traffic Calming: A Practitioner's Manual of Implemented Local Area Traffic Management and Blackspot Devices*.

4

Section 4

Techniques for reducing traffic noise during propagation

Land-use planning and development controls

Future road traffic noise problems can often be avoided through zoning mechanisms that do not permit noise-sensitive land uses along transport corridors which have not been designed in accordance with good acoustic principles.

Recreational, commercial and light industrial land uses can provide effective buffer zones between busy roads and residential communities.

While the RTA has no control over development approvals outside road reserves, it takes an active role in advising other authorities during the preparation of planning instruments and during planning and approval processes for new developments. For details, please refer to *Practice Note XI*.

In many locations there may be limited opportunities to avoid incompatible zonings, particularly where noise-sensitive developments have already occurred or urban consolidation objectives need to be met. *Development Control Plans*, *Local Environmental Plans* and site-specific development approval conditions can assist by ensuring that future developments utilise noise-affected sites in an acoustically effective manner and that the layout, orientation, height, design and acoustic insulation of new buildings minimise the potential for noise impacts.

Design considerations should also maximise “barrier” characteristics that will reduce road traffic noise impacts at surrounding sensitive receptors.

The RTA/EPA document *Reducing Traffic Noise: A Guide for Homeowners, Designers and Builders* provides guidance on site planning, housing design and building techniques to reduce road traffic noise. The *Australian Model Code for Residential Development*, published by the Commonwealth Department of Housing and Regional Development in 1995, describes acceptable ways of meeting acoustic privacy performance criteria.

Modifying road alignments

The horizontal alignment for most road developments in urban areas is determined by available land, the required areas to be serviced and safety issues such as minimum bend radii.



The “sunken” vertical alignment of the Eastern Distributor parkway helps to reduce noise levels at nearby residences

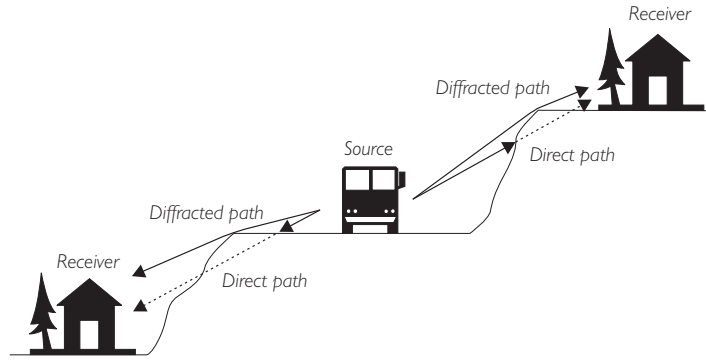


Figure 4.1. Embankments and cuttings can form noise barriers.

Generally access corridors in urban areas are selected many years before the road is built. Because there are only limited opportunities for substantial changes to horizontal alignments once a route has been selected, it is essential to ensure noise impacts and potential noise mitigation measures are adequately considered during the route selection and option analysis stage.

Modification of the road’s vertical alignment during the concept and detailed design phases can be a cost-effective approach with substantial urban design and acoustic benefits, particularly in densely populated areas.

The effectiveness of cuttings and embankments in minimising the transmission of road traffic noise is increased when the line of sight between the noise source and the receiver is broken. The edge of an embankment or the top of a cutting can often act as an effective acoustic barrier.

Roadside noise walls and mounds

Acoustic barriers provide immediate reductions in road traffic noise at the shielded properties once barrier construction is complete.

Road traffic noise barriers, in the form of “noise walls” or mounded earthworks, must break the lines-of-sight between road traffic noise sources — including reflections of traffic noise from solid walls etc — and the noise-sensitive receiver, to gain maximum effectiveness, however important noise reductions may still be achievable from barriers of a lower height.

The acoustic effectiveness of a barrier depends on its density, height, length and location.

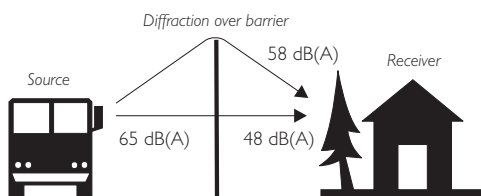


Figure 4.2. A roadside barrier must reduce directly transmitted noise to a level at least 10 dB(A) below that of noise diffracted over the top of the barrier. In this example, the minimum required direct transmission loss is 17 dB(A).

Table 4.1

Noise barrier attenuations

Reduction in sound level	Reduction in acoustic energy	Degree of difficulty to attain
5 dB(A)	70%	Simple
10 dB(A)	90%	Attainable
15 dB(A)	97%	Very difficult
20 dB(A)	99%	Nearly impossible



Figure 4.3 A 160° subtended angle at a reception point is generally considered to provide a minimum barrier length. If this barrier attenuated noise by 11 dB(A), an “infinite” barrier (180°) would provide an attenuation of about 16 dB(A).



Vegetation screening a noise wall on the M4.



The higher the barrier (compared to the direct line-of-sight from the source to the receiver) and the closer its location to either the source or the receiver, the greater the noise attenuation provided.

The barrier also needs to have a sufficient length. Roadside barriers, as distinct from barriers close to dwellings, usually have to provide shielding along an appreciable length of road to be effective.

Roadside barriers can therefore be efficient in providing attenuation to groups of residences, but will not be cost-effective for single structures and may be ineffective where openings are required for driveway access.

The physical heights of barriers can usually be reduced if the pavement is lowered. Opportunities for taking advantage of this should be examined during the earliest stages of planning for new roads.

Combinations of earth mounding and lower height noise walls can reduce the scale and potential visual impacts of fabricated barriers, especially in conjunction with landscape treatments.

Noise walls have been constructed using timber, pre-cast concrete panels, lightweight aerated concrete, fibre cement panels, transparent acrylic panels and profiled steel cladding.

The RTA publication *Noise Barriers and Catalogue of Selection Possibilities* provide information on barrier designs and types.

Every opportunity should be taken to design noise barriers in a way that reduces their adverse visual impacts and enhances landscaping opportunities. For more information and case studies, refer to the RTA’s *Urban Design Practice Notes (Beyond the Pavement)* and *Roadscape Guidelines*.

While dense vegetation screen planting will have visual and privacy benefits, it provides only minor acoustic attenuation, about 1 dB(A) for a 10 m depth. For significant noise



attenuation, a solid barrier (earth mounding, noise wall, cutting, etc) is required.

Noise barriers close to dwellings

As already indicated, noise barriers such as moundings and noise walls are most effective when they are located either close to the road's traffic stream or close to the affected dwelling(s) or other noise-sensitive land uses.

With the consent of owners, acoustic barriers can sometimes be located within a residential property boundary so that they provide maximum shielding of the dwelling.

These barriers might also be designed to form a courtyard, providing some benefit for an outdoor area near the dwelling. *Practice Note IV(b)* describes a process to follow in providing acoustic treatments to individual dwellings.

This approach may reduce the extent of roadside barriers otherwise required, and is often the most cost-effective solution for isolated, noise-exposed residences.

Noise mitigation treatment of existing buildings

Sometimes it is necessary to provide noise control treatments to buildings with noise-sensitive uses.

For example, individual house treatments can be provided in lieu of, or in conjunction with, noise control measures such as low noise road surfaces, roadside noise barriers and barriers near the dwellings.

Any such acoustic architectural treatments may be implemented only after extensive consultation with the residents and after obtaining the agreement of all affected parties, as described in *Practice Note IV(b)*.

Building treatments should generally be considered only when external road traffic noise criteria (as set out in the *ECRTN*) cannot be achieved at the premises and other measures are impractical or not cost-effective.

The mitigation measures should be designed to achieve the internal noise levels that would have prevailed had the external traffic noise criteria been able to be achieved. Most buildings will achieve an internal noise level 10 dB(A) below the external noise level with the windows open, without providing additional treatment.

Specific treatments of the windows and façades of buildings are somewhat expensive, as they usually necessitate the provision of alternative ventilation so that the windows can be kept closed during noisier times of the day. These types of building treatments do not provide any external noise reduction benefit, but the internal noise reductions may be higher than for most external noise barrier solutions.

Approaches to the acoustic treatment of buildings include:

- Improved glazing and door construction in the façades exposed to the road.

Table 4.2

Indicative building noise reduction (adapted from FHWA 1995)

Building type	Windows	Internal noise reduction
All	Open	10 dB(A)
Light frame	Single glazed (closed)	20 dB(A)
	Single glazed (closed)	25 dB(A)
Masonry	Double glazed (closed)	35 dB(A)

Heavier glass can sometimes be just as effective as double glazing, especially if the air gap between the two panes cannot be made greater than about 75 mm.

Where space permits, however, it may be less costly and disruptive to the occupants to install a second, separate “window” in the same frame opening. Acoustic window and door seals and purpose-built add-on windows or “jockey sashes” are available.

- The provision of fresh air ventilation systems. Care needs to be taken to ensure that any new ventilation system does not introduce a sound “leakage” path, which could offset the benefits of the other acoustical measures.
- The installation of courtyard walls. Screen walls within a private property can provide a localised reduction in external noise.

The RTA does not usually provide treatments that require modification of the building structure. However, other noise control measures which a building owner may consider include:

- Upgrading of the façades if the existing building materials are acoustically inadequate, as could be the case with weatherboard or metal-clad dwellings or where there are ventilation vents in external walls.
- Upgrading of the roof structure if the existing structure is inadequate. Possible approaches include applying additional sheet(s) of plasterboard to ceilings, laying insulation batts on the ceiling and fixing plywood or a heavy “loaded vinyl” barrier above the ceiling joists.
- Closing off openings to the under-floor space or upgrading the floors if they are acoustically inadequate. Dwellings with timber floors on elevated piers are especially prone to poor acoustic performance.

Relocation of dwellings

If a residence is located on a large block of land, it might be able to be relocated further from the roadway, thereby reducing road traffic noise at the residence through distance attenuation.

To achieve a noticeable reduction in general road traffic noise levels for the resident — a reduction of about 3 dB(A) — the distance from the roadway to the residence would need to be doubled. This would reduce the peak noise levels of individual vehicles by a more substantial 6 dB(A).

This approach could be a feasible and beneficial option in rural areas, especially where truck noise at night is a potential issue.

The practicality of relocating a residence obviously depends on the comparative cost-effectiveness of other treatments and whether the building's construction and materials will allow it to be moved with minimal, repairable damage.

Further reading

Commonwealth Department of Housing and Regional Development (1995) *Australian Model Code for Residential Development*

EPA (1999) *Environmental Criteria for Road Traffic Noise*

Planning NSW (formerly the NSW Department of Urban Affairs and Planning) (1997) *NSW Model Code: A Model for Performance-Based Multi-Unit Housing Codes*

FHWA (1995) *Highway Traffic Noise Analysis and Abatement*

RTA and EPA (1991) *Reducing Traffic Noise: A Guide for Homeowners, Designers and Builders*

RTA (1999) *Beyond the Pavement: RTA Urban Design Practice Notes*

RTA (1998) *Roadscape Guidelines*

RTA (1991) *Noise Barriers and Catalogue of Selection Possibilities*

Standards Australia (1989) AS3671-1989 *Acoustics – Road Traffic Noise Intrusion – Building Siting and Construction*.

5

Section 5

Techniques for controlling construction and maintenance noise and vibration

Road construction and maintenance works can generate significant traffic movements.

In particular, heavy trucks associated with these works can cause adverse impacts, and means of minimising their noise emissions need to be examined and implemented.

For more details on procedures for assessing and controlling construction and maintenance noise and vibration, see Sections 9 and 10 and Practice Notes VI and VII.

Construction and maintenance works can also necessitate temporary diversions of through traffic. The potential impacts again need to be assessed and minimised.

The noise and vibration impacts of the construction and maintenance activities themselves can often cause disturbance, especially when maintenance work has to be carried out at night because work during the day would be highly disruptive to traffic flow.

A detailed construction noise and vibration assessment may need to be carried out, based on detailed construction work plans.

While the following list of noise and vibration management options (*Table 5.1*) is not exhaustive, it will assist in reducing impacts. These and any other available options should be considered when planning works, and should be implemented where practical and cost-effective.

Table 5.1

Construction and maintenance noise and vibration management options	
Source controls	
Time constraints	Limit work to daylight hours. Consider implementing respite periods with low noise/vibration-producing construction activities.
Scheduling	Perform noisy work during less sensitive time periods.
Equipment restrictions	Select low-noise plant and equipment. Ensure equipment has quality mufflers installed.
Emission restrictions	Establish stringent noise emission limits for specified plant and equipment. Implement noise monitoring audit program to ensure equipment remains within specified limits.

Table 5.1 (continued)

Construction and maintenance noise and vibration management options	
Source controls	
Substitute methods	Use quieter and less vibration emitting construction methods where possible. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration reduction benefits.
Limit equipment on site	Only have necessary equipment on site.
Limit activity duration	Where possible, concentrate noisy activities at one location and move to another as quickly as possible.
Site access	Vehicle movements outside construction hours, including loading and unloading operations, should be minimised and avoided where possible.
Equipment maintenance	Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the design specifications.
Reduced equipment power	Use only necessary size and power.
Quieter work practices	For example, implement worksite induction training, educating staff on noise sensitive issues and the need to make as little noise as possible.
Reversing alarms	Consider alternatives, such as manually adjustable or ambient noise sensitive types (“smart” reversing alarms) and closed circuit TV systems. Alternative site management strategies can be developed, in accordance with the <i>Occupational Health and Safety Plan</i> , with the concurrence of the Occupational Health and Safety Officer.
Blasting regime	The noise and vibration impacts of blasting operations can be minimised by: <ul style="list-style-type: none"> • Choosing the appropriate blast charge configurations • Ensuring appropriate blast-hole preparation • Optimising blast design, location, orientation and spacing • Selecting appropriate blast times, and • Utilising knowledge of prevailing meteorological conditions. AS 2187.2 <i>Explosives-Storage, transport and use, Part 2: Use of Explosives</i> provides more detailed advice on ground vibration and airblast overpressure impact minimisation options.
Path controls	
Noise barriers	Consider installing temporary construction noise barriers. Install any permanent noise barriers required to minimise road traffic noise as early as possible in the construction process. Locate equipment to take advantage of the noise barriers provided by existing site features and structures, such as embankments and storage sheds.
Enclosures	Install noise-control kits for noisy mobile equipment and shrouds around stationary plant, as necessary.
Increased distance	Locate noisy plant as far away from noise-sensitive receptors as possible.
Site access	Select and locate site access roads as far away as possible from noise-sensitive areas.

Table 5.1 (continued)

Construction and maintenance noise and vibration management options	
Receptor controls	
Architectural treatment	Upgrade the glazing or window shutters of affected bedrooms.
Structural surveys and vibration monitoring	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.
Temporary relocation	In extreme cases.
Consultation	<p>Community consultation, information, participation and complaint responses are essential aspects of all construction noise management programs.</p> <p>They typically involve:</p> <ul style="list-style-type: none"> • A community information program before construction and/or high risk activities are commenced. This usually involves a leaflet distribution and direct discussions and negotiations with affected residents, explaining the type, time and duration of expected noise emissions. • The involvement of affected residents in the development of acceptable noise management strategies. • A nominated community liaison officer with a contact telephone number. • A complaints hotline. • Timely responses to complaints, providing information on planned actions and progress towards the resolution of concerns.

Adapted from Thalheimer (2000).

Tunnel construction noise and vibration

The construction of tunnels can generate significant noise, depending on the methods used.

If the tunnel is being bored, most of the noise will be confined to the tunnel but some will escape from the portals. Noise from ventilation fans can also be a problem, depending on the nature of the surrounding areas and the size of the fans.

If the tunnel is being constructed by “cut and cover”, noise will arise from normal earth-moving equipment such as excavators, front-end loaders, bulldozers and rollers, and possibly also from pile drivers, if piles are used for tunnel wall supports, and cranes used to put wall and tunnel roof panels in place. Careful consideration of the timing of all these activities is needed, to minimise their noise impacts.

A “cover then cut” approach, however, will progressively cause excavation works to take place in an enclosed environment, with substantial noise reduction benefits.

Vibration impacts from tunnelling also need to be addressed. Sources of vibration include rock breaking, vibrating rollers, sheet piling, tunnel boring machines and/or the roadheaders used to drive tunnels. Vibration from rock breakers, which rely on impulsive actions, is significantly greater than from large roadheaders, which tend to grind rock away.

Depending on the distance to the nearest residences, adverse impacts from tunnel boring machines and roadheaders are more likely to arise from structure-borne noise at night than from tactile vibration.

The use of roadheaders at night should be minimised when the tunnel is close to residential areas, and rock breakers should not normally be used at night at all.

Further reading

Thalheimer E (2000) *Construction Noise Control Program and Mitigation Strategy at the Central Artery/Tunnel Project*, Noise Control Engineering Journal, Vol 48, No 5, Sept–Oct.



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Part II

Framework

for noise and vibration management

6

Section 6

Legislative frameworks and noise and vibration criteria, standards and guidelines

Environmental Planning and Assessment Act 1979

Under Section 111(1) of the Environmental Planning and Assessment Act 1979, a “determining authority” deciding whether to approve a proposed “activity” must take into account, to the fullest extent possible, all matters affecting or likely to affect the environment.

Under Clause 228 of the Environmental Planning and Assessment Regulation 2000, these factors expressly include any:

- Environmental impact on a community
- Long-term effects on the environment
- Degradation of the quality of the environment, and
- Pollution of the environment.

Noise and vibration are thus clearly among the impacts on the environment that need to be assessed.

Volume 3 of the RTA’s *Environment Manual, Environmental Impact Assessment Policy, Guidelines and Procedures* provides a guide on how to conduct and report an effective environmental impact assessment.

The conditions attached to approvals may include requirements to mitigate traffic and construction noise and other environmental impacts.

Protection of the Environment Operations Act 1997

The Protection of the Environment Operations Act provides for the control of noise from most sources, including motor vehicles, industry, construction, water craft, products and neighbourhood sources.

The Protection of the Environment Operations (Noise Control) Regulation 2000 sets out maximum permissible noise levels for various classes of motor vehicles.

Under the Protection of the Environment Operations Act the EPA may issue Environment Protection Licences and notices relating to RTA premises or activities, whether “scheduled” or not, to control noise as follows:

- Anyone carrying out a “scheduled activity” listed in Schedule 1 to the Protection of the Environment Operations Act must obtain an Environment Protection Licence from the EPA before the activity may commence.

“Scheduled activities” include:

- Freeway and tollway construction (for new, rerouted or additional carriageways) if the completed works will have:
 - Physically separated carriageways for traffic moving in different directions,
 - At least four lanes, and
 - No access for traffic between interchanges

for at least 1 km of the road’s length in the Sydney, Newcastle, Illawarra, Blue Mountains greater metropolitan area or at least 5 km in any other area. The maintenance of freeways and tollways is specifically excluded from this “scheduled activity” definition.

An EPA Licence is not required for the construction of other roads or for operating noise (i.e. traffic noise) from any road, although the EPA’s comments on these issues are routinely sought during the environmental impact assessment phase for new projects.

It should be noted, however, that if a “non-scheduled” activity will result in the pollution of waters, this discharge will need to be licensed by the EPA, and noise mitigation conditions can be attached to this Environment Protection Licence.

- Quarries, gravel pits, concrete works, bitumen pre-mix and hot-mix works, dredging works and crushing, grinding or separating works, depending in some cases on their size and other factors described in Schedule 1.

In issuing an Environment Protection Licence for a “scheduled activity” the EPA may impose conditions for the monitoring and mitigation of environmental impacts, including traffic noise and construction noise and vibration.

- The EPA may issue Environment Protection Notices (Sections 95 and 101) and Noise Control Notices (Section 264) to control noise, requiring specific actions to be taken, prohibiting specified activities and/or limiting the times of operation of an activity or article.

Environmental Criteria for Road Traffic Noise (ECRTN)

The EPA worked closely with the RTA and other stakeholders in developing the *ECRTN*.

The *ECRTN* adopt a non-mandatory, performance-based approach.

But although the *ECRTN* themselves are not mandatory, they are intended to provide the basis for noise control conditions which will be applied to future road development approvals, land-use development approvals and EPA environment protection licences.

The *ECRTN* document presents **comprehensive traffic noise level criteria** for:

- New and “redeveloped” roads of various types in urban and rural areas
- New residential developments affected by traffic noise
- Land use developments that might create additional traffic on different types of roads, and
- Particularly sensitive types of land uses (school classrooms, hospital wards, churches, active recreation areas, passive recreation areas and school playgrounds).

For details on these definitions and guidance on how to determine which criteria apply, please refer to *Practice Note 1*.

Road “redevelopments” are defined as works where it is proposed to increase traffic-carrying capacity, change the traffic mix or change the road’s alignment through design or engineering changes. They do not include “minor” roadworks to improve safety, such as the straightening of curves, the installation of traffic control devices or “minor” realignments.

The *ECRTN* also sets out noise measurement and assessment methodologies and strategies for reducing traffic noise, to help:

- Land-use planners to consider the extent to which the judicious location and design of development can mitigate or avoid unacceptable traffic noise impacts
- Road designers, regulators and the community to consider how to avoid or reduce noise from new roads and the redevelopment or upgrading of existing roads, and
- Manufacturers and users of vehicles to consider the contributions they can make to reduce noise.

The *ECRTN* establish target noise levels for a range of developments and land uses. The *ECRTN* acknowledge, however, that these targets may not be able to be achieved through traffic management, architectural acoustic treatments, quieter pavement surfaces or roadside treatment measures such as noise barriers. In these cases longer term strategies — expressly including controls on road users’ behaviour (e.g. speeding, indiscriminate use of engine brakes), land use planning and building designs — need to be evaluated.

Noise levels higher than the target levels may be specified in planning approvals if it can be *demonstrated* that the target levels cannot be met by applying “all feasible and reasonable mitigation measures”. In these cases the target levels should be approached as closely as possible, with the aim of

adopting “broader supporting strategies” to achieve the criteria in the longer term.

In this context, “feasibility” refers to engineering practicality, while “reasonableness” is to be judged by taking account of:

- Noise mitigation benefits and costs
- Community views and aesthetic impacts
- Existing and future noise levels at affected land uses, and
- The benefits of the proposed development.

The *ECRTN* aim to refocus the mitigation of road traffic noise from relatively late in the road development process to a much earlier stage, so that land-use planning and regulatory and policy decisions can be applied to avoid noise where possible, and so that road routes can be selected and alignments and designs developed, right from the start, to meet the target noise levels where practicable.

This approach marks an important departure from “traditional” noise mitigation approaches, which have relied very heavily on “add on” engineering approaches such as extensive and often unsightly noise barriers and low noise road pavements. These approaches have become increasingly costly and have not always effectively protected the community from excessive noise.

In short, to address the *ECRTN*, **noise control issues now need to be integrated into the overall design process, rather than treated as “after-the-event” mitigation responses.**

Section 7 and *Practice Note 1* include further advice regarding the interpretation and application of the *ECRTN*.

Planning NSW EIS Guideline *Roads and Related Facilities*

Planning NSW’s EIS Guideline *Roads and Related Facilities* (Planning NSW 1996) outlines the issues to be addressed in environmental impact assessment and the factors to consider when preparing an EIS.

It also provides guidance for consultations and describes procedures for route and site selection.

EPA construction noise guidelines

Chapter 171 of the EPA’s *Environmental Noise Control Manual* recommends noise level and time restrictions for construction activities.

These EPA guidelines take account of the facts that construction activities can be of a transient nature and that noise from construction activities is often difficult to limit even with good control measures.

Background noise levels should be determined using the “tenth percentile method” described in the EPA’s *NSW Industrial Noise Policy*.

EPA NSW Industrial Noise Policy

This policy sets criteria and objectives for the management of noise impacts from industrial and commercial sites. It does not cover the management of road traffic or construction noise.

Even so, the “tenth percentile method” for determining the background L₉₀(15 min) noise level should also be applied in the assessment of road construction noise impacts.

Australian Road Rules 1999

The Australian Road Rules makes it an offence to start or drive a vehicle in a way that makes unnecessary noise.

Road Transport (Safety and Traffic Management) (Road Rules) Regulation 1999

These regulations require the driver of a motor vehicle, when it is stationary, to stop its engine so far as necessary for the prevention of noise.

Road Transport (Vehicle Registration) Regulation 1998

Under this regulation a person may not use a registrable vehicle on a road or road-related area unless the vehicle complies with defined vehicle noise standards and is fitted with an exhaust silencing device.

Vibration standards

The standards that may be used for measuring and assessing the impacts of vibration are:

- British Standard BS 7385: *Part 2: Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration*
- German Standard DIN 4150, *Part 3: Structural Vibration in Buildings: Effects on Structures*
- British Standard BS 6472 *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*
- Australian Standard AS 2670, *Evaluation of Human Exposure to Whole Body Vibration, Part 2: Continuous and Shock-Induced Vibration in Buildings (1 to 80 Hz)*
- Environmental Noise Control Manual, Chapter 174, *Vibration in Buildings*, EPA.

These standards provide vibration assessment goals and outline basic procedures for measuring and assessing vibration.

Blasting guidelines

The documents that may be used for measuring and assessing the impacts of blasting are:

- The ANZECC *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*, adopted by the EPA.

These guidelines are not intended to be structural damage criteria. They do, however, provide a conservative approach to assessing blasting impacts.

- Australian Standard AS 2187.2-1993: *Explosives – Storage, Transport and Use, Appendix J – Ground Vibration and Airblast (Informative)*.

This standard also provides guidelines for blasting overpressure and ground vibration, consistent with the ANZECC guidelines. It sets out a basis for measuring impacts and estimating peak particle velocities from the maximum charge weight per delay, geological conditions and the type of blasting (confined or free face).

7

Section 7

Processes to manage traffic noise from new and upgraded roads

An outline of the road development process and a framework for managing traffic noise from new and redeveloped roads, right from the route option and concept planning stages through to implementation and project completion. This framework should be read in conjunction with the construction noise and vibration management framework described in Section 9.

Issues

Noise impacts and potential noise mitigation strategies and designs need to be identified, developed and assessed throughout the road development process, right from the initial strategic and concept stages through to construction and project opening.

This allows the formulation of optimum noise impact control measures as an integrated part of the overall road design process — and not merely as “add on” mitigation after its concept design and much of its detailed design has already been carried out.

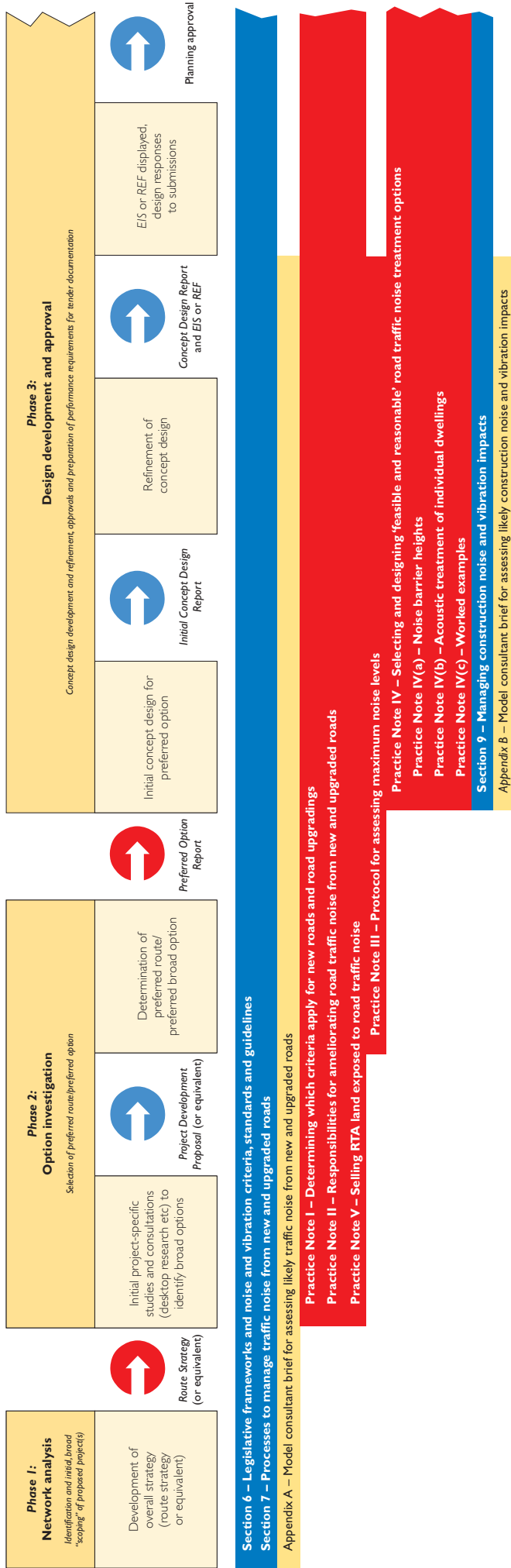
This approach is in accordance with the RTA’s 1999 Project Management Framework (see the RTA’s *Urban Design Practice Notes, Beyond the Pavement*). This framework splits the design and construction of new, redeveloped or upgraded roads into five project “phases”, with specific documentation and review (“hold point”) requirements within and between these phases.

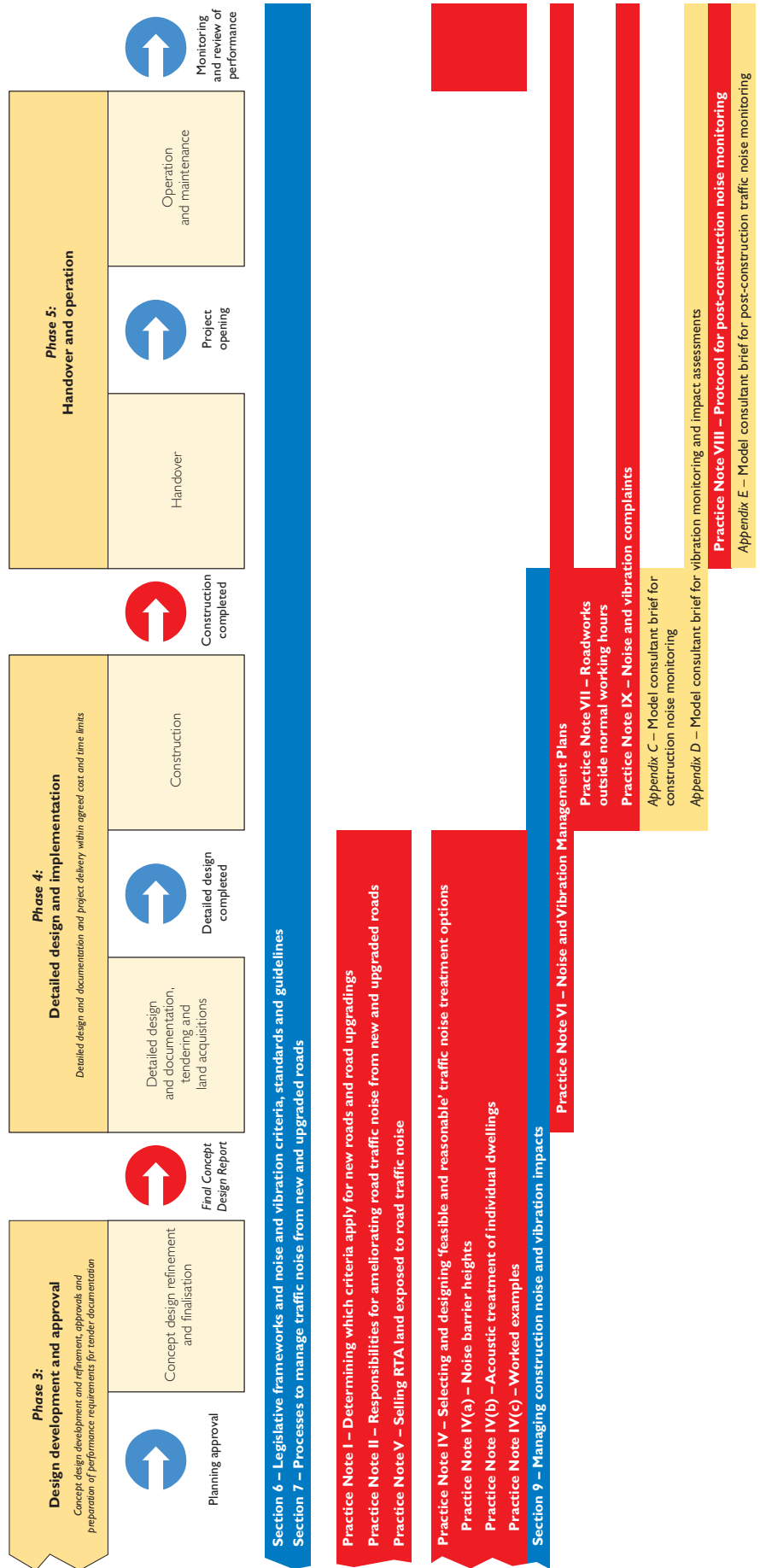
- **Phase 1 is a “network analysis” phase.** Its objective is to strategically identify and broadly “scope” and prioritise possible road options within an area or corridor.

The strategies developed in this phase are based on analyses of transport needs, Government priorities and initial analyses of regional environmental and urban design considerations.

- **Phase 2 is an “option investigation” phase** for each road option within the broad strategies developed in Phase 1. Its objective is to select a preferred route (if this is an issue) and/or a preferred project option.

These selections are initially based on broad investigations of conceptual options for the project, including analyses of their likely environmental, urban and regional design benefits and adverse impacts.





Following the selection of a preferred route a more detailed investigation of road traffic noise impacts and peak impacts, such as those caused by heavy vehicles, should be undertaken. This impact assessment can then be used as a basis for further quantification and prioritisation of available vertical and horizontal alignment options and the selection of a preferred option.

- **Phase 3 is a “design development and approval” phase.** Its objectives are to:
 - ◻ Further develop and progressively refine design concepts
 - ◻ Obtain planning approval and other environmental approvals and licences for the project, and
 - ◻ Develop performance requirements, including specified urban and regional design outcomes, for the detailed design and construction of the project during Phase 4 and the subsequent (Phase 5) operation and maintenance of the project.

Among other things, Phase 3 involves the production of a series of *Concept Design Reports*, an *Environmental Impact Statement or Review of Environmental Factors*, in some cases a *Representations Report* and finally, after the project is approved, a *Final Concept Design Report*.

- **Phase 4 is the “detailed design and implementation” phase.** Its objective is to ensure the intent of the project is achieved within agreed cost and time limits.

Phase 4 involves detailed design and documentation of the project, in accordance with its Phase 3 concept designs, performance requirements and approval conditions, and tendering and construction processes.

- **Phase 5 is the “handover and operation” phase.** Post-construction monitoring is carried out following the opening of the project.

It is emphasised again that under this framework noise and vibration management tasks are vital components of *all five* phases.

The tasks involved are described below.

Phase 1: network analysis (route strategy development)

Phase 1:
Network analysis
Identification and initial, broad “scoping” of proposed project(s)

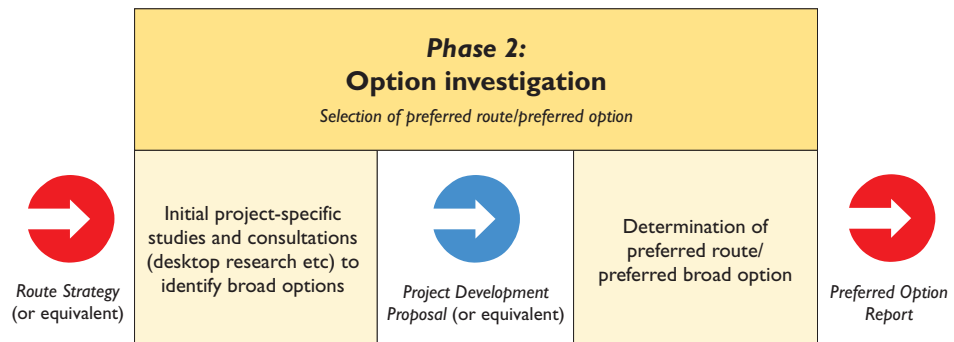
Development of overall strategy (route strategy or equivalent)



Route Strategy (or equivalent)

- Establish a “project noise issues planning checklist” and check it against the RTA *Environmental Impact Assessment Policy, Guidelines, Procedures* to ensure that noise issues will be adequately considered in all stages of the project, from initial “route strategy” analyses to monitoring after the completion of construction.
- Broadly evaluate potential noise issues and noise impacts associated with the strategy options in terms of the populations affected/benefited and cumulative contributions from other sources, such as heavy industry and aircraft flight paths.

Phase 2: route selection and option investigation



The outputs of Phase 2 are:

- A *Project Development Proposal*, which documents the options being considered after preliminary route and option investigations, and
- A *Preferred Option Report*, which documents the preferred option after more detailed investigations, including a value management study.

If the proposed route is well defined, Phase 2 investigations will be focussed on the development of a preferred vertical/ horizontal alignment option.

It is essential to conduct sufficient noise impact analyses to gain an adequate understanding of noise issues as inputs to Phase 2's value management study or studies.

Phase 2(a) *Project Development Proposal*

As inputs to the selection of a preferred route:

- Define noise-related design objectives, criteria and principles.
- Undertake a preliminary identification of potential noise issues at a corridor/route level:
 - For all potential corridor(s) and/or route(s), identify possible noise and vibration issues and concerns, the applicable noise level targets for different sections of the corridor/route as stipulated in the *ECRTN*, all possible means of achieving these targets, and their potential design, cost, community consultation and planning and environmental approval implications.
 - As part of this process, initiate consultations with other agencies, stakeholders, interest groups and local communities. In particular, negotiate with key agencies such as Planning NSW and the EPA on their assessment and approval criteria, processes and documentation requirements for the project, identify their concerns and review the options with them as relevant information becomes available. (For guidance on consultation processes generally, please refer to the RTA's *Community Involvement: Practice Notes and Resources Manual* and *Practice Note 5* in the RTA's *Urban Design Practice Notes, Beyond the Pavement*.)

Before finalising and comparing route options, it is essential to discuss all noise issues with Planning NSW, the EPA and the

relevant local government authorities to obtain an indication of the noise and vibration issues that are likely to be of concern to them.

- Conduct site inspections with all members of the project design team and with relevant local stakeholders, interest groups and community members who can often provide very useful information as inputs to route selections and concept design development.
- Evaluate the noise impacts of the route options using broad descriptors. Projected traffic flows and mixes are useful indicators of noise levels.
- Review all available traffic data and noise monitoring data of relevance to the options, especially to identify site-specific noise issues such as low background noise levels and intermittent peak noise events.
- Develop plans identifying significant topographical features, all potentially affected areas, residences and other noise-sensitive receivers.
- If helpful or necessary at this stage, conduct indicative ambient noise monitoring.

Usually road traffic noise monitoring is not necessary at this stage, as potential road traffic noise impacts can be adequately identified through simple noise modelling, with the only inputs being required, in order to broadly identify setbacks from the road alignment where noise criteria should be able to be met, being projected traffic volumes, mixes and speeds.

- Analyse and compare the noise and vibration-related costs and benefits of all the identified options.

This analysis is used as an input into wider-ranging evaluations of the options' costs and benefits and their economic and financial viability, taking account of the options' likely "beyond the pavement" costs and benefits (e.g. changes in accessibility, environmental quality, land uses and property values). The RTA's *Economic Analysis Manual* provides advice on a range of cost-benefit methodologies that could be used.

- Document these noise and vibration-related investigation processes and their outcomes in the *Project Development Proposal*.

Phase 2(b) Preferred Option Report

The design team's resources should be directed to developing the preferred concept design prior to the initiation of the EIA, so that any significant concept design changes can be made as easily as possible (see *Practice Note 6* in *Beyond the Pavement*).

Following on from the initial work leading to the *Project Development Proposal*, in assessing the identified options in more detail it is essential to continue to clarify noise and vibration issues and concerns, assess existing noise environments and confirm the applicable noise level targets for each section of the route under the *ECRTN*.

As already indicated in *section 6*, the main noise level targets in the *ECRTN* apply for new roads and road “redevelopments”. Road “redevelopments” are defined in the *ECRTN* as works where it is proposed to increase traffic carrying capacity, change the traffic mix or change the road’s alignment through design or engineering changes. They do not include road reconstruction and “minor” roadworks to improve safety, such as the straightening of curves, the installation of traffic control devices or “minor” realignments. There are no noise level targets in the *ECRTN* for minor road upgrades.

Practice Note I in Part III of this *Environmental Noise Management Manual* further clarifies the noise criteria by providing principles that should be applied to sites affected by new roads, road “redevelopments” and road upgrades that are not “redevelopments”. These principles apply to a range of different development types and to sites affected by a transition between differing road development types.

The nature, extent and detail of the noise assessment required for any particular project will obviously depend on the likely impacts of the proposal.

New roads and road redevelopments will require more detailed assessments than road upgrades not involving any increase in design traffic flows.

Minor upgrades such as turning lanes and parking lanes may only require a relatively broad assessment of changes in the surrounding noise environment, based on traffic volumes, compositions and changes in the distances between noise sources and receivers.

Noise studies for road upgrades which are not classified as “redevelopments” generally do not need to be commenced until Phase 3. If this is the case, follow the steps set out below during Phase 3.

The measurement of existing noise levels and the prediction of future traffic noise must be undertaken by an accredited acoustic consultant, eligible for the minimum grade of “Member” with the Australian Acoustical Society.

In the case of multi-level residential buildings, noise impacts should be evaluated for all exposed façades. Decisions on whether to provide noise controls to reduce noise impacts for each individual occupancy within these buildings will depend on an analysis of the extent of the impacts, changes in noise levels, cost-effectiveness, practical and aesthetic constraints on noise barrier heights, upper cost limits for architectural acoustic treatments (see *Practice Note IV(b)*), any limitations on the installation of treatments as a result of access difficulties and the availability of fresh air ventilation within the buildings (it will generally be impractical to provide fresh air ventilation to multi-level residential buildings).

In some situations the RTA has acquired properties with noise-sensitive buildings, with the intention of reselling these properties at a later time. Any such sites must be included in the noise impact assessment and noise controls must be implemented if the noise assessment indicates they are necessary. (*Practice Note V* sets out the RTA’s position relating to the *sale* of RTA land exposed to road traffic noise.)

Step 1: Identify issues and noise level targets

- Define the affected area(s) by identifying potentially affected residences and other noise-sensitive receptors on a plan.

- Use site inspections, consultations, traffic data and previous noise monitoring data (if available) to identify potential noise issues, including low background noise and intermittent peak noise events.
- Define the categories of roadworks and identify the corresponding operational noise level targets for the project.
- Broadly identify all possible control mechanisms to meet these targets.

Step 2: Measure existing noise levels

- Monitor existing noise levels to assess the existing road traffic noise environment relative to current traffic volumes and compositions.
 - Measure existing noise levels at sites which would be affected by the proposal and are representative of other similar sites. Considerably fewer monitoring locations will be required in areas with low existing traffic noise.
 - Typically, seven consecutive days would be considered the minimum number of days to monitor. However, monitoring may be carried out over a lesser number of days in areas where there is low existing traffic noise or the monitoring period can be competently justified as being representative of the road traffic noise currently being experienced.
 - Exclude noise from sources other than road traffic. If this is not possible, document the other noise sources and their estimated contributions to the measured noise levels. In these circumstances, noise level reporting should also include noise levels adjusted by subtracting the extraneous contributions.
 - Road traffic volumes and compositions may need to be recorded for a full day of noise monitoring to permit later verification and, if appropriate, calibration of noise prediction models (Step 3 below). Ensure there are no special events which will result in atypical noise levels or traffic conditions during these measurements.
 - Avoid monitoring during rain, when the road is wet or when the wind speed exceeds 5 m/sec. Any data collected under these conditions should be discarded.
- Pre-construction noise monitoring for road traffic noise assessment purposes may not be necessary for some minor upgrades where existing noise impacts are not significant and the potential impacts can be adequately represented by simple modelling of the changes in noise levels.
- *Appendix A* sets out a model consultant brief to carry out the entire traffic noise assessment, including the route strategy development, route and option analysis and pre-construction road traffic noise monitoring.

Step 3: Predict future noise levels

- Assess the predicted noise environment. The model consultant brief in *Appendix A* outlines modelling considerations for these noise predictions.

- Verify the models predicted noise levels against monitored existing noise levels.

The noise model predictions must be verified against the measured existing noise levels using AADT and/or monitored traffic data as noise model inputs. The nature of the model verification process will depend on the particular project and sites (flat or hilly terrain, the presence of natural noise barriers, the presence of extraneous noise sources, etc). The noise consultant must identify the key issues relating to verification for the specific project and implement the required verification methodology.

- Where appropriate, model the existing noise environment based on the monitored noise levels and the results of model verification.

The need to conduct a detailed assessment of the existing noise environment as early as possible in the project's concept design will often mean noise monitoring is conducted some years before project opening.

In these situations noise levels at sites affected by existing road traffic noise will often increase because of an increase in traffic flow between the time of the original monitoring and the opening date. The noise criteria to be applied for the project, which partly depend on "existing" noise levels (see *Section 6* and *Practice Note I*), may be affected by this change.

To address this situation, noise levels from existing sources of road traffic noise may be predicted for the time of project opening. This predicted level of "existing" traffic noise is often termed the "**future existing**" noise level.

In developing these predictions of "future existing" noise levels for a road it is imperative to ensure that traffic flow projections can be applied with confidence and that the noise predictions are adequately verified.

Existing road traffic noise levels still need to be monitored and still provide the basis for assessing whether the existing noise environment is already high.

It will also be necessary to conduct traffic monitoring prior to construction to validate the prediction model and verify the suitability of the proposed noise controls. Accordingly, existing road traffic noise levels, traffic volumes and mix still need to be measured in order to validate modelling for future traffic conditions.

The use of "future existing" noise levels only applies to projects with a long lead time (e.g. five years) and needs to be justified. Ideally, existing road traffic noise levels should be based on actual measured levels at the time of assessment.

If "future existing" noise levels are used, they must be applied to the whole project route, without including any changed traffic conditions resulting from individual redevelopment projects within the route (e.g. Pacific Highway reconstruction project), so that progressively higher redevelopment-induced noise levels do not occur.

- Predicted noise levels should include road traffic noise from the proposal and from other roads which may influence the predicted levels.
- In all cases, predict the noise environment at the time of project opening.
- For new roads and road redevelopment projects, also predict the noise environment 10 years after opening.
 - If traffic volumes are expected to reach design capacity within 10 years, predict noise levels at the time design capacity will be reached.

Step 4: Evaluate noise impacts

- For each of the vertical/horizontal alignment options under consideration, identify all road traffic noise impacts for the predicted noise environment (including any part of the surrounding road network affected by a proposal).
 - For new roads and road redevelopments where numerous noise-affected sites are identified, present this information in the form of noise contours on maps, as well as in a tabular form.
 - For options where the surrounding development comprises sparsely located single dwellings or there are unlikely to be any significant increases in noise impacts, it may be acceptable to just present the information in a tabular form.
- Compare the predicted noise levels with the “base” target noise levels (columns 2 and 3 of Tables 1 and 2 in the *ECRTN*).
- If noise levels are predicted to exceed the “base” targets in the *ECRTN*, determine the number and location of residences and other noise-sensitive receptors that will be affected for each of the options being considered.
- Evaluate existing and likely future maximum noise level impacts and other changes in the impact of traffic noise, using vehicle emission levels, monitored and predicted AADT traffic volume and composition data and monitored and predicted noise level data.
 - This assessment will include an evaluation of whether the impacts are likely to increase or decrease as a consequence of the project.
 - The extent of assessment required will depend on the size of the project and the likelihood of maximum noise level impacts. More detailed assessments may require an analysis of simultaneously recorded classified traffic counts and noise monitoring data.
 - The evaluation should include the calculation of representative values for maximum noise levels, the extent to which the maximum noise levels exceed ambient L_{Aeq} noise levels and the number of noise events.
 - Sleep disturbance criteria are currently not defined in the *ECRTN*. The maximum noise level assessment may, however, be used to

assist in prioritising the available route options and noise control options.

- Please refer to *Practice Note III* for a maximum noise level assessment protocol.

Step 5: Evaluate and select a preferred option

- Evaluate all available options and select a preferred option that is both “feasible” and “reasonable” for reducing noise impacts towards the target noise levels.

- As discussed in *Section 6* and detailed in the *ECRTN*, where it can be demonstrated that it is neither “feasible” or “reasonable” to reduce noise levels to the “base” targets, higher noise levels may be acceptable and longer term noise control strategies will need to be considered.

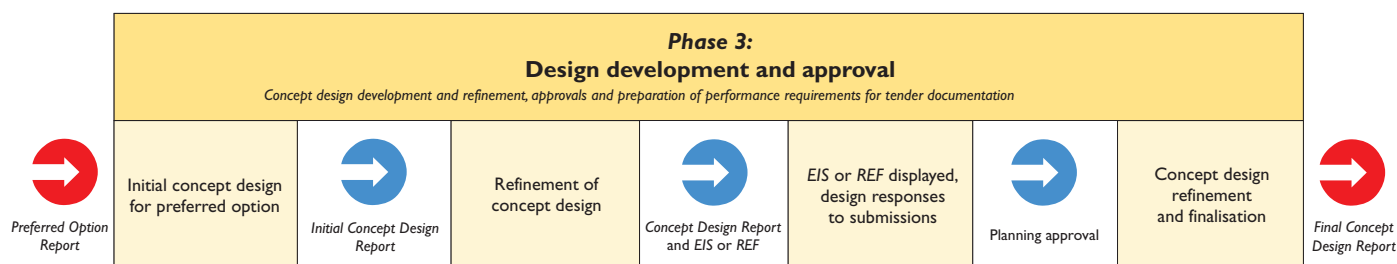
“Feasibility” relates to engineering considerations and what can practically be built.

“Reasonableness” is to be judged in terms of noise mitigation benefits and costs, community views, aesthetic impacts, existing and future noise levels at the affected sites and the benefits arising from the development.

These issues will be explored in detail during Phase 3 and Phase 4 of the project development.

- The evaluation should consider “what if” scenarios based on noise modelling results for each of the options under consideration.
- The options under consideration may include a range of traffic management scenarios and adjustments to horizontal and vertical alignments to optimise the benefits of making use of surrounding topographic and screening features. This evaluation should also take into account the surround land-use types and their relative sensitivity.
- As an input to any wider value management study comparing the options, conduct a cost-benefit analysis of all the options.
 - The RTA’s *Economic Analysis Manual* provides advice on cost-benefit methodologies that could be used during development of the preferred option.
 - At this stage of the development process, the cost-benefit analysis is used to prioritise and select a preferred option. A comparative cost-effectiveness analysis of noise control treatments — such as barriers, architectural treatments and quieter pavements — may also need to be conducted during Phase 3 of the development process, during the EIA if required, and may later need to be refined during the detailed design stage of Phase 4.
- Finalise the preferred option, including preliminary design concepts, taking into account the findings of the Value Management Study workshop.

Phase 3: design development and approval



Phase 3(a) Preparation of initial concept designs

- For the preferred option, continue to clarify noise and vibration issues and concerns and confirm the applicable noise level targets for each section of the route under the *ECRTN*.
- In liaison with all other members of the multi-disciplinary project design team, develop initial design concepts for possible means of achieving the target noise levels, as part of overall initial concept designs for the project.
 - If not already undertaken, conduct an assessment of noise impacts by following the Phase 2 *Preferred Option Report* steps described above.
 - As part of this process, continue to consult with other agencies, stakeholders, interest groups and local communities. Review initial design concepts for the preferred option with key agencies such as Planning NSW and the EPA.
- Document these noise and vibration related investigation and concept design processes and their outcomes in the design team's progressively developed design reports.

Phase 3(b) Noise inputs to concept design refinement, the *EIS/REF* and the *Representations Report*

If possible, the noise related sections of the *EIS* or *REF* should be prepared by the project design team members who have conducted or managed the noise investigations and design studies listed above, rather than by new consultants brought in specifically for this task. The proposal or “activity” for which approval is being sought should be the result of the efforts so far of the people preparing the *EIS* or *REF*, not their starting point.

A model for preparing *EIS* or *REF* noise assessment reports is set out at the end of this section 7.

- As inputs to the preparation of concept designs and the *EIS* or *REF* and any subsequent *Representations Report*, conduct a systematic **road traffic noise impact assessment** based on Phase 2 investigations and the refined design concepts. Where the assessment identifies that the target noise levels are likely to be exceeded, noise mitigation options will need to be evaluated.

Evaluation of suitable noise controls

- Identify and list all available short-term and long-term noise-controls.

See Section 9 for a framework for managing construction noise and vibration impacts.

For guidance on RTA and developer responsibilities for ameliorating noise impacts on sensitive developments, see *Practice Note II*.

Guidelines for analysing the “feasibility and reasonableness” of quieter pavement surfacing, noise barriers and acoustic treatments for individual dwellings are set out in *Practice Note IV*.

A procedure for determining an acceptable balance between noise barrier heights and cost-effectiveness is set out in *Practice Note IV(a)*.

A procedure for selecting appropriate acoustic treatments for individual buildings is set out in *Practice Note IV(b)*.

Worked examples of analyses of “feasible and reasonable” noise treatments are provided in *Practice Note IV(c)*.

- In consultation with the multi-disciplinary project design team, other agencies, stakeholders, interest groups and the community, identify a set of preferred options.
- In addition to considering engineering feasibility and noise mitigation performance — including the techniques and options outlined in *Sections 1 to 5* — take full account of all other relevant factors, including aesthetics, landscaping options, the protection of views and the local “character” of affected areas, the avoidance of shadowing, the avoidance of interference to radio or television reception, equity issues (e.g. whether affected residential developments were established in areas that were already exposed to road traffic noise), community preferences, safety issues, heritage issues, community access and severance and the protection of natural environments (e.g. the effects of any changes to stormwater flows).
- For suggestions on these issues, please refer to the RTA’s *Urban Design Practice Notes (Beyond the Pavement)* and the *RTA Roadscape Guidelines*.
- Conduct a systematic **construction noise and vibration impact assessment** based on the refined concept designs (see *Section 9*).
- **Evaluate the “feasibility and reasonableness”** of the proposed and alternative noise control concept designs by referring to *Practice Note IV*.

This *Practice Note* includes a process for analysing comparative cost-effectiveness in the consideration of practicality issues, treatment effectiveness, visual impacts, changes in noise levels and community preferences.

- **Assess the durability and maintainability** of the proposed and alternative noise-control concept designs, in consultation with the RTA’s Asset Management Branch.
- **Revise and refine the concept designs and their construction methods** in the light of the findings of these assessments and consultations and (later) in the light of responses to the project’s EIA.
- If the target noise levels are likely to be exceeded, document all aspects of the design and selection of noise mitigation options and techniques, including their practicality, expected noise-mitigation performance, cost-effectiveness, aesthetic impacts and community preferences and responses.

EIA finalisation and approval

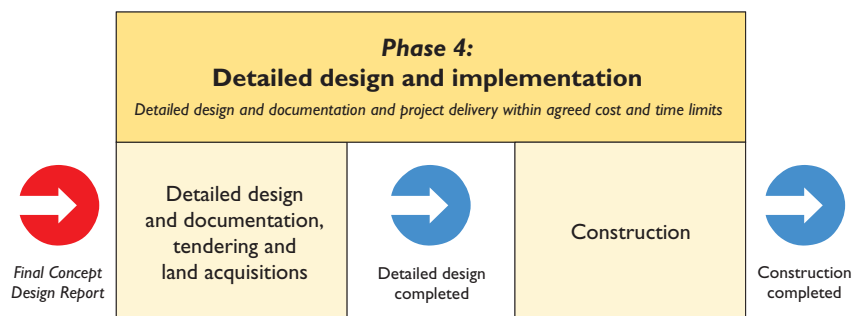
- **Document** all these noise and vibration related investigation and design refinement processes and their outcomes in the design team’s progressively developed design reports, culminating in the draft *EIS* or *REF* and a *Concept Design Report*.
- If an *EIS* or *REF* is exhibited, document the noise and vibration related aspects of the RTA’s responses to the submissions received, including amendments to the project’s concept designs, and summarise these responses in a draft of the *Representations Report*.

- Prepare draft noise and vibration related performance requirements for tenderers.
 - These will ultimately reflect the outcomes and conditions of the project's planning approval and any environment protection licence, as well as the designs and standards developed and refined during Phases 2 and 3 of the design process.

Phase 3(c) After planning approval is obtained

- Document all the conditions attached to the project's approvals and licences.
- Conduct any further noise or vibration investigations that might be needed to address concerns and to refine the concept design.
- Develop final concept designs, including responses to noise and vibration-related planning approval and environment protection licence conditions.
- Refine the noise and vibration related aspects of the draft performance requirements for tenderers to reflect the final design concepts and all relevant planning approval and any environment protection licence conditions.

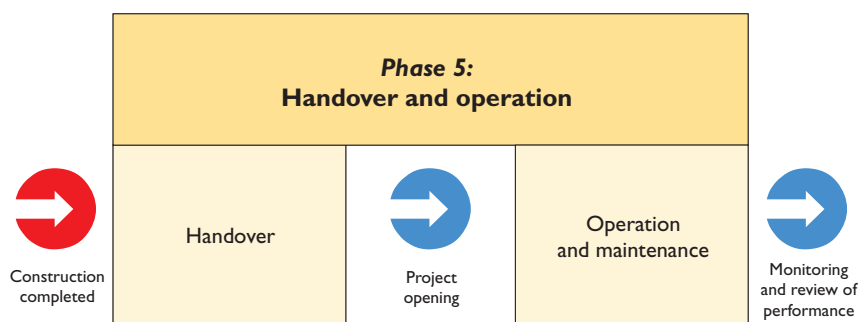
Phase 4: detailed design and implementation



- In liaison with other design team members and the EPA, and in consultation with local communities, prepare the noise and vibration related aspects of the RTA's *PEMP*, addressing all noise and vibration issues, standards, safeguards and noise management practices for the construction and operational phases of the project, including the maintenance of roadside noise treatments.
 - For projects likely to have significant noise and vibration impacts, the RTA's *PEMP* must include a requirement for the successful tenderer to prepare a *NVMP* as part of its *CEMP* (a model *NVMP* is provided in *Practice Note VI*).
- If preliminary detailed design is being undertaken by the project's RTA design team, carry out the noise and vibration related aspects of this work.
- Finalise the noise and vibration related aspects of tender documentation, including the final form of the performance requirements for tenderers progressively developed during Phase 3 and from the *PEMP*.

- With other members of the RTA's design team, **assess the noise and vibration related aspects of tenders** using pre-defined selection criteria — including, in the case of D&C, DCM and BOOT projects, the tenderers' noise and vibration related design resources and designs.
- If the RTA's design team is undertaking **detailed design and documentation** prior to the letting of construction tenders or prior to construction by the RTA,
 - Finalise the selection of noise control options.
 - Finalise the development and documentation of detailed noise-related designs consistent with the project's planning approval and any environment protection licence, again taking account of all other relevant design considerations, including practicality, cost effectiveness, visual impacts, community preferences, equity, storm-water flows, maintenance requirements, community access and severance, safety issues and heritage issues.
 - Refer the complete noise treatment design plan to the RTA Noise Wall Panel for review. (The Noise Wall Panel reviews and makes recommendations on noise wall design proposals and advises on whole-of-life maintenance issues relating to noise wall treatments and associated landscaping.)
- If contractors are undertaking detailed design and documentation (under a D&C, DCM or BOOT contract structure), then prior to applying for an Environment Protection Licence (or, where this is not required, prior to the commencement of construction):
 - Refer the complete noise treatment design plan to the RTA Noise Wall Panel for review, as discussed above.
 - With other RTA design team members, review and agree to the *CEMP*, including any *NVMP*.
 - Monitor the compliance of the successful tenderer's designs with:
 - The noise and vibration-related performance specifications and standards set out in the final tender documentation prepared by the RTA, including the *PEMP*, and
 - Planning approval and environment protection licence requirements.
- Before construction, review and agree to the *CEMP*, including any *NVMP*, if this has not already been done.
- The *NVMP* should include documentation of the “**design noise level for year 1**” for each of the selected noise-mitigation options. This is the noise level for the road development at the year of project opening, after all feasible and reasonable mitigation strategies have been applied.
- It is important to undertake **accurate modelling of the treatment measures**. If post-construction monitoring later shows that any treatment design goals established by Planning NSW have not been met, additional noise treatments may then be required.

Phase 5: Operation



After completion:

See Appendix E for a model consultant brief for post-construction noise monitoring.

- For projects to be maintained by the RTA, ensure that the contractor prepares a **Project Maintenance Plan** which addresses all aspects of the project affecting its noise and vibration performance, including the maintenance of road surfaces, vegetated noise mounds and noise barriers.
- Monitor and review the effectiveness of the “as built” designs and assess the need for modifications.
 - A protocol for post-construction monitoring and evaluation of noise-control performance is provided in *Practice Note VIII*.
- Report the results of this monitoring and review to the community.
- Record the provided noise treatments on the RTA’s *Noise Abatement Program* (NAP) database (see *Section 8*).

Further reading

- EPA (1999) *Environmental Criteria for Road Traffic Noise*
- RTA (2001) *Environmental Impact Assessment Policy, Guidelines, Procedures*
- RTA (1998) *Community Involvement: Practice Notes and Resource Manual*
- RTA (1998) *Roadscape Guidelines*
- RTA (1999) *Economic Analysis Manual, Version 2*
- RTA (1999) *Beyond the Pavement: RTA Urban Design Practice Notes*.

Model format and content for REF/EIS noise assessment reports

Introduction/project description and purpose

- Outline the background and purpose of the proposal.
- Describe the proposal.
- Identify whether the proposal will increase the traffic carrying capacity, change the traffic mix or involve more than minor realignments of the roadway.
- Identify the relevant road classification for applying the target noise levels in the *ECRTN* (e.g. new freeway or arterial road/redeveloped freeway or arterial road).

Traffic flow and composition summary

- Outline the source(s) of the traffic data and the traffic volume and composition predictions (the traffic data reported in this section are used as inputs for the noise prediction model).
- Tabulate the projected day and night traffic volumes and compositions, including percentages for each class of vehicle, for the existing environment, at project opening (once traffic levels have stabilised) and at year 10 (or at design capacity, if traffic flows are predicted to reach this capacity in the short to medium term).
 - For road upgrades where it is not planned to increase traffic carrying capacity or change the traffic mix and involving only minor realignments, traffic data need be reported only for the time of project opening. Minor road upgrades may require only a statement of whether they are likely to affect traffic volumes or compositions.

Existing noise environment

- Describe the study area.
- Discuss the noise catchments, noise monitoring procedures and identify the monitoring locations and corresponding monitoring periods. Include, as an attachment, a map clearly identifying the monitoring locations, and the existing and proposed route alignments.
- Outline instrumentation used.
- Tabulate locations and measured noise levels.
 - As a minimum, noise levels should be tabulated on the basis of the descriptors $L_{Aeq}(24hr)$, $L_{Aeq}(15hr)$ and $L_{Aeq}(9hr)$.
 - As a minimum, graphical representation of the descriptors L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , for each 15-minute period should be presented in the report's attachments.
- Tabulate traffic volumes and percentages for each class of vehicle, during the course of noise monitoring (if traffic measurements are taken for noise prediction model verification).

Noise criteria

- Specify road traffic noise criteria applicable to the project and identify the prediction years.

Noise prediction modelling

- Describe the noise prediction model used, detailing the model's assumptions (speed, road surface, source heights, corrections, etc) and the prediction model verification procedure.
- Tabulate the prediction model's verification results, comparing measured and predicted existing noise levels during the time of noise monitoring.
- Discuss the verification and justify any variances.
- Identify and justify any calibration corrections that are applied.

Road traffic noise assessment

- For new roads and road redevelopment projects, tabulate:
 - The prediction locations.
 - The applicable traffic target noise levels as set out in columns 2 and 3 of Table 1 and/or Table 2 in the *ECRTN* (the “base” target noise levels), and, if the “future existing” noise levels exceed these target noise levels, the applicable allowances over “future existing” noise levels as set out in column 4 of Table 1 and/or Table 2 in the *ECRTN*.
 - ☞ *Note that these allowances may not be adopted as noise goals by default. An assessment of the feasibility and reasonableness of meeting the “base” target noise levels must be undertaken, as described under “Noise mitigation options” below.*
 - Monitored existing $L_{Aeq}(24hr)$, $L_{Aeq}(15hr)$, $L_{Aeq}(9hr)$ and $L_{Aeq}(1hr)$ (*as required*) noise levels at the prediction locations.
 - Predicted existing $L_{Aeq}(24hr)$, $L_{Aeq}(15hr)$, $L_{Aeq}(9hr)$ and $L_{Aeq}(1hr)$ (*as required*) noise levels at the prediction locations, if applicable.
 - Predicted $L_{Aeq}(24hr)$, $L_{Aeq}(15hr)$, $L_{Aeq}(9hr)$ and $L_{Aeq}(1hr)$ (*as required*) noise levels for the proposed road environment at the time of project opening. Show the changes in noise levels between existing and the proposed road environment at the time of road opening, and indicate any exceedances over the “base” target noise levels and over any allowances applied above existing noise levels.
 - Predicted $L_{Aeq}(24hr)$, $L_{Aeq}(15hr)$, $L_{Aeq}(9hr)$ and $L_{Aeq}(1hr)$ (*as required*) noise levels for the proposed road environment 10 years after project opening and at design capacity (if applicable). Indicate any exceedances over the “base” target noise levels and over any allowances applied above existing noise levels.
- Reported noise levels should be rounded off to whole numbers. Decimals below 0.5 should be rounded down and decimals equal to or greater than 0.5 should be rounded up.
- For road upgrades not increasing traffic carrying capacity or changing the traffic mix and involving only minor realignments, present the tabulations described above, but omitting Year 10 and design capacity noise level predictions.
- Discuss the results and assess the potential changes in the noise environment and their impacts.
 - Include a discussion of the changes in noise levels, the number of noise sensitive receivers affected and the extent of positive and negative impacts.

Maximum noise level assessment

- Identify all prediction and evaluation assumptions and the basis for these assumptions.

- Tabulate the representative predicted maximum noise levels, the value of $L_{Amax} - L_{Aeq}$, and the number of noise events.
- Where existing road traffic noise predominates, compare predicted impacts with any impacts prevailing for the existing environment.
- Discuss the results and the likely changes in impact.

Noise mitigation options

- Where the “base” target noise levels are forecast to be exceeded, or an allowance over the future existing noise level might be applied, list all available short and long-term noise mitigation options.
- Assess the feasibility and reasonableness of meeting the “base” target noise levels at the various locations, taking account of the practicality of providing effective treatments, potential noise mitigation benefits and costs, community views, aesthetic impacts, existing and future noise levels at affected land uses, and the benefits of the proposal.
- Select and discuss a set of preferred mitigation options.
 - Assess their practicality, potential effectiveness, cost-effectiveness, aesthetic issues, equity issues and community preferences.
 - If the preferred options are roadside treatment measures, tabulate the predicted noise levels, with mitigation in place, at each of the prediction locations for each of the preferred treatment options.
 - For architectural treatment measures, state the indicative noise reductions that could be achieved.

Conclusions and recommendations

- Present the study’s conclusions concerning the impacts and suitability of the proposal and potential mitigation options.
- Where the target noise levels are forecast to be exceeded, include a recommendation that the RTA should adopt the proposed options to reduce noise levels at identified noise-sensitive receptors, subject to further evaluation of the issues relating to “feasibility” and “reasonableness”, taking account of any design changes, during the detailed design.
 - Include a brief description of how the selection and design development of preferred options will proceed during Phases 3 and 4 of the project’s overall design process, including the opportunities for inputs through consultation processes.

Attachments

- Site map(s) that clearly identify existing and proposed road alignments and noise prediction and measurement locations.
- Site map(s) and/or aerial photographs with overlays of noise contours for the predicted noise environment, with (if applicable) and without proposed mitigation measures. (This is not necessary for projects where surrounding development is isolated or there are unlikely to be any significant increases in noise impacts.)
- Tabular noise monitoring results, including graphical representations of L_{Amax} , L_{A10} , L_{Aeq} , and L_{A90} for each 15-minute noise-monitoring period.

8

Section 8

Noise Abatement Program for existing roads

A management framework for implementing the NSW Government's Noise Abatement Program for existing roads.

Overview and criteria

The *Noise Abatement Program* (NAP) targets locations or lengths of existing roadways where road traffic noise levels are very high and are considered excessive for noise-sensitive land uses such as residences, schools, churches and health care institutions.

Section 3.2 of the *Environmental Criteria for Road Traffic Noise* sets guideline L_{Aeq} noise levels for existing roads that are not subject to “redevelopment” of 60 dB(A) for the 15-hour day period from 7 am to 10 pm and 55 dB(A) for the 9-hour night period from 10 pm to 7 am.

The purpose of these guideline levels is to “provide a basis for measuring and defining the extent of any existing traffic noise impacts”. The *ECRTN* recognise that resources for noise abatement on existing roads are generally limited, and identify the NAP as an appropriate response for addressing acute existing road traffic noise impacts.

Sites may be identified as “noise affected” if road traffic noise levels exceed 60 dB(A) $L_{eq(15hr)}$ or 55 dB(A) $L_{eq(9hr)}$. However, sites are not currently given priority for treatment unless road traffic noise levels are at least 65 dB(A) $L_{eq(15hr)}$ or 60 dB(A) $L_{eq(9hr)}$.

The NAP is developed on a regional basis, with priorities for treatments being set for each region. To obtain funding, clear justifications of the value of the highest priority projects need to be provided to the RTA's Road Network Infrastructure Directorate. Funds are allocated on the basis of available resources, after assessing the relative value and benefit of each project proposed throughout NSW.

Because both the State and Federal Governments provide funding for NAP projects, priorities are determined separately for State and Federal roads.

The treatment measures available under the NAP include noise barriers, noise mounds, quieter pavement surfaces and architectural treatments.

Sites may be eligible for noise treatment when:

- They are located along an existing State or Federal road and the road is not subject to any upgrading works
- Noise levels are at least 65 dB(A) $L_{eq}(15hr)$ or 60 dB(A) $L_{eq}(9hr)$
- At least one noise complaint has been received
- The developments affected are residences, schools, places of worship or health care institutions, and
- Treatment of the site is deemed cost-effective, equitable and practical.

In the case of multi-level residential buildings, the provision of treatments to all individual occupancies would be a cost-prohibitive drain on NAP resources. For this reason, treatments are only provided to buildings with no more than two habitable levels above at most one non-habitable level (i.e. garage/laundry).

As previously stated, treatments are provided on a prioritised basis. Accordingly, fulfilment of the above criteria does not necessarily mean that noise abatement is provided.

Setting up a NAP

The NAP database

The NAP database developed by Sydney Client Services fulfils the NAP data input requirements. The complaints database can hold the following data inputs:

- Details of complainant(s)
- Property descriptions
- Local government areas
- Noise level data and the date of recording
- Location of proposed NAP treatments and timeframes for implementation
- Number of residences, places of worship and schools predicted to benefit, and the extent of this benefit (in dB(A))
- Actual benefits identified through a review of noise abatement effectiveness, where conducted
- The location and other descriptions of treatments actually provided through the NAP, including the noise treatments' installation date(s), and
- The location and other descriptions of treatments provided through new road projects and road redevelopment projects, including the noise treatments' installation date(s).

An indicative regional evaluation of noise exposure will assist in the initial development of regional NAPs. “Loud spots” can be identified by:

- Examining traffic volumes as an indicator of the most exposed locations
- Examining any noise monitoring data that are already available, and/or
- Arranging for short-term ambient noise monitoring to be conducted at the most exposed locations or at noise complaint sites.

An alternative, if funding is available, is to conduct a regional study of baseline noise levels. Such a study can help determine NAP priorities for a specific region by comparing noise impacts at different locations, but it is not designed to assist the selection and design of specific noise treatments.

- The RTA's Environment and Community Policy Branch can assist in developing study methodologies to meet the specific needs of each region.

Implementation

Step 1:

Preliminary analysis and prioritisation of noise-affected sites

- Upon receiving a complaint, follow the complaints management procedure set out in *Practice Note IX* and conduct a preliminary evaluation of the validity of the complaint.
- If the preliminary evaluation indicates that prevailing traffic noise levels are likely to be high, conduct long term noise monitoring, usually over seven consecutive days. Please refer to the model consultant brief in *Appendix F*.

The criteria for determining priorities for later detailed investigation (Step 3) include:

- Existing noise levels and the affected land use (i.e. the number of residences, churches, schools and/or health care institutions affected).

This noise level priority assessment is quantified by the relationship:

$$\text{Noise Level Priority} = \frac{\text{Existing external noise level}}{\text{Target noise level}}$$

for the most affected residence, where:

- The target noise level is 60 dB(A) $L_{eq(15hr)}$ (day) or 55 dB(A) $L_{eq(9hr)}$ (night), and
 - The existing external noise level may be either the existing day-time noise level or the existing night-time noise level, depending on which of these represents the greatest deviation from the target noise level.
- The number of complaints received.

- A preliminary evaluation of whether treatments are likely to be cost-effective and practical.
- An “equity” evaluation.

Noise treatment for new developments in locations already exposed to road traffic noise is primarily the responsibility of the relevant developers, builders and occupants, and also of local councils giving development approvals.

Noise treatment is usually provided only when 85% of the affected residences:

- Have not had a change in ownership for the previous seven years, and
- Were the subject of a development approval before 1 January 2000.

If these circumstances do not apply, treatments may only be provided where affected noise-sensitive sites have been developed in accordance with architectural acoustic principles *and* it can be shown that there has been a substantial increase in noise impacts since the architectural acoustic principles were incorporated into the development.

- Consult with the local council and investigate whether there are any opportunities for road traffic noise impacts to be addressed in its land-use planning and development control processes (see *Practice Note X*).
- Consult with Road Network Infrastructure Directorate on the development of a regional “Forward Program of Noise Abatement Works” based on the preliminary prioritisation of affected locations.

Step 2: Detailed noise assessment of prioritised sites

Once a location for noise treatment has been identified for more detailed evaluation and funding for the evaluation has been approved, carry out the following processes to assist the development of treatment measures:

- Review the area and identify site and traffic characteristics which contribute to the problem.
- On a plan, define the affected study area and identify noise-sensitive receivers which might be affected.
- Identify data needs for the noise assessment, including current traffic volumes and compositions and equivalent estimates for a future design year.
- Obtain distance/coordinate information needed for computer modelling.
- Include details from any previous environmental impact assessments and any other more recent data and information.

- Engage a consultant to conduct a detailed noise assessment. A model consultant brief for this type of investigation is set out in *Appendix F*.

The reported noise levels should be rounded off to whole numbers. Decimals below 0.5 should be rounded down and decimals equal to or greater than 0.5 should be rounded up.

The noise assessment should include the selection and design of noise treatment options in consultation with the Project Manager, taking account of community preferences, aesthetics, practicality and cost-effectiveness.

- Define the road traffic noise catchment area.

For the purposes of this methodology, the road traffic noise catchment area to be assessed is generally defined as all of the area within the least distant of:

- A 300 m setback from the road alignment
- The $L_{eq(15hr)} 55 \text{ dB(A)}$ contour
- The $L_{eq(9hr)} 50 \text{ dB(A)}$ contour, and
- The noise level contour beyond which the proposal will have no effect,

in each case with no noise mitigation in place.

- Identify all noise-sensitive receivers within the road traffic noise catchment area.

Divide the overall catchment area into sub-catchments likely to have similar noise exposures, on the basis of factors such as topography, the road's design (cuttings, embankments, intersections, etc), setbacks and types of residences and other noise receptors.

Further divide the sub-catchments into segments of similar noise impact, approximately within a 5 dB(A) range.

On a plan, identify all individual dwellings and other noise-sensitive receptors in each of these segments within the project's catchment area.

Each affected dwelling in buildings containing multiple residences should be considered separately.

- Enter the new noise data into the NAP database.
- Calculate noise treatment and site priorities.

In terms of the criterion of cost effectiveness, noise treatment priorities, expressed in terms of a "Priority Index", are calculated using the following relationship:

$$PI = \left\{ \frac{\sum_{i=1}^n (Nd \times R \times Nr)_i}{C} + \frac{\sum_{i=1}^n (Nd_A \times R_A \times Nr_A)_i}{2 \times C_A} \right\} \times 10^3$$

where:

PI is the Priority Index

Nd is the difference between the existing external noise level and the target noise level for each affected receiver or for each group of R similarly affected receivers ($R \geq 1$), where road treatments are proposed

R is the number of similarly affected receivers in each similarly affected group, where road treatments are proposed

Nr is the noise level reduction attributable to the road treatments proposed for the affected receiver(s)

C is the total cost of the road treatments proposed

Nd_A is the difference between the existing external noise level and the target noise level for each affected receiver among a group of R_A similarly affected receivers ($R_A \geq 1$), where architectural treatments are proposed

R_A is the number of similarly affected receivers in each similarly affected group, where architectural treatments are proposed

Nr_A is the estimated noise level reduction attributable to the architectural treatments proposed for the affected receiver(s), as set out in the table below, and

C_A is the total cost of the architectural treatments proposed.

In the equation above, the fact that C_A is multiplied by 2 reflects a subjective and somewhat arbitrary judgment that because architectural acoustic treatments provide no external noise benefit, they should be regarded as providing only half the benefit of road treatment measures which reduce both external and internal noise levels.

- Proposals with the highest Priority Index obtain the highest priority for NAP treatment if judgments on this are made purely on the basis of noise-reduction cost effectiveness.

However, community consultation or a visual assessment may indicate a preference for more expensive barrier designs. In these circumstances, priorities determined on the basis of the Priority Index may need to be weighted to adequately take these preferences into account. The weighting factors should be clearly identified and justified in the priority assessment.

- If noise barriers or mounds are being considered, use the procedures described in *Practice Note IV(a)* to compare noise barrier height options.

Select the preferred barrier height option and then assign a barrier installation cost based on the barrier material to be used. The preferred barrier option may incorporate a combination of treatments, such as quieter pavement surfacing and architectural acoustic treatments, allowing a reduced barrier height.

For funding to be provided, noise barriers and mounds must be able to reduce noise levels at the most affected receiver by at least 5 dB(A).

- As the noise reduction benefit for quieter pavement surfacing is limited, the residences identified as receiving a benefit are restricted to the first row of residences adjacent to and facing the road alignment.

The effectiveness of quieter pavement surfaces depends on their impact on noise emissions from the pavement/tyre interface. Pavement tyre noise begins to emerge as a dominant road traffic noise source only at speeds of 70 km/h and above. Accordingly, quieter pavements should only be considered where the posted speed limit is above 70 km/h.

Quieter pavements are generally provided only where small reductions in noise, of 2 to 4 dB(A), are important. They should only be considered in conjunction with other treatments such as noise barriers and architectural acoustic treatments.

- Architectural acoustic treatments such as courtyard screen walls provide some external noise reduction, but no external noise reduction is achieved by treatments confined to the building elements (i.e. ventilation systems and upgraded glazing).

Even so, building element treatments usually provide a greater internal noise reduction benefit than barriers or quieter pavement surfacing during sleeping hours.

For building element treatments, insert in the Priority Index formula the noise level reduction values (Nr_A) shown in *Table 8.1*, as applicable:

Table 8.1

Noise level reduction values for architectural acoustic treatments.

Building type	Treatment	Nr_A (dB(A))
Light frame	Fresh air ventilation system	10
	Fresh air ventilation system, upgraded window and door seals	12
Masonry	Fresh air ventilation system	15
	Fresh air ventilation system, upgraded window and door seals and sealed wall vents	20
	Fresh air ventilation system, upgraded window and door seals, upgraded glazing, solid core doors and sealed wall vents	25

Practice Note IV(b) provides guidance on the selection of architectural treatments and the application of a maximum treatment cost per residence. A 10 dB(A) traffic noise reduction can be achieved through the facade of most buildings with the windows sufficiently open to provide acceptable fresh air ventilation. On this basis, 10 dB(A) should be subtracted from the existing external noise level and the target noise level when calculating the Priority Index for building element upgrades.

- Identify and consult with the local council, community groups and other interested stakeholders, and involve these groups in the development and assessment of treatment options.
- Enter the location and type of noise treatment proposed into the NAP database.

- Enter the number of receivers expected to benefit and the extent of the estimated benefit (in dB(A)), as identified in the detailed noise assessment.

The benefits for schools, churches and health care institutions could take into account the number of students, the type of student activities affected, the number of worshippers, the number of patients, the type of treatment provided and the times activities are affected.

Step 3: Develop a regional 'Noise Abatement Program of Works'

- Consult with Road Network Infrastructure Directorate (RNI) to confirm or vary the forward program of noise treatment works.
- Provide a comprehensive justification of the value of the project in a submission to RNI to obtain NAP funding, supported by:
 - The detailed noise assessment conducted in Step 2
 - Information on community preferences, as identified through consultations with affected communities and local councils
 - The results of consultations with the RTA's Asset Management Branch on the durability and maintainability of the preferred noise treatment(s), and
 - A visual assessment of the proposed treatment measures (see the RTA's Urban and Regional Design Practice Notes, *Beyond the Pavement*, and *Roadscape Guidelines*).
- Liaise with RNI before submitting the request for funding.

Step 4: Finalise the design and install the treatments

- Refer the complete noise treatment design plan to the RTA Noise Wall Panel for review. (The Noise Wall Panel reviews and makes recommendations on noise wall design proposals and advises on whole-of-life maintenance issues relating to noise wall treatments and associated landscaping.)
- Finalise the proposed noise treatment measures in consultation with Road Asset Management Services, taking account of maintenance requirements.
- When funding is approved, engage a contractor to construct/install the treatments.
- Enter the location, type and date of installation of noise treatments into the NAP database. (Note that information on noise treatments provided for new roads and road redevelopment projects are also to be entered into the NAP database.)

Step 5: Monitor and review effectiveness

- Conduct post-construction noise monitoring for selected projects to validate the noise modelling process and verify the noise benefits achieved.

The sample size for projects requiring post-construction monitoring depends on the historical record of noise prediction accuracy and community concern. Unlike the post-construction monitoring regime applying to new roads and road redevelopments, simultaneous traffic monitoring is not necessary for NAP projects. This is because there will be little change in the traffic volume and mix during project evaluation and development.

A model consultant brief for post-construction noise monitoring is set out in *Appendix E*.

Noise monitoring is generally conducted to give at least seven consecutive days of data.

Classified traffic monitoring is conducted simultaneously with this noise monitoring.

- If the post-treatment monitored noise levels are 2 dB(A) or less above the treatment design noise level, no further action is required, as the variation from the design noise level would not be significant.
- If the post-treatment monitored noise levels are more than 2 dB(A) above the treatment design noise level for road opening, a review of the applied treatment and prediction/monitoring methodologies will be necessary for quality assurance.
- Enter the new noise data into the NAP database and record the actual benefits achieved, in terms of the numbers of residences, churches, schools and health care institutions and the extent of their benefits in dB(A).

Step 6: Preparation of regional NAP *Annual Reports*

An annual report on the NAP needs to be prepared by the NAP manager for each RTA region. This report must include at least the following data, categorised into State and Federal funded projects:

- Total funding allocated to the NAP
- Total NAP expenditure
- Projects completed and projects in progress
- The cost of each project
- The type(s) of treatment provided
- Site photographs
- The number of residences, churches, schools and health care institutions benefited, and the estimated or monitored benefits in dB(A)

- The cost per residence, school, church or health care institution
- A justification of the selection of sites, including each site's Priority Index value and a justification of any weightings attributable to factors other than noise-reduction cost-effectiveness, and
- Where possible, projects planned for the year ahead.

Further reading

ARRB Transport Research (1998) *Road Surface Characteristics and Condition: Effects on Road Users*, Research Report ARR314

EPA (1999) *Environmental Criteria for Road Traffic Noise*

FHWA (1995) *Highway Traffic Noise Analysis and Abatement*

Karachlis N, Pontifix G and Samuels S E (1996) *The Acoustical Attributes of Some Traffic Calming Devices*, Proceedings, Roads 96 Conference, Part 6

Renzo Tonin & Associates (1996) *Traffic Calming Devices: Part 1, Effects on Attitudinal Behaviour and Roadside Noise Levels and Part 2, Community Attitudinal Survey, Background, Methodology and Data Analysis*

WSROC (1993) *Towards Traffic Calming: A Practitioner's Manual of Implemented Local Area Traffic Management and Blackspot Devices*.

Calculating the Priority Index: a worked example

Let us suppose a preliminary analysis and prioritisation of noise-affected sites has identified a section of road as needing more detailed evaluation.

This worked example applies the necessary steps to calculate the *Priority Index (PI)* for this section of road. The *PI* calculated in this way will then be used to determine the treatment or mix of treatments that would be assigned the highest priority for Noise Abatement Program (NAP) funding at a particular site.

In our example the section of road is an existing arterial road adjacent to a residential development comprising 36 single storey dwellings and four double storey dwellings. More than 85% of the dwellings have not had a change of ownership in the last seven years.

The *Environmental Criteria for Road Traffic Noise (Criteria)* do not set noise criteria for existing roads that are not subject to upgrade works. Even so, the *Criteria* do present guideline levels to “provide a basis for measuring and defining the extent of any existing traffic noise impacts”. These guideline levels for existing freeway/arterial roads are daytime 60 dB(A) $L_{eq}(15\text{hour})$ and night-time 55 dB(A) $L_{eq}(9\text{hour})$.

Noise modelling shows that the daytime guideline is more stringent than the night-time guideline for this arterial road example. In other words, the exceedance of the daytime guideline at residences in the noise catchment, with no noise mitigation, is greater than the exceedance at night.

An analysis of noise level decay over distance in the areas around the road section shows that the noise catchment should be defined, in this case, as the area of land within the 55 dB(A) $L_{eq}(15\text{hour})$ noise contour.

This noise catchment is then dissected into sub-catchments and further subdivided into segments of similar noise exposure.

The residential development sub-catchment considered in this example is divided into three segments. *Table 8.2* and *Figure 8.1* list, for each segment, the corresponding affected noise sensitive receptors and representative noise exposures (at the worst affected residence), with no mitigation in place.

Table 8.2
Noise exposure with no treatment in place

	Noise-sensitive receptors	Representative noise level (dB(A))
Segment 1	19	73
Segment 2	13	64
Segment 3	8	60

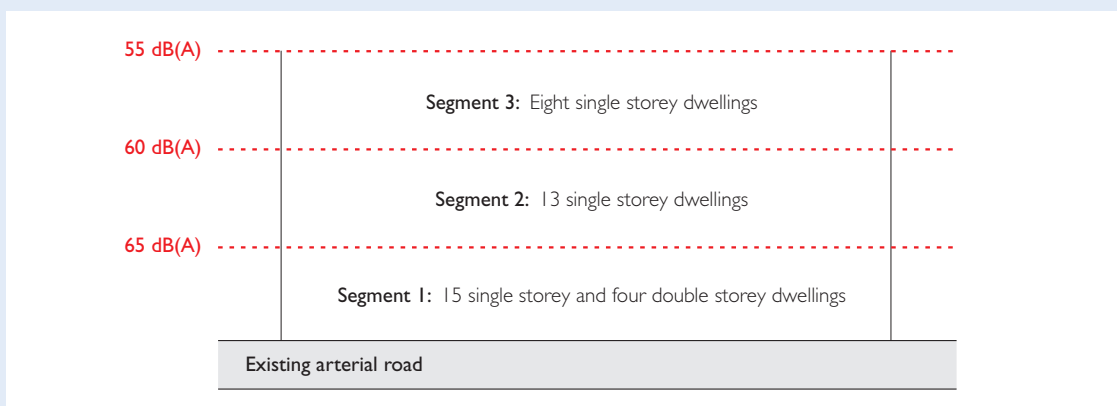


Figure 8.1. Segments in the noise sub-catchment.

Calculating the Priority Index for the Assessed Barrier alone

Let us suppose the “Assessed Barrier”, calculated using the procedures in *Practice Note IV(a)*, is a 3.5 m x 300 m barrier. Assuming an installation cost \$300/m², the total Assessed Barrier cost is \$315,000. The predicted cumulative noise level and barrier insertion loss for each segment with the Assessed Barrier in place are tabulated in *Table 8.3*.

Table 8.3
Noise exposure with a 3.5 m high barrier

	Cumulative representative noise level (dB(A))	Barrier insertion loss (dB(A))
Segment 1	61	12
Segment 2	56	8
Segment 3	52	8

The *PI* applying to the Assessed Barrier is now calculated from the relationship:

$$PI = \left\{ \frac{\sum_{i=1}^3 (Nd \times R \times Nr)_i}{C} \right\} \times 10^3$$

where:

$$Nd(\text{Segment 1}) = 73 - 60 = 13 \text{ dB(A)}$$

$$Nd(\text{Segment 2}) = 64 - 60 = 4 \text{ dB(A)}$$

$$Nd(\text{Segment 3}) = 60 - 60 = 0 \text{ dB(A)}$$

$$R(\text{Segment 1}) = 19$$

$$R(\text{Segment 2}) = 13$$

$$R(\text{Segment 3}) = 8$$

$$Nr(\text{Segment 1}) = 12 \text{ dB(A)}$$

$$Nr(\text{Segment 2}) = 8 \text{ dB(A)}$$

$$Nr(\text{Segment 3}) = 8 \text{ dB(A)}$$

$$C = \$315,000$$

Therefore:

$$PI = \left\{ \frac{(13 \times 19 \times 12) + (4 \times 13 \times 8) + (0 \times 8 \times 8)}{315,000} \right\} \times 10^3 = 10.73$$

Calculating the PI for the Assessed Barrier in conjunction with architectural treatments

Now let us suppose further analysis of barrier heights has indicated that the Assessed Barrier could be reduced in height if the barrier design only accounted for the ground level of the four double-storey dwellings, with architectural acoustic treatments being provided for the upper level of these dwellings.

It is assumed here that all the buildings are of masonry construction.

Suppose the revised Assessed Barrier is a 2.5 m x 300 m barrier, with an installation cost of \$225,000, and the predicted cumulative noise level and barrier insertion loss for each segment with this 2.5 m barrier are as tabulated in *Table 8.4*.

Table 8.4
Noise exposure with a 2.5 m high barrier

	Cumulative representative noise level (dB(A))	Barrier insertion loss (dB(A))
Segment 1	63	10
Segment 2	57	7
Segment 3	53	7

The inputs to the *PI* calculation for the 2.5 m Assessed Barrier are:

$$Nd(\text{Segment 1}) = 73 - 60 = 13 \text{ dB(A)}$$

$$Nd(\text{Segment 2}) = 64 - 60 = 4 \text{ dB(A)}$$

$$Nd(\text{Segment 3}) = 60 - 60 = 0 \text{ dB(A)}$$

$$R(\text{Segment 1}) = 19$$

$$R(\text{Segment 2}) = 13$$

$$R(\text{Segment 3}) = 8$$

$$Nr(\text{Segment 1}) = 10 \text{ dB(A)}$$

$$Nr(\text{Segment 2}) = 7 \text{ dB(A)}$$

$$Nr(\text{Segment 3}) = 7 \text{ dB(A)}$$

$$C = \$225,000$$

Therefore:

$$PI = \left\{ \frac{(13 \times 19 \times 10) + (4 \times 13 \times 7) + (0 \times 8 \times 7)}{225,000} \right\} \times 10^3 = 12.60$$

The *PI* applying to the upper level architectural treatment for the four double-storey dwellings (all in Segment 1) is determined with reference to *Practice Note IV(b)*. If the 2.5 m Assessed Barrier is adopted, the external noise level in Segment 1 will be 63 dB(A). As the difference between the external noise level and the guideline noise level will be less than 10 dB(A), the upper cost limit of \$15,000 is assumed to be the architectural treatment value for each of the dwellings.

A fresh air ventilation system with upgraded window and door seals and sealed wall vents may be offered in accordance with *Practice Note IV(b)*. This will allow the existing windows to be kept shut, thereby providing sufficient noise reduction. As the dwellings are of masonry construction, the noise reduction value (from *Table 8.1*) will be 20 dB(A).

The *PI* applying to the architectural treatments is calculated by the relationship:

$$PI = \left\{ \frac{\sum_{i=1}^1 (Nd_A \times R_A \times Nr_A)_i}{2 \times C_A} \right\} \times 10^3$$

The inputs to the *PI* calculation are:

$$Nd_A(\text{Segment 1}) = 73 - 60 = 13 \text{ dB(A)}$$

$$R_A(\text{Segment 1}) = 4$$

$$Nr_A(\text{Segment 1}) = 20 \text{ dB(A)}$$

$$C_A = \$60,000$$

Therefore:

$$PI = \left\{ \frac{13 \times 4 \times 20}{2 \times 60,000} \right\} \times 10^3 = 8.67$$

The combined *PI* for the 2.5 m Assessed Barrier in conjunction with the architectural treatments will therefore be:

$$PI = 12.6 + 8.67 = 21.27$$

The 2.5 m Assessed Barrier in conjunction with architectural treatments has a considerably higher *PI* than the 3.5 m Assessed Barrier without architectural treatments, and would therefore be given a higher priority for treatment under the NAP.

Calculating the Priority Index for architectural treatments on their own

In this scenario treatment only needs to be considered for the 19 dwellings within Segment 1 and the 13 dwellings within Segment 2, as all the dwellings within Segment 3 will experience noise levels equal to or below the guideline noise level of 60 dB(A).

It is again assumed here that all the buildings are of masonry construction.

As the representative external noise level (without treatment) for Segment 1 is more than 10 dB(A) above the guideline noise level, architectural treatments may be offered to the owners of dwellings within this segment, up to a limit of \$20,000. The types of treatment which may be offered to the owners of these dwellings include fresh air ventilation, upgraded window and door seals, upgraded glazing, solid core doors and sealed wall vents. From *Table 8.1*, these treatments correspond to a noise reduction value of 25 dB(A).

In Segment 2 the representative noise level (without treatment) will be less than 10 dB(A) above the guideline noise level, and treatment may be offered up to a value of \$15,000. The types of treatment which may be offered to the owners of these dwellings include fresh air ventilation, upgraded window and door seals and sealed wall vents. These treatments correspond to a *Table 8.1* noise reduction value of 20 dB(A).

The inputs to the *PI* calculation are:

$$Nd_A(\text{Segment 1}) = 73 - 60 = 13 \text{ dB(A)}$$

$$Nd_A(\text{Segment 2}) = 73 - 60 = 4 \text{ dB(A)}$$

$$R_A(\text{Segment 1}) = 19$$

$$R_A(\text{Segment 2}) = 13$$

$$Nr_A(\text{Segment 1}) = 25 \text{ dB(A)}$$

$$Nr_A(\text{Segment 2}) = 20 \text{ dB(A)}$$

$$C_A = (19 \times \$20,000) + (13 \times \$15,000) = \$575,000$$

The *PI* for the architectural treatments without barriers will therefore be:

$$PI = \left\{ \frac{(13 \times 19 \times 25) + (4 \times 13 \times 20)}{2 \times 575,000} \right\} \times 10^3 = 6.27$$

This “architectural treatment only” option has a lower *PI* than the other two scenarios considered above, and therefore has the lowest NAP priority.

9

Section 9

Managing construction noise and vibration impacts

A framework for managing construction noise and vibration from new and upgraded roads. Section 10 describes a framework for managing road maintenance noise. This section should also be read in conjunction with the road development process and road traffic noise management framework described in Section 7.

Steps in construction noise and vibration assessment

The measurement of existing ambient noise levels and the assessment of future construction site noise and vibration impacts must be undertaken by an accredited acoustic consultant eligible for the minimum grade of “Member” with the Australian Acoustical Society.

As with the traffic noise assessment processes, it is stressed that the management of construction noise and vibration is an integral part of the overall design process of the project development framework and needs to be undertaken in conjunction with all the other activities listed in *Section 7*. It is *not* simply part of “preparing the *EIS/REF*”.

For most projects the assessment will be undertaken during Phase 3 of the overall design process (design development and approval), but well before work commences on documentation phases of the *EIS* or *REF*.

Typical noise levels of construction plant items (dB(A) at 7 m)	
Scraper	86
Bulldozer	85
Grader	84
Front-end loader	86
Vibrating roller	82
Backhoe	83
Excavator	80
Compressor	75
Concrete vibrator	87
Concrete pump	84
Dump truck	83
Water tanker	84
Compactor	85
Concrete saw	93

Step 1

- Where the works will involve the use of construction plant and machinery, identify noise-sensitive locations near the work site and list all potential measures to reduce noise emissions and vibration impacts.

Step 2

- Monitor pre-construction noise levels.
 - Measure the existing noise levels at sites which are likely to be affected by the proposal and are representative of the background noise environment at surrounding sites.
 - Typically, seven consecutive days would be considered a minimum number of days to monitor ambient noise levels. However, monitoring may be carried out over a lesser number of days and

at fewer locations in areas where background noise levels are likely to be constant.

- From the monitored results calculate the existing ambient background noise level(s).
 - The existing ambient background noise level(s) is calculated by applying the tenth percentile method described in detail in the *NSW Industrial Noise Policy*, published by the EPA, for the proposed construction hours. The tenth percentile background noise level may be calculated for a range of defined periods throughout the day, to account for daytime shifts in the background noise level.
 - If the construction hours are proposed to extend through to the evening and night, the tenth percentile noise level is determined for each of the day, evening and night periods. Determine the lowest tenth percent LA90(15min) noise level for each period.
- *Appendix B* sets out a model consultant brief to carry out the entire construction noise and vibration impact assessment, including pre-construction noise monitoring.

Step 3

- Identify the noise, vibration and blasting criteria to be applied to the project (see *Section 6*).
- Define construction noise goals, based on the calculated pre-construction background noise levels.

Step 4

- Conduct an indicative assessment of construction noise and vibration impacts (see the model consultant brief in *Appendix B*).
 - Identify the types of plant and equipment to be used during construction and their corresponding noise emission and vibration levels.
 - Broadly describe the construction activities that are expected to occur (earthworks, pavement construction, bridge construction, etc).
 - Calculate the worst-case noise and vibration impact for each group of noise and/or vibration-sensitive receivers, taking account of distance corrections and the combined noise and/or vibration levels of all the equipment to be used simultaneously during each activity.
 - In obtaining an initial indication of likely vibration levels, it can be assumed that the vibration level is inversely proportional to distance. Note, however, that field data show a wide variation in distance attenuation, with the distance relationship generally varying between $d^{-0.8}$ and $d^{-1.6}$ rather than being fixed at d^{-1} .
 - Take account of the typical duration, timing and frequency of various construction activities, the use of various plant and equip-

Typical vibration levels of construction plant items (peak particle velocities at 10 m) (mm/s)	
Piling	12–30
Loader breaking kerbs	6–8
15 tonne roller	7–8
7 tonne compactor	5–7
Roller	5–6
Pavement breaker	4.5–6
Dozer	2.5–4
Backhoe	1
Jackhammer	0.5

ment potentially affecting the noise and/or vibration-sensitive receivers and the masking effects of any high existing ambient noise levels.

- Assess blasting impacts, if any.
 - Estimate the charge size(s) required to conduct blasting activities, and calculate the resultant airblast overpressure on the basis of distance setbacks and the resultant ground vibration levels on the basis of prevailing geological conditions and the distance from sensitive receivers.
 - Compare the calculated airblast overpressure and ground vibration levels with the ANZECC *Guidelines* to determine impacts.
 - AS 2187.2 describes a blasting ground vibration prediction method which can be a useful indicative impact assessment tool (see the standards and guidelines listed in *Section 6*).

Step 5

- Evaluate potential construction noise and vibration impacts with reference to a comparison of estimated noise and vibration levels with noise and vibration goals.

Step 6

- Identify all potential best practice and cost-effective construction noise and vibration control options that could be used to reduce noise and vibration levels towards the goals (see *Section 5*).
- In consultation with the project design team, other agencies, stakeholders, interest groups and the community, identify a set of preferred options on the basis of their expected practicality and effectiveness.
- Progressively refine this identification of preferred control options and the designs of these approaches as part of the overall concept design development process (including the preparation of the project's EIS/REF), the tender standards development process, and the preparation of the RTA's PEMP, during Phase 3 of the design process.
 - The series of concept design reports described in *Section 7* and the EIS/REF developed from these reports should clearly identify the preferred option(s) to reduce construction noise and vibration impacts at all affected sensitive sites and explain the reasons for these choices.
 - This refinement will continue during Phase 4 of the overall design process as described in *Section 7*, based on a detailed construction work plan.
- Depending on the procurement method adopted:
 - Finalise the selection and design of construction noise and vibration control approaches during final detailed design and documentation of the project by the RTA early in Phase 4, or
 - Review the selections and designs developed by the successful D&C, DCM or BOOT tenderer for consistency with the RTA's

design objectives and contractual requirements, including all performance standards and specifications developed during Phase 3.

Step 7

Before construction commences:

- The RTA/Contractor's representative with authority over the works should apply for a *Road Occupancy or Road Development Licence* from the RTA's Transport Management Centre (Sydney region) or the Regional Traffic Commander (rest of NSW).

Construction works must not commence until a *Road Occupancy or Road Development Licence* has been granted.

- The *Licence* may require construction activities to be undertaken outside normal working hours where there is a clear need to minimise potential impacts on traffic flows or to maintain full traffic capacity during peak demand periods.

“Normal working hours” are defined in the EPA's *Environmental Noise Control Manual* as 7 am to 6 pm Monday to Friday and 8 am to 1 pm on Saturdays (or 7 am to 1 pm on Saturdays if the noise is not audible on residential premises).

- Project objectives may also necessitate the conduct of some works outside normal working hours. This information should be provided when applying for the *Licence*.
 - Refer to *Practice Note VII* for procedural guidance if roadworks outside normal working hours are proposed.
- The EPA must be consulted if an Environment Protection Licence is required (see *Section 6*), and the *CEMP* will need to be revised to include any additional EPA requirements.
- With other RTA design team members, review and agree to the *CEMP*, including any *NVMP*, if this has not already been done.
 - A guide for preparing a contractor's *NVMP* is provided in *Practice Note VI*.
- Conduct a community information program, including the distribution of leaflets explaining the type, time and duration of expected noise and vibration emissions from construction activities, and conduct direct discussions and negotiations with affected residents.
- Nominate a community liaison officer and a complaints hotline number.
- Where relevant, conduct pre-construction surveys of the structural integrity of vibration-sensitive buildings.
- Notify the Traffic Management Centre or Regional Traffic Commander, as applicable, prior to the commencement of the works and again upon completion of the works, in accordance with traffic management procedures.

Step 8

During construction:

- With other RTA design team members, inspect the works and monitor the compliance of construction activities and constructed components of the project with planning approval and environment protection licence requirements, contractual environmental requirements, the RTA's *PEMP* and the *CEMP*.

For a model consultant brief for the monitoring of noise from road construction and maintenance works, see *Appendix C*.

For a model consultant brief for the monitoring and assessment of vibration levels and impacts associated with construction, maintenance and/or traffic, including vibration damage assessments, see *Appendix D*.

- Conduct noise and vibration monitoring studies, as necessary, to check for compliance and determine impacts on nearby sensitive receivers.
- Ensure monitoring locations and times are selected so as to provide an accurate picture of these impacts, with at least one survey during each high-noise risk activity and, where appropriate, additional surveys in response to complaints.
- The noise monitoring regime selected will depend on the construction activities taking place, the potential for significant impacts and whether there are specific high-risk noise sources (i.e. blasting operations, pile driving or rock hammering).

For example, long-term unattended monitoring for one or two days is appropriate where there is a reasonable risk of noise impact associated with general construction activity. In this case the noise data collected may be compared to background noise levels identified in the EIS/REF to determine whether guidelines could be exceeded and whether there is a need for attended monitoring of specific activities or equipment.

Attended monitoring is conducted to “check compliance” and assist in optimising impact minimisation options. It is generally conducted at locations and over a sufficient amount of time to be representative of the maximum impact. This will usually require a minimum monitoring duration for each identified location/activity of four 15-minute periods during times of maximum impact. The loudest recorded 15-minute construction plant/activity noise levels are then compared to monitored background noise levels representative of what was occurring during the 15 minutes of construction activity.

- For blasting operations, the monitoring period is the duration of the blast under consideration.
 - The vibration monitoring period is highly dependent on the character of the vibration being emitted, and must be long enough to characterise the vibration impact. For example, spot monitoring is all that is necessary for monitoring ground vibration from blasting activities, but monitoring periods of 24 hours may be necessary where there is intensive general construction activity affecting sensitive receivers.
- Where necessary, update the RTA's *PEMP*, consistently with the RTA's contractual rights, to improve environmental safeguards.

- Ensure the *CEMP* and any *NVMP* are also updated to reflect these changes.
- Ensure site/works supervisors are aware of these changes and have up-to-date copies of the *CEMP*.
- Periodically review the *CEMP* and any *NVMP* to ensure their details are up to date.
- With other RTA design team members, evaluate any variation proposals for compliance with planning approval and environment protection licence requirements, contractual environmental requirements, the RTA's *PEMP* and the *CEMP*, including the *NVMP*.

Further reading

ANZECC *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*

AS 2187.2 *Explosives – Storage, Transport and Use, Appendix J Ground Vibration and Airblast (Informative)*

AS 3671 *Acoustics Road Traffic Noise Intrusion Building Siting and Construction*

BS 6472 *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*

BS 7385 *Evaluation and Measurement for Vibrations in Buildings, Part 2 Guide to Damage Levels from Ground-borne Vibration*

DIN 4150, *Part 3: Structural Vibration in Buildings: Effects on Structures*

EPA *Environmental Noise Control Manual*, Chapter 171

EPA NSW *Industrial Noise Policy*

RTA (2001) *Environmental Impact Assessment Policy, Guidelines, Procedures.*

Model format and content for construction noise and vibration assessment reports

Introduction

- Describe the proposal.

Existing noise environment

- Describe the study area.
- Discuss noise monitoring procedures and identify the monitoring locations and corresponding monitoring periods. Include, as an attachment, a map clearly identifying the monitoring locations.
- Outline the instrumentation used.
- Tabulate the monitoring locations and their measured noise levels.
 - As a minimum, compute the L_{A90} noise levels for the time segments 7 am to 6 pm, 6 pm to 10 pm and 10 pm to 7 am and determine the background noise level from the tenth percentile L_{A90} noise level ($L_{A90, 15\text{min}}$) for each time segment during the entire measurement period.

Construction noise, vibration and blasting criteria

- Specify the construction noise, vibration and blasting criteria applicable to the project.
- Tabulate the tenth percentile L_{A90} background noise level(s) and the corresponding target noise level for each prediction location during the proposed construction hours.

Construction noise assessment

- Set out an indicative construction noise assessment that identifies expected construction activities and the plant and equipment to be used.
 - If a detailed construction work plan is available, the assessment approach should be detailed rather than indicative.
 - Tabulate noise emission levels for the various items of plant and equipment taken into account in the construction noise assessment.
- For each group of noise-sensitive receivers, calculate the “worst case” construction noise level and tabulate this noise level against the corresponding construction noise goal.
- Discuss the potential construction noise impacts, taking account of exceedances of the goals and the potential masking effects of any high existing ambient noise environments.

Construction vibration and blasting impact assessment

- Identify vibration emissions expected from key plant and equipment and discuss their potential impacts on surrounding sensitive receivers.
 - This assessment should reflect human comfort and building structural integrity goals.

- Assess overpressure and ground vibration impacts from blasting activities in relation to the specified criteria.
 - This will involve an assessment of expected linear noise emissions (in dB) and ground vibrations (in mm/s) from various charge size and delay configurations. This assessment could be enhanced by presenting predicted noise and vibration contours around the blasting sites.

Construction noise and vibration mitigation options

- Where noise goals will potentially be exceeded, discuss the practicality of meeting the noise goals.
- List all available noise mitigation options that should be included in the project's *Noise and Vibration Management Plan/Environment Management Plan*.
- Where vibration and blasting impacts are identified, list all available impact management options that should be included in the project's *Noise and Vibration Management Plan/Environment Management Plan*.

Conclusions

- Present the study's conclusions concerning likely construction noise and vibration impacts and potential mitigation options.
 - Where relevant, point out that this is an indicative assessment only (e.g. if the assessment precedes a detailed work plan, or does not take account of the masking of construction noise by high existing ambient noise environments, temporal fluctuations in background noise levels, etc).
 - Include a brief description of how the selection and design development of preferred mitigation options will proceed during Phases 3 and 4 of the project's overall design process, including the opportunities for inputs through consultation processes.
 - Identify the noise and vibration mitigation options that should be included or considered for inclusion in the project's *Noise and Vibration Management Plan/Environment Management Plan*.

Attachments

- Site map(s) that clearly identify existing and proposed road alignments and noise and vibration prediction and measurement locations.
- Tabular noise monitoring results and graphical representations of L_{Amax} , L_{A1} , L_{A10} , L_{Aeq} and L_{A90} for each 15-minute noise-monitoring period.

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Section 10

Maintenance works

A framework for managing noise and vibration from road maintenance projects.

Environmental Management Plans

As with construction projects, all maintenance works require the preparation of an RTA *PEMP* and a *CEMP*.

- The level of detail required in these *EMPs* depends on the size of the works and the potential noise and vibration impacts.
- As a minimum the *EMPs* should identify all aspects of the works likely to cause excessive noise or vibration impacts and the measures to be taken to manage the identified impacts.
- For minor maintenance works activity-based rather than site-specific *EMPs* may be sufficient.
- For large projects and other projects likely to have significant noise and vibration impacts, the *CEMP* may need to include a *NVMP*. Suggestions on the contents of such a plan are set out in *Practice Note VI*.

Consultation requirements

- Road maintenance projects are not “scheduled activities” under the Protection of the Environment Operations Act (see *Section 6*), so contact with the EPA before works commence is not required unless the works will involve a discharge to a waterway, necessitating an Environment Protection Licence.

As indicated in *Section 6*, the EPA may issue Environment Protection Notices (under Sections 95 and 101 of the Protection of the Environment Operations Act) or Noise Control Notices (under Section 264) if noise problems arise, requiring specific actions to be taken, prohibiting specified activities and/or limiting the times of operation of an activity or article.

- Before works commence, the RTA/Contractor’s representative with authority over the works should apply for a *Road Occupancy or Road Development Licence* from the RTA’s Transport Management Centre (Sydney region) or the Regional Traffic Commander (rest of NSW).

Construction works must not commence until a *Road Occupancy or Road Development Licence* has been granted.

- The *Road Occupancy or Road Development Licence* may require maintenance activities to be undertaken outside normal working hours where there is a clear need to minimise potential impacts on traffic flows or to maintain full traffic capacity during peak demand periods.

“Normal working hours” are defined in the EPA’s *Environmental Noise Control Manual* as 7 am to 6 pm Monday to Friday and 8 am to 1 pm on Saturdays (or 7 am to 1 pm on Saturdays if the noise is not audible on residential premises).

- Refer to *Practice Note VII* for procedural guidance if roadworks outside normal working hours are proposed.
- Notify the Traffic Management Centre or Regional Traffic Commander, as applicable, prior to the commencement of the works and again upon completion of the works, in accordance with traffic management procedures.

Other guidelines

- Refer to the *CEMP* for information on minimum noise management requirements and *Section 5* of this *Environmental Noise Management Manual* for other noise management options.
- Where required by the *CEMP*, monitor noise and/or vibrations from the maintenance works.
 - A discussion on possible noise and vibration monitoring regimes is included in *Section 9*.
 - A model consultant brief for the monitoring of noise from road construction and maintenance works is set out in *Appendix C*.
 - A model consultant brief for the monitoring of vibration levels and impacts from road construction and maintenance works and/or traffic, including vibration damage assessments, is set out in *Appendix D*.
- Where contractor(s) prepare a *CEMP*, ensure it is periodically reviewed and its details are up to date.

For a model consultant brief for the monitoring of noise from road construction and maintenance works, see *Appendix C*.

Further reading

ANZECC (1990) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*

AS 2187.2 *Explosives – Storage, Transport and Use, Appendix J Ground Vibration and Airblast (Informative)*

AS 3671 *Acoustics Road Traffic Noise Intrusion Building Siting and Construction*

BS 6472 *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*

BS 7385 *Evaluation and Measurement for Vibrations in Buildings, Part 2 Guide to Damage Levels from Ground-borne Vibration*

DIN 4150, *Part 3: Structural Vibration in Buildings: Effects on Structures*

EPA *Environmental Noise Control Manual*, Chapter 171

RTA (2001) *Environmental Impact Assessment Policy, Guidelines, Procedures*.



Section II

Management of vehicle noise at the source

A management framework for vehicle noise in NSW.

Standards for quieter vehicles

The ADRs, administered by the Commonwealth Department of Transport and Regional Services under the Motor Vehicle Standards Act 1989, establish minimum performance requirements for safety and the emission of air pollutants and noise for all new motor vehicles sold in Australia.

The standards for air pollutants and noise are developed through the Motor Vehicle Environment Committee (MVEC), in consultation with government, industry, employee, consumer, environment and community representatives. The RTA represents NSW on this committee.

Current Australian vehicle noise standards are much less demanding than international standards, and the RTA and the EPA have advocated more stringent standards.

As a result, ADR 28/01 (*External Noise of Motor Vehicles other than L-Group Vehicles*) is now being revised to bring the noise standards in line with current European standards. An engine brake noise requirement is being investigated for inclusion in this revised ADR.

MVEC is also investigating the development of a roadside engine brake noise testing procedure. The use of noisy engine brakes is not able to be restricted until an engine brake requirement is included in the ADR and a roadside noise testing procedure is developed.

Vehicle noise enforcement

Vehicle noise tends to increase with vehicle age and use, as a result of equipment failure, incorrect maintenance and tampering with noise control equipment.

If the benefit of improved standards for new and in-service vehicles is to be realised, compliance with these standards will need to be checked and enforced.

These standards, based on the ADRs, are specified in regulations under the NSW Protection of the Environment Operations Act 1997. They are enforced by the EPA, which, among other things, may authorise an officer or employee of the EPA to issue penalty notices for the sale, resale or use of vehicles that

exceed prescribed noise emission levels. The EPA also has the power to stop any motor vehicle for the purpose of investigating compliance with noise standards and noise control equipment standards.

The Police have the authority to enforce the provision under the Australian Road Rules that relates to the making of unnecessary noise. The Road Transport (Safety and Traffic Management) (Road Rules) Regulation 1999 also gives the Police the power to require an engine to be stopped when a vehicle is stationary, so far as may be necessary for the prevention of noise.

Under the provisions of the Road Transport (Vehicle Registration) Regulation 1998, the RTA regulates heavy vehicle noise standards.

Councils and the Police regulate noisy vehicles on private property.

The legislative framework for vehicle noise is outlined in *Section 6*.

The RTA's role in vehicle noise management

The RTA does not have the legislative power to randomly stop vehicles for the purpose of environmental compliance. The RTA's power to stop vehicles is limited to investigating safety issues.

Investigations of defective noise control equipment such as mufflers are conducted during periodic inspections. Heavy vehicles are checked at annual inspections for compliance with vehicle noise standards. Upon the receipt of a complaint, the RTA can also require a heavy vehicle to be presented to its inspection stations for testing.

The RTA supports the enforcement role of the EPA by:

- Testing heavy vehicles for faulty noise emission control equipment at periodic inspections or following complaint, issuing defect notices where warranted.
- Recording all vehicle noise complaints and referring complaints relating to vehicles other than heavy vehicles to the EPA (see *Practice Note IX*).
- Developing driver behaviour education strategies targeted at reducing vehicle noise emissions.
- Partnering industry in the development of a code of practice to promote the purchase of quiet vehicles and the responsible use of engine brakes.

A key driver behaviour education strategy implemented by the RTA is the distribution of brochures through Heavy Vehicle Inspection Stations and the installation of signs warning against the inappropriate use of noisy engine brakes in residential areas. For details, see *Practice Note XI*.

The RTA is the approval authority for the installation of "No Trucks" signs for traffic management and amenity purposes. Councils may approve "No Trucks" signs only for the purpose of protecting the road pavement.

Further reading

Motor Vehicle Environment Committee (1998) *Strategic Plan*

Renzo Tonin and Associates (1997) *Heavy Vehicle Noise Reduction Study*.



Roads and Traffic Authority
www.rta.nsw.gov.au

Part III

Guidelines

and supporting procedures



Determining which noise level criteria apply for new roads and road upgradings

A guideline for determining which target noise levels apply to sites affected by new roads, road “redevelopments” and road upgrades not categorised as “redevelopments”.

Background

As outlined in *Section 6*, the *Environmental Criteria for Road Traffic Noise* present target noise levels for “new” and “redeveloped” roads of various types.

“**New**” roads are defined in the *ECRTN* as roads on new road corridors — or corridors not previously used for the same category of road, such as an arterial road being built on the corridor of what was previously a local road — and existing roads that are being “substantially” realigned.

“**Redevelopments**” are defined in the *ECRTN* as works “where it is proposed to increase traffic-carrying capacity, change the traffic mix or change the road alignment through design or engineering changes”, but expressly do *not* include “minor road works designed to improve safety, such as straightening curves, installing traffic control devices or making minor road [re]alignments”.

This definition makes it clear that if road upgrading works are intended to increase traffic-carrying capacity or change the traffic mix, they are to be classified as “redevelopment” for the purposes of the *Environmental Criteria for Road Traffic Noise*, and the noise target levels for “redevelopments” will apply.

But in the case of road upgrading works (such as a realignment) designed to improve safety, it is not always obvious whether the works are “minor”, in which case the *ECRTN* do not set target noise levels, or whether they are more than “minor”, in which case the *ECRTN* noise target levels for “redevelopments” or “new roads” will apply.

This *Practice Note* sets out principles which can be applied in determining the most appropriate road development category, and hence the corresponding noise target criteria, in otherwise difficult-to-interpret situations, especially where there is a transition between the road categories, including minor and substantial realignments.

These principles have been developed to take account of:

- Road traffic noise exposure from existing routes

- Significant contributions to noise exposure from a road development or upgrade
- New road traffic noise sources, and
- The location of existing route corridor alignments relative to proposed works.

A flow chart and two examples are provided in this *Practice Note* to assist in interpreting the guidance it provides.

This *Practice Note* should be read in conjunction with the *Environmental Criteria for Road Traffic Noise*.

Definitions

'Existing road traffic noise exposure'

A site is defined as having an “existing road traffic noise exposure” if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) $L_{eq}(15hr)$ (day) or 50 dB(A) L_{eq} (9hr) (night).

The noise level contours corresponding to these day and night noise levels define the “noise catchment” for an existing road. In areas outside these contours, road traffic is unlikely to be a significant noise source.

'Significant contribution to road traffic noise exposure'

A “significant contribution to road traffic noise exposure” from a road development or upgrading proposal is defined as an increase in road traffic noise at any exposed façade of more than 2 dB(A) compared to the road traffic noise level from the existing road.

'New source of road traffic noise'

A “new road traffic noise source” can be either:

- A new road where a road of the same category (i.e. arterial, collector or local road) did not previously exist
- A new road within an existing but previously undeveloped road corridor,
or
- An alignment or realignment producing noise at a receptor *from a different direction* which makes a “significant contribution to noise exposure”, as defined above, on top of any increase in traffic noise from the same direction as at present.

To determine whether the noise contribution attributable to the new emission direction is “significant”:

- Subtract the road traffic noise contribution generated from the existing alignment (after any road redevelopment or upgrade on this alignment) from the combined noise exposure, to determine the contribution from the new direction.
- If the new noise emission direction contributes more than 2 dB(A) at any exposed façade, it is “significant”, and this means the

new alignment or realignment is a “new noise road traffic noise source”.

Determining which criteria apply

The easiest way to understand the notes below is to refer to the flow chart on page 82 of this *Practice Note* as you proceed.

Application of the ‘new road’ criteria

The “new road” criteria in the *Environmental Criteria for Road Traffic Noise* apply at the exposed façades of noise-sensitive receivers affected by road traffic noise from:

- Any duplicated carriageway, realignment or new road wholly or partly outside an existing road corridor for the same road category where there is no “existing road traffic noise exposure”, as defined above, and/or
- Any new road or realignment that constitutes a “new road traffic noise source”, as defined above. (In the case of works on an existing road corridor of the same road category, this is effectively testing whether the road has been “substantially” realigned, as required under the definition in the *Environmental Criteria for Road Traffic Noise*.)

At locations where there is a transition between road development types (e.g. a road duplication, or the intersection of a new road or realignment with an existing or redeveloped road), the location of each noise-sensitive receiver relative to the road traffic noise source(s) being considered in assessing the noise contribution of the proposal determines whether the “new road” or “redeveloped road” criteria should be applied (see *Example 1* below).

Application of the ‘redeveloped road’ criteria

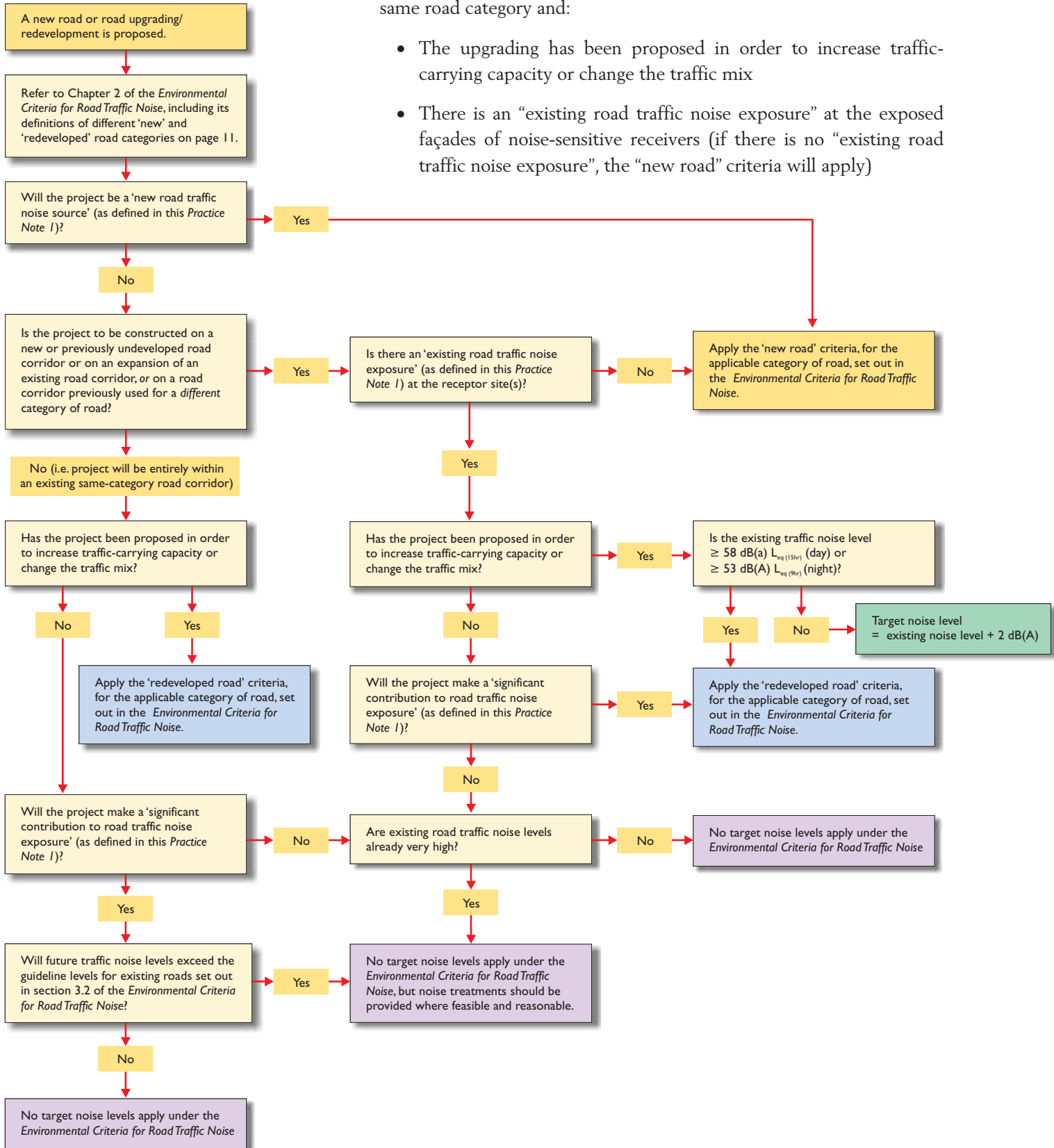
“Redeveloped road” criteria apply in four quite distinct situations.

- (1) The “redeveloped road” criteria in the *Environmental Criteria for Road Traffic Noise* apply at the exposed façades of noise-sensitive receivers affected by road traffic noise from any road duplication or other road upgrading, including even a minor realignment, that generally follows an existing alignment *within* a previously developed existing road corridor for the same road category, if the upgrading has been proposed in order to increase traffic-carrying capacity or change the traffic mix.
- (2) The “redeveloped road” criteria in the *Environmental Criteria for Road Traffic Noise* also apply at the exposed façades of noise-sensitive receivers affected by road traffic noise from a road upgrading marginally *outside* an existing road corridor for the same road category if:
 - The upgrading has been proposed in order to increase traffic-carrying capacity or change the traffic mix
 - There is an “existing road traffic noise exposure” (as already indicated, if there is no “existing road traffic noise exposure”, the “new road” criteria will apply)

- The existing traffic noise level is *equal to or greater than* the criteria applying to “redeveloped roads” (when allowances are taken into account, these are effectively 58 dB(A) $L_{eq}(15hr)$ (day) and 53 dB(A) $L_{eq}(9hr)$ (night)), *and*
- The upgrading does not involve a “new road traffic noise source” (if it does, as already indicated the “new road” criteria will apply).

(3) If a road upgrading is proposed *outside* an existing road corridor for the same road category and:

- The upgrading has been proposed in order to increase traffic-carrying capacity or change the traffic mix
- There is an “existing road traffic noise exposure” at the exposed façades of noise-sensitive receivers (if there is no “existing road traffic noise exposure”, the “new road” criteria will apply)



- The existing traffic noise level at the exposed façades of noise-sensitive receivers is *less than* the criteria applying to “redeveloped roads” (when allowances are taken into account, these are effectively 58 dB(A) $L_{eq}(15hr)$ (day) and 53 dB(A) L_{eq} (9hr) (night)), *and*
- The upgrading does not involve a “new road traffic noise source” (if it does, the “new road” criteria will apply),

the “redeveloped road” criteria still need to be applied, so as to take account of significant increases in road traffic noise, even though these criteria will not be exceeded. In this case noise treatments will need to be offered and designed to maintain predicted noise levels within the existing noise level plus 2 dB(A).

- (4) The “redeveloped road” criteria in the *Environmental Criteria for Road Traffic Noise* apply at the exposed façades of noise-sensitive receivers affected by road traffic noise from a road realignment *outside* an existing road corridor — even if the upgrading is designed only to improve safety and not to increase traffic-carrying capacity or change the traffic mix — if:
- There is an “existing road traffic noise exposure”, as defined above (if there is no “existing road traffic noise exposure”, the “new road” criteria will apply)
 - The realignment will make a “significant contribution to noise exposure”, as defined above, *and*
 - The realignment does not involve a “new road traffic noise source” (if it does, the “new road” criteria will apply).

Road upgrades that are not ‘redevelopments’

If none of the “new road” and “redeveloped road” situations listed above applies, there are no noise level targets in the *Environmental Criteria for Road Traffic Noise*.

For example, if safety works not involving any new alignment or realignment, or involving a realignment entirely within a previously developed road corridor, do not fall within either of the two “new road” categories or any of the “redeveloped road” categories (1) to (4) above, the works are not subject to noise level targets under the *Environmental Criteria for Road Traffic Noise* or the “existing noise level plus 2 dB(A)” requirement set out in (3).

This reflects the fact that — subject to the amount of heavy vehicle traffic — safety projects such as roundabouts, traffic signals, turning lanes, lane widening, minor straightening of curves, other minor realignments, overtaking lanes and road reconstruction usually do not significantly increase road traffic noise impacts at noise-sensitive receivers.

However, if the noise level during the day or the night is predicted to increase by more than 2 dB(A) L_{eq} as a result of upgrade works (other than realignments) which are not “redevelopments”, and the predicted noise level is higher than the guidelines for existing roads set out in section 3.2 of the *Environmental Criteria for Road Traffic Noise*, noise treatments should be provided where feasible and reasonable.

At some locations the existing noise level for this type of project can already be very high. In these situations it is preferable to consider minimising noise impacts even when the increase in noise levels will be 2 dB(A) or less.

Examples

Example 1:

New road alignment intersecting with an existing road and a redeveloped existing road

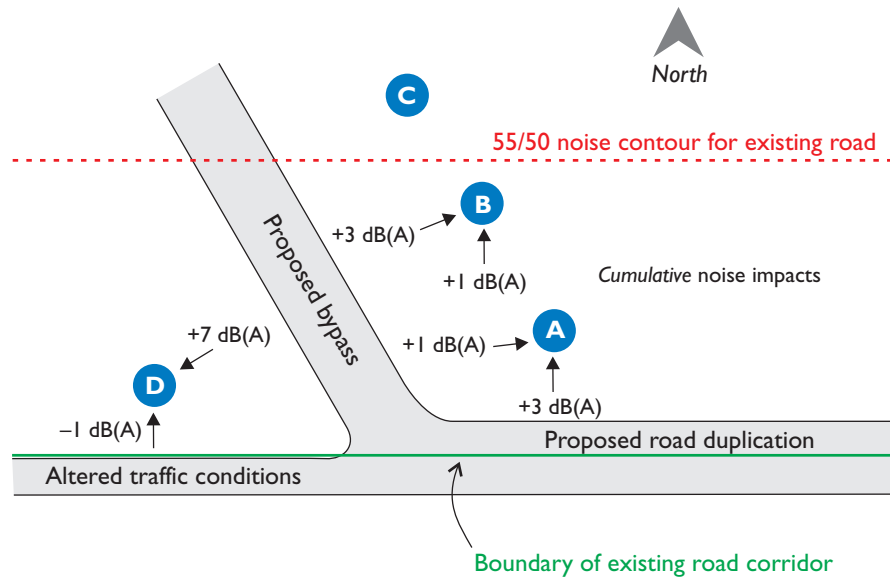


Figure PNI-1. Example 1.

In this example, a new bypass and the northern carriageway of an upgraded (duplicated) existing road will extend beyond the existing road corridor.

No matter what is to happen to the rest of the existing road, the effect of the bypass and changed traffic conditions on the upgraded section of the existing road must be assessed, and the cumulative road traffic noise impacts of both the existing and new alignments, including any noise reduction benefits, must be analysed.

The *cumulative* impact associated with the bypass is calculated by subtracting the noise contribution associated with the existing road and upgraded existing road from the predicted combined noise level at the exposed façades.

Figure PNI-1 shows:

- The “future existing” day 55 dB(A) L_{eq} and night 50 dB(A) L_{eq} noise contour
- The existing road corridor boundary
- Four noise-sensitive sites, A, B, C and D, and
- Noise contributions and directions at the noise-sensitive sites within the 55/50 noise contour.

Site A is located well within the 55/50-noise contour for the existing road alignment and therefore has an “existing road traffic noise exposure”. For the

purposes of this example, let us assume that the existing noise levels at site A exceed 58 dB(A) $L_{eq(15hr)}$ (day) and 53 dB(A) $L_{eq(9hr)}$ (night). The new carriageway of the upgraded existing road is outside the existing road corridor boundary and is obviously intended to increase traffic capacity and/or change the traffic mix. If it were not for the new bypass, the relevant criteria for site A would therefore be the “redeveloped road” criteria set out in the *Environmental Criteria for Road Traffic Noise*. And for this site, the cumulative noise increase from the bypass — calculated by subtracting the redeveloped road’s noise contribution from the combined noise level increase resulting from both the redeveloped road and the bypass — is forecast to be only 1 dB(A), so the criteria for “redeveloped” roads will apply.

Site B, on the other hand, is expected to experience a cumulative noise increase from the bypass of 3 dB(A). The bypass is clearly on a new road corridor. Even though this site already has an “existing road traffic noise exposure”, the noise contribution from the bypass, coming from a different direction to noise from the redeveloped existing road, represents a “new road traffic noise source”, so the “new road” criteria set out in the *Environmental Criteria for Road Traffic Noise* will apply to façades exposed to noise from the new bypass at this site.

Site C is outside the 55/50 noise catchment contour, so the “new road” criteria set out in the *Environmental Criteria for Road Traffic Noise* will apply.

At Site D, the noise level at façades exposed to the existing road will be reduced and the “redeveloped road” criteria may be applied at these façades. However, there will be a considerable increase in noise levels, of 7 dB(A), at façades facing the proposed bypass, and the “new road” criteria will apply when evaluating noise impacts and treatment measures at these façades.

Example 2:

Road duplication requiring an expansion of an existing road corridor

In this example a duplicated carriageway is proposed outside an existing road corridor, closer to sites A, B and C (*Figure PN1–2*).

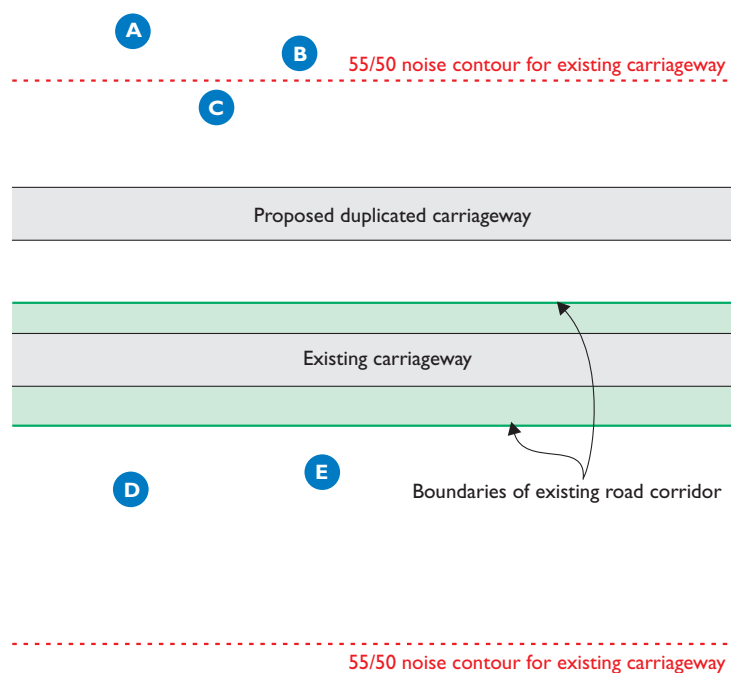


Figure PN1–2. Example 2.

Sites A and B are located outside the 55/50 noise catchment contour for the existing carriageway, indicating that there is not an “existing road traffic noise exposure”. The “new road” criteria will therefore apply at sites A and B.

Site C is within the 55/50 noise catchment contour, indicating an “existing road traffic noise exposure”. The noise criteria for “redeveloped” roads will therefore apply.

Sites D and E are also located within the 55/50 noise catchment contour for the existing carriageway, so again the criteria for “redeveloped” roads will apply.

Should the existing noise level at sites C, D or E be equal to or exceed 58 dB(A) $L_{eq}(15hr)$ (day) or 53 dB(A) $L_{eq}(9hr)$ (night), the relevant “redeveloped road” criteria will be those set out in the *Environmental Criteria for Road Traffic Noise*. Should the existing noise levels at these sites be less than these levels, noise treatment(s) should be offered and designed to maintain the predicted noise level within 2 dB(A) of the existing noise level.



Responsibilities for ameliorating road traffic noise from new and upgraded roads

This Practice Note sets out the RTA's position on the apportionment of responsibility for treating noise-sensitive developments affected by traffic noise from new and upgraded roads.

Background

As discussed in *Section 6*, the Environmental Planning and Assessment Act imposes a responsibility on the RTA to take into account of the environmental impacts of its road development projects, including road traffic noise.

It also imposes a responsibility on development consent authorities considering noise-sensitive land uses to ensure that environmental factors such as road traffic noise are adequately considered as part of the approval process.

The *Environmental Criteria for Road Traffic Noise* provide noise targets and guidance for developers on the incorporation of acoustic principles into the design of new noise-sensitive developments.

Definitions

A 'new road development'

A new road, road redevelopment or road upgrade for which approval has been received.

'Development consent'

"Development consent" means consent granted under Part 4 of the Environmental Planning and Assessment Act. A development consent may, amongst other things, relate to the use of land, the subdivision of land or the erection of a building.

'Noise-sensitive development'

"Noise sensitive development" means:

- Developed land zoned for residential, educational, religious or health care purposes, and

- Vacant land zoned for residential, educational, religious or health care purposes, but only if —
 - ◻ The vacant land has been the subject of a development consent for a subdivision of land, permitting the erection of a building for the permitted noise-sensitive use(s), *or*
 - ◻ There is a development consent or complying development certificate for the erection of a building on the vacant land for the permitted noise-sensitive use(s).

'Existing noise sensitive development'

An “existing noise-sensitive development” means any noise-sensitive development, including a proposed noise-sensitive development, for which a development consent or a complying development certificate has been issued before a road development or upgrading proposal has been approved.

New and upgraded roads: RTA responsibilities

If a new road development or road upgrading will necessitate the provision of road traffic noise treatment(s) to reduce impacts at *existing* noise-sensitive developments, the responsibility for providing the noise treatment(s) will usually lie with the RTA.

The process for selecting the most appropriate noise treatment(s) (noise barriers, quieter pavements and/or architectural acoustic treatments) is described in *Practice Note IV*.

Noise treatments for vacant land zoned for noise-sensitive development should be implemented during the life of the project.

The selection and design of noise treatment(s) for vacant land should be based on the assumption that future development will be single storey and adjacent to the building line, regardless of the number of storeys that the zoning may allow. The developer will then be responsible for incorporating acoustic design principles into any future development on the vacant land, taking into account the noise treatments already provided by the RTA.

In many situations architectural acoustic treatment of individual dwellings may be evaluated as the most suitable treatment measure. In the case of vacant land, it will obviously not be possible to design these architectural treatments until a development application to erect a building has been submitted, and this may not occur until some years after the project has been completed and funding for treatment is no longer available.

If architectural treatment of individual dwellings is the most suitable treatment measure, but at the time of project completion a noise-sensitive development has not yet been built to a stage that would allow the installation of the architectural treatment, it will not be feasible or reasonable for the RTA to provide this treatment.

Noise-sensitive land uses: developers' responsibilities

Developers, and not the RTA, are responsible for providing noise treatment(s) for all noise-sensitive developments proposed after a new road development or

upgrading has been approved, and also where existing road traffic noise is a problem.

The RTA should provide developers with any relevant information that is available on likely future traffic volumes and existing and proposed RTA noise treatments.

If architectural treatment of individual dwellings is evaluated as the most suitable treatment measure for a road project, but at the time of completion of the road project a noise-sensitive development has not yet been built to a stage that would allow the installation of the architectural treatment, responsibility for this treatment lies solely with the developer.

Traffic-generating developments: developers' responsibilities

Practice Note X outlines the requirements of State Environmental Planning Policy 11, *Traffic Generating Developments*, under which the advice of the RTA must be sought before proposals for certain types of developments are approved.

As discussed in *Practice Note X*, developers need to observe the criteria in the *Environmental Criteria for Road Traffic Noise* which specifically relate to land-use developments with a potential to create additional traffic.

Mitigation measures may be needed to reduce the impact on noise-sensitive land uses affected by the additional traffic. These measures are the responsibility of the developer.

Road proposals which have not yet been approved

Some new road routes, including upgrades, may be well defined even though they have not yet been approved.

In these cases, discussions should be held with the local council(s) on potential opportunities for addressing road traffic noise impacts in their approvals process for noise-sensitive developments.

Developers and land owners should also be actively consulted on co-operative opportunities for improvements in the cost-effectiveness and visual appearance of noise treatments.

Subdivision layouts and building orientations and designs that take account of acoustic principles can maximise acoustic benefits, reduce visual impacts and improve land value.

There may be opportunities for the RTA to incorporate treatment measures such as earth mounds into a new subdivision at no extra cost to the developer and a reduced cost to the RTA.



Protocol for assessing maximum noise levels

A guide for assessing maximum noise levels to evaluate potential sleep disturbance impacts from road traffic noise. This Practice Note should be read in conjunction with the Environmental Criteria for Road Traffic Noise.

Background

Although sleep assessment goals are not provided in the *Environmental Criteria for Road Traffic Noise*, the *ECRTN* recommend that an assessment of maximum noise levels should be made where impacts may occur during the night.

This maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.

The *ECRTN* recommend that the assessment should include a calculation of the maximum noise levels, the extent to which the maximum noise levels for individual vehicle pass-bys exceed the L_{eq} for each hour of the night, and the number of maximum noise events.

A substantial portion of the *ECRTN* is a review of international sleep disturbance research, indicating that:

- Maximum internal noise levels below 50–55 dB(A) are unlikely to cause awakening reactions, and
- One or two noise events per night with maximum internal noise levels of 65–70 dB(A) are not likely to significantly affect health and well-being.

At locations where road traffic is continuous rather than intermittent, the $L_{eq(9hr)}$ (night) target noise levels should sufficiently account for sleep disturbance impacts.

However, where the emergence of L_{max} over the ambient L_{eq} is equal to or greater than 15 dB(A), the $L_{eq(9hr)}$ criteria may not sufficiently account for sleep disturbance impacts.

A “maximum noise event” can therefore be defined as any pass-by for which

$$L_{max} - L_{eq(1hr)} \geq 15 \text{ dB(A)}.$$

Assessment protocol

The assessment is used to rank and prioritise design options and noise mitigation strategies.

In situations where there may be impacts attributable to maximum noise events, there may be traffic management or other long-term noise management opportunities which could be investigated even if the $L_{eq(9hr)}$ (night) noise level is less than the target.

The *ECRTN* do not include a requirement to evaluate maximum noise level impacts for road upgrades that are not “redevelopments” as defined in Practice Note I. Even so, an evaluation of maximum noise levels may prove beneficial in managing the concerns of surrounding residents if interruptions to traffic flows are proposed (such as would occur with the installation of roundabouts or traffic lights).

A maximum noise level assessment can also be beneficial in prioritising treatments identified as necessary for “new road” or “redeveloped road” works in order to satisfy the *ECRTN* criteria described in *Practice Note I*.

If a road upgrade is expected to involve interruptions to traffic flows and a maximum noise level assessment is proposed, the protocols for undertaking this type of assessment are set out below.

Maximum noise level monitoring

The objectives of this monitoring are to identify individual maximum noise impacts for the existing noise environment and to use the recorded data as a basis for predicting future impacts.

Monitoring of maximum noise levels needs to be undertaken for all projects other than minor road upgrades. (The maximum noise impacts associated with minor upgrades involving interruptions to traffic flows may be evaluated by applying a prediction method which does not require maximum noise level monitoring, as described below.)

The instrumentation used may be a chart recorder or an integrated sound level meter capable of electronic storage of instantaneous sound pressure levels at intervals of about $\frac{1}{4}$ second.

The storage of noise levels over longer intervals, such as 1-second L_{eq} levels, may be appropriate but should be justified.

The monitoring period should be sufficient to be representative of prevailing traffic flows, and must be conducted over a minimum of one night. The monitoring period used should be justified.

For projects (other than minor upgrades) involving interruptions to the traffic flow or changes to the traffic mix, classified traffic counts need to be taken simultaneously with the maximum noise level monitoring at representative locations exposed to road traffic noise from the existing alignment (see below).

Collate from the monitored and/or predicted existing noise levels — as appropriate for the size and potential impact of the project — the external L_{\max} and L_{eq} noise levels for each hour between 10 pm and 7 am.

For minor road upgrade projects involving interruptions to traffic flow:

While there are no criteria for this type of project, changes in maximum noise impacts are likely to result.

For these projects, calculate the L_{\max} noise levels from the prevailing vehicle types and distributions, using:

- Classified hourly traffic counts (where available) and AADT data for the existing situation, and
- Representative pass-by noise levels for each of the prevailing vehicle types.

Monitored or predicted L_{eq} noise levels for each hour during the night should also be reported.

For 'new roads' and 'redevelopments' that are free-flowing and do not involve interruptions to the traffic flow or changes to the traffic mix:

Changes in maximum noise impacts associated with this type of project will usually be proportional to traffic growth.

For these projects, the L_{\max} and L_{eq} noise levels for the existing environment should be collated from the monitored data.

For other 'new roads' and 'redevelopments':

The maximum noise impacts may not be proportional to traffic growth, as changes in traffic mix and any interrupted traffic flows are likely to cause changes in the magnitude and frequency of maximum noise levels and L_{\max} – L_{eq} maximum noise events.

This means any assessment of maximum noise impacts for the design year needs to evaluate both the expected increases in traffic growth and the expected increases in L_{\max} noise levels from vehicle pass-bys.

As already indicated, this necessitates classified traffic counts simultaneously with the maximum noise level monitoring at representative locations exposed to road traffic noise from the existing alignment.

For projects which will cause interruptions to traffic flow, consider conducting this simultaneous monitoring of classified traffic counts and L_{\max}/L_{eq} noise levels for the existing alignment at both a section of free-flowing traffic and at a section of interrupted traffic flow, where practical. A comparison of these data will allow the differences in maximum noise impacts for the different types of traffic flows to be characterised when predicting impacts for the design year of the road project.

Reporting requirements

Report the following aspects for the existing noise environment:

- The L_{\max} noise levels greater than 65 dB(A) where $L_{\max} - L_{\text{eq}} \geq 15$ dB(A).
- The number and distribution of the $L_{\max} - L_{\text{eq}}$ maximum noise events from road traffic on an hourly basis between 10 pm and 7 am.

The report should discuss the likelihood and extent of maximum noise impacts on the basis of these parameters.

Evaluation of the predicted noise environment for the design year

For minor road upgrade projects involving interruptions to traffic flow:

Refer to the AADT traffic data for the design year, likely vehicle type distributions and representative maximum noise levels for each of the prevailing vehicle types.

Calculate the likely number and distribution of $L_{\max} - L_{\text{eq}}$ maximum noise events occurring during the night.

For 'new roads' and 'redevelopments' that are free-flowing and do not involve interruptions to the traffic flow or changes to the traffic mix:

Refer to the AADT traffic data for the existing environment and the design year.

Calculate the $L_{\max} - L_{\text{eq}}$ maximum noise events for the design year using the monitored existing L_{\max} and L_{eq} noise levels and the projected traffic growth.

For other 'new roads' and 'redevelopments':

If the project will *not* involve changes in the traffic mix but *will* cause interruptions to traffic flow:

- Refer to the noise levels and classified traffic counts recorded at the free-flowing and interrupted sections of the existing alignment, if available.
- Refer to the predicted traffic growth for the design year.
- Calculate the maximum noise levels and the frequency of $L_{\max} - L_{\text{eq}}$ maximum noise events for the design year by applying the percentage increase in traffic to monitored noise data representative of the traffic flow type under consideration.
- If it was not possible to monitor existing interrupted traffic flows, apply a correction to the monitored L_{\max} noise levels for free-flowing traffic, representative of the increase in pass-by noise levels that will occur for each of the vehicle types being considered.

If the project will involve changes to the traffic mix:

- Refer to the L_{\max} and L_{eq} noise levels and classified traffic counts recorded for the existing alignment

- Calculate the L_{\max} and L_{eq} noise levels from the AADT data for the existing alignment, the data obtained from the classified hourly traffic counts of vehicle types and distributions and representative pass-by noise levels for each of the vehicle types being considered.
- Compare the monitored and predicted L_{\max} and L_{eq} noise levels for the existing alignment and calculate any differences in terms of both magnitude and frequency.
- Calculate the $L_{\max} - L_{\text{eq}}$ maximum noise events for the design year from the predicted traffic volume and mix for the design year, representative pass-by noise levels for each of the vehicle types being considered, and the reported differences between monitored and predicted data for the existing alignment.

Reporting requirements

- Report:
 - Differences between monitored and predicted noise levels for the existing alignment and how they were accounted for in predicting maximum noise impacts, if applicable.
 - L_{\max} noise levels greater than 65 dB(A) where $L_{\max} - L_{\text{eq}} \geq 15$ dB(A).
 - The number and distribution of the $L_{\max} - L_{\text{eq}}$ maximum noise events from road traffic on an hourly basis between 10 pm and 7 am.
- Evaluate whether maximum noise impacts will reduce or increase for the design year.
- On the basis of this evaluation, take account of maximum noise levels when prioritising, selecting and designing noise control measures.

Selecting and designing ‘feasible and reasonable’ treatment options for road traffic noise from ‘new’ and ‘redeveloped’ roads affecting residential land uses

A process for selecting and designing “feasible and reasonable” noise treatment options for reducing the impacts of road traffic noise from “new” and “redeveloped” roads on residential land uses.

Processes for evaluating noise treatment options for other types of noise-sensitive land uses will be investigated for inclusion in future revisions to this Manual.

Background

As discussed in *Section 6*, the *Environmental Criteria for Road Traffic Noise (ECRTN)* require that all “feasible and reasonable” mitigation measures should be adopted to meet target noise levels set out in the *ECRTN*. These targets are specified in columns 2 and 3 of Table 1 of the *ECRTN*.

“**Feasibility**” relates to engineering considerations (what can be practically built). These engineering considerations may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources
- Safety issues, such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access requirements
- Maintenance requirements, and
- The suitability of building conditions for architectural treatments.

“**Reasonableness**” relates to the application of wider judgments. The factors to be considered are:

- The noise reduction provided and the number of people protected
- The cost of mitigation, including the total cost and cost variations with different benefits provided

- Community views and wishes
- Visual impacts
- Existing and future noise levels, including changes in noise levels, and
- The benefits arising from the proposed road or road redevelopment.

In many cases existing road traffic noise levels will already be above the *ECRTN* targets. In these cases, the *ECRTN* provide allowances over the existing noise levels, as listed in column 4 of Table 1 of the *ECRTN*, and the primary noise objective for any proposal will be, as a minimum, to contain any increases in noise impact to within these *ECRTN* allowances. However, all “feasible and reasonable” mitigation opportunities should still be explored, to endeavour to reduce existing noise levels towards the target noise levels.

As specified in *Section 7*, potential noise mitigation strategies and designs need to be identified, developed and assessed throughout the road development process, right from the initial strategic and concept stages through to the detailed design stage and project opening.

Road design noise control features will generally have been evaluated during the preparation of the *Preferred Option Report* and refined during initial concept design development (see *Section 7*). This evaluation will have included an economic analysis consistent with the RTA's *Economic Analysis Manual* and consideration of all other issues pertaining to “feasibility” and “reasonableness”.

These road design features may include:

- Adjustments to vertical and horizontal alignments
- Tunnels and acoustic enclosures
- The development of partnerships for the utilisation of airspace above roads for acoustically designed land use developments
- Road gradient modifications
- Traffic management, and
- Alternative design speeds.

The process described in this *Practice Note* aims to provide a consistent approach to the evaluation, selection and design of the most appropriate mix of noise control options *in addition to* these road design features, at locations where the road design features will not be sufficient, by themselves, to reduce noise levels to within the *ECRTN* goals.

These additional noise control options include noise barriers/mounds, architectural treatments and quieter pavement surfaces.

This *Practice Note* will generally apply:

- During the final stages of project concept design development, for inclusion in the concept design report and the *EIS* or *REF*, and
- Later during the project's detailed design.

The process may also be applied if a re-evaluation of the noise treatments provided is considered necessary, upon analysis of the results of post-construction noise monitoring.

The *ECRTN* recognise that in some instances, the application of all available “feasible and reasonable” noise control options may still be insufficient to reduce noise levels to within the *ECRTN* targets. In these situations, there will also be a need to rely on long-term strategic measures, such as:

- Improved land use planning, design and construction (see *Practice Note X*)
- Reduced vehicle emissions through new vehicle standards and the regulation of in-service vehicles (see *Section 11*)
- Greater use of public transport, and
- Alternative methods of freight haulage.

Process

The process described below is summarised in a flow chart at the end of this *Practice Note*. Worked examples are included in *Practice Note IV(c)*.

Step 1: Define the road traffic noise catchment area

For the purposes of this methodology, and regardless of the target noise levels set out in the *ECRTN*, the road traffic noise catchment area to be assessed is generally defined as all the area of land within the closer of:

- The $L_{Aeq}(15hr)$ 55 dB(A) (day) or $L_{Aeq}(9hr)$ 50 dB(A) (night) contour, and
- The noise level contour beyond which the proposed new road or road redevelopment will have no effect,

in each case with no noise mitigation in place.

The road traffic noise catchment area will generally not extend beyond a setback of 300 m from the road alignment, as beyond this distance most noise models are not capable of producing reliable predictions.

Step 2: Identify all noise-sensitive receivers within the noise catchment area

- Divide the overall catchment area into sub-catchments likely to have similar noise exposures, on the basis of factors such as topography, the road's design (cuttings, embankments, intersections, etc), setbacks and types of residences and other noise receptors.
- Further divide the sub-catchments into segments of similar noise impact, approximately within a 5 dB(A) range.
- On a plan, identify all individual dwellings and other noise-sensitive receptors in each segment of the project catchment area.

Each affected dwelling in buildings containing multiple residences should be considered separately.

Step 3:

Calculate existing and future noise levels, including changes in noise levels

One of the considerations stipulated in the *ECRTN* for assessing “reasonable-ness” is the “existing and future noise levels at affected land uses”.

There are two situations in which the RTA believes it is *generally* not “reasonable” to take action to reduce predicted noise levels through the adoption of measures (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) *beyond* the adoption of all “feasible and reasonable” traffic management and other road design measures:

- (1) For proposed “new” roads and road “redevelopments” (see *Practice Note 1*), the RTA believes it is *generally* not “reasonable” to take action to reduce predicted noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:
 - Within 2 dB(A) of “future existing” noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), *and*
 - No more than 2 dB(A) above the target noise levels set out in columns 2 and 3 of Table 1 in the *ECRTN*.

This approach is based on the insignificance of the changes in noise levels involved and the insignificant exceedances of the target noise levels.

It applies only if it can be *demonstrated* that all “feasible and reasonable” traffic management and other road design opportunities for reducing traffic noise have been exhausted.

- (2) For proposed “redevelopments” of roads where existing noise levels already exceed the *ECRTN* target noise levels, and all “feasible and reasonable” traffic management and noise-reducing design opportunities have been incorporated into the road design, the RTA believes it is *generally* not “reasonable” to apply *additional* treatments such as noise barriers/mounds, quieter pavement surfaces and architectural treatment of private dwellings if the predicted design year noise levels:
 - Do not exceed the *ECRTN* allowances (in column 4 of Table 1 in the *ECRTN*) over the “future existing” noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), *and*
 - Will not be acute (i.e. the noise levels are predicted to be less than 65 dB(A) $L_{eq}(15hr)$ (day) and 60 dB(A) $L_{eq}(9hr)$ (night)).

Again, this approach is based on the insignificance of the change in noise levels involved, but recognises the increased importance of reducing noise levels where existing or predicted road traffic noise impacts are acute.

If either of these two “exceptions” applies, no further investigation of noise controls is required.

If these two “exceptions” do *not* apply, proceed to Step 4.

Step 4: Identify all the options

If the *ECRTN* target noise levels will not be met without additional noise control measures beyond those already incorporated into the road design, identify all remaining potential noise-control options, such as quieter pavement surfaces, noise walls, noise mounds and architectural treatments.

Step 5: Analyse the barrier height and other road treatment options

- If the affected residences are grouped in numbers of three or less, go straight to Step 6.
- Otherwise, use the methodology set out in *Practice Note IV(a)* to determine the barrier height required to meet the target noise levels in columns 2 and 3 of Table 1 in the *ECRTN* at the most affected residence, if it is feasible to meet these targets. This barrier is termed the “**target barrier**” option.
 - ◻ No further investigation of options is necessary if this “target barrier” option can be adopted in accordance with the project objectives, at a reasonable cost and with acceptable visual impacts, and is preferred by the community.
 - ◻ Sometimes it will not be feasible to meet the *ECRTN* target noise levels with a noise barrier, because of other road traffic noise from other sources coming from directions. In these situations, the “target barrier” option is the barrier option that will result in the lowest noise level that can be feasibly achieved, taking account of traffic noise from other roads which are not part of the proposal under investigation.
- If the height or other features of the “target barrier” option present problems concerning the option’s cost, aesthetics or community preferences, the “reasonableness” of alternative barrier heights and other treatment options will need to be explored.
 - ◻ Using the methodology set out in *Practice Note IV(a)*, identify the barrier heights providing the greatest marginal noise reduction benefit and the greatest benefit per unit of barrier area, and select the most cost-effective barrier height on the basis of these factors. This barrier is termed the “**assessed barrier**” option.
 - ◻ If both the “target barrier” option and the “assessed barrier” option are feasible, compare the “reasonableness” of these options in terms of the following three factors stipulated in the *ECRTN*:
 - (i) *Noise mitigation benefits and costs*
 - Identify all the residences that would be affected by noise levels above the *ECRTN* target levels or the *ECRTN* allowances, as applicable, if the “assessed barrier” option were adopted instead of the “target barrier” option.

- Calculate, for these residences only, what the extra cost per dB(A) reduction per residence would be if the “target barrier” option were adopted in preference to the “assessed barrier” option.
- Assess the “reasonableness” of this extra cost per dB(A) reduction per residence:
 - * If the cost per dB(A) reduction per residence of the “assessed barrier” option is within 25% of the cost per dB(A) reduction per residence for the “target barrier” option, *and* the “target barrier” option would achieve a noise reduction benefit more than 2 dB(A) better than the “assessed barrier” option, the “target barrier” option would normally be preferred (before any consideration of aesthetics and community views).
 - * If the cost per dB(A) reduction per residence of the “assessed barrier” option is within 25% of the cost per dB(A) reduction per residence for the “target barrier” option, but the increased benefit would be only 2 dB(A) or less, the “assessed barrier” option would normally be preferred (again, this is before any consideration of aesthetics and community views). In these circumstances the provision of additional architectural treatments would normally not be cost-effective.
 - * If the difference between the costs per dB(A) reduction per residence is 25% or greater, the cost differences should be considered “significant” and further evaluation of the options, in accordance with Step 6 below, will be warranted.

(ii) *Community views and aesthetic impacts*

- The RTA *Urban and Regional Design Practice Notes (Beyond the Pavement)* and the RTA *Roadscape Guidelines* provide guidance on the integration of noise control into road and transitway design.
- The RTA *Community Involvement Practice Notes and Resource Manual* details RTA policies on effective community involvement and provides guidance on how this can be achieved.
- Community views should be fully taken into account in following the processes for evaluating and selecting noise treatments.

(iii) *The benefits of the proposed development*

- These typically include travel time reductions, improved levels of service and improved safety.
- Repeat these Step 5 processes for barriers in conjunction with other road treatment measures such as quieter pavement surfaces, to determine the most cost-effective “mix” of road treatment options.

Note, however, that the final decision on the optimal mix of options (Step 6 below) is to be based on all the project's objectives, not just financial cost-effectiveness considerations.

Step 6: Optimise the mix of road treatment and architectural treatment options

Barriers and other road treatments that reduce external noise are normally preferred over architectural treatments that only reduce noise levels within the home, but architectural treatments may be considered in the situations discussed below.

Architectural treatments should be offered only in accordance with the procedures and cost limits described in *Practice Note IV(b)*.

- If residences are closely grouped in numbers of three or less, architectural treatments are preferred over roadside barriers, as it is likely that the cost per residence for barriers will be at least twice that for architectural treatments.

If architectural treatment is selected in lieu of noise barriers, further assessment of treatment options is not required.

- If the difference in cost per dB(A) reduction per residence between the “target barrier” option and the “assessed barrier” option is found to be “significant” (Step 5), the following further evaluation of the barrier options should be carried out:
 - Identify all the residences that would be affected by noise levels above the *ECRTN* target levels or the *ECRTN* allowances, as applicable, if the “assessed barrier” option were adopted instead of the “target barrier” option.
 - Calculate, for these residences only, what the extra cost per residence would be if architectural treatments were selected.
 - Compare this with the extra cost per residence for these residences if the “target barrier” option were adopted in preference to the “assessed barrier” option.
- If the *ECRTN* target noise levels are already exceeded but the noise levels at all affected sites with the “assessed barrier” option are predicted to be *within* the *ECRTN* allowances set out in column 4 of Table 1 in the *ECRTN*, the “assessed barrier” option should be preferred over the “target barrier” option, and architectural treatments may only be considered:
 - As an *alternative* to the “assessed barrier” option
 - If the community prefers them, *and*
 - If they cost less than the “assessed barrier” option.
- On the other hand, if the “assessed barrier” option will result in noise levels *higher* than:
 - The *ECRTN* target noise levels (columns 2 and 3 of Table 1 in the *ECRTN*), or

- The *ECRTN* allowances (column 4 of Table 1 in the *ECRTN*), as applicable, architectural treatments may be considered:

- If the cost per residence for architectural treatments is less than or equal to 50% of the increase in cost per residence for the “target barrier” option, architectural treatments in combination with the “assessed barrier” option should be preferred.
- If the cost per residence for architectural treatments is greater than 50% of the increase in cost per residence for the “target barrier” option, the “target barrier” option should be preferred over the combination of the “assessed barrier” option and architectural treatments.

- In some situations, even after following the process described above, engineering “feasibility” and visual impact considerations may still warrant a reduction in the height of the selected barrier option.

In these cases, after all available road treatment options have been included in the design, architectural treatments may be offered — *in combination with* the reduced height barrier, and in accordance with the procedures and cost limits described in *Practice Note IV(b)* — for all residences where noise levels are predicted to exceed:

- The *ECRTN* target noise levels (columns 2 and 3 of Table 1 in the *ECRTN*), or
- The *ECRTN* allowances (column 4 of Table 1 in the *ECRTN*),

as applicable.

- More generally, architectural treatments may be provided, as an *alternative* to a noise barrier and again in accordance with the procedures and cost limits described in *Practice Note IV(b)*, to all residences where:
 - The *ECRTN* target noise levels or the *ECRTN* allowances (as applicable) are exceeded
 - The community prefers them, *and*
 - They cost less than the optimal combined barrier and architectural treatment option, determined as described above.

If the “architectural treatment in lieu of noise barrier” option is *not* largely supported by the community, and/or if architectural treatment of individual dwellings will cost more than a noise barrier, the optimal *combination* of road treatment and architectural treatment options should be applied, as described above.

- Note that external screen walls on private land that provide a continuous barrier and protect a number of houses should be assessed in the same manner as roadside noise barriers.

Further reading

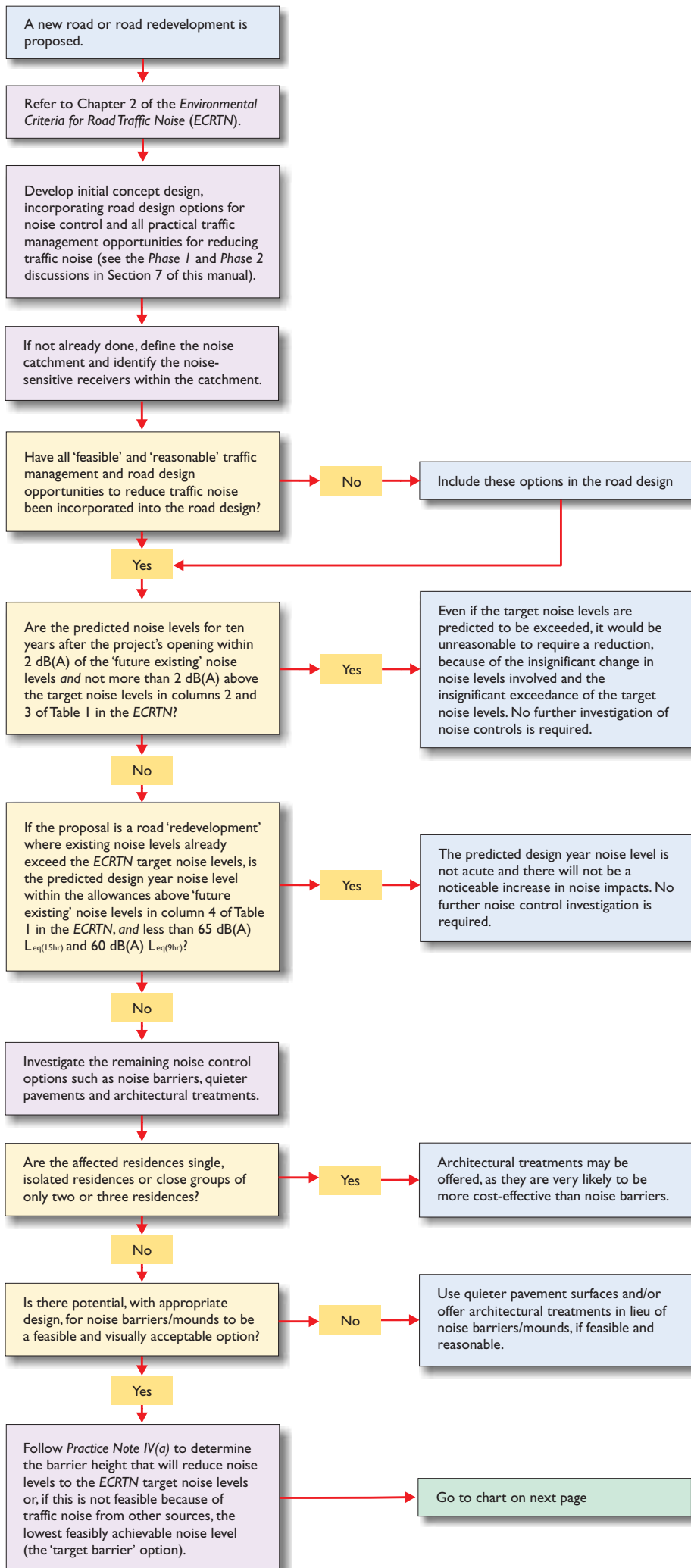
EPA (1999) *Environmental Criteria for Road Traffic Noise*

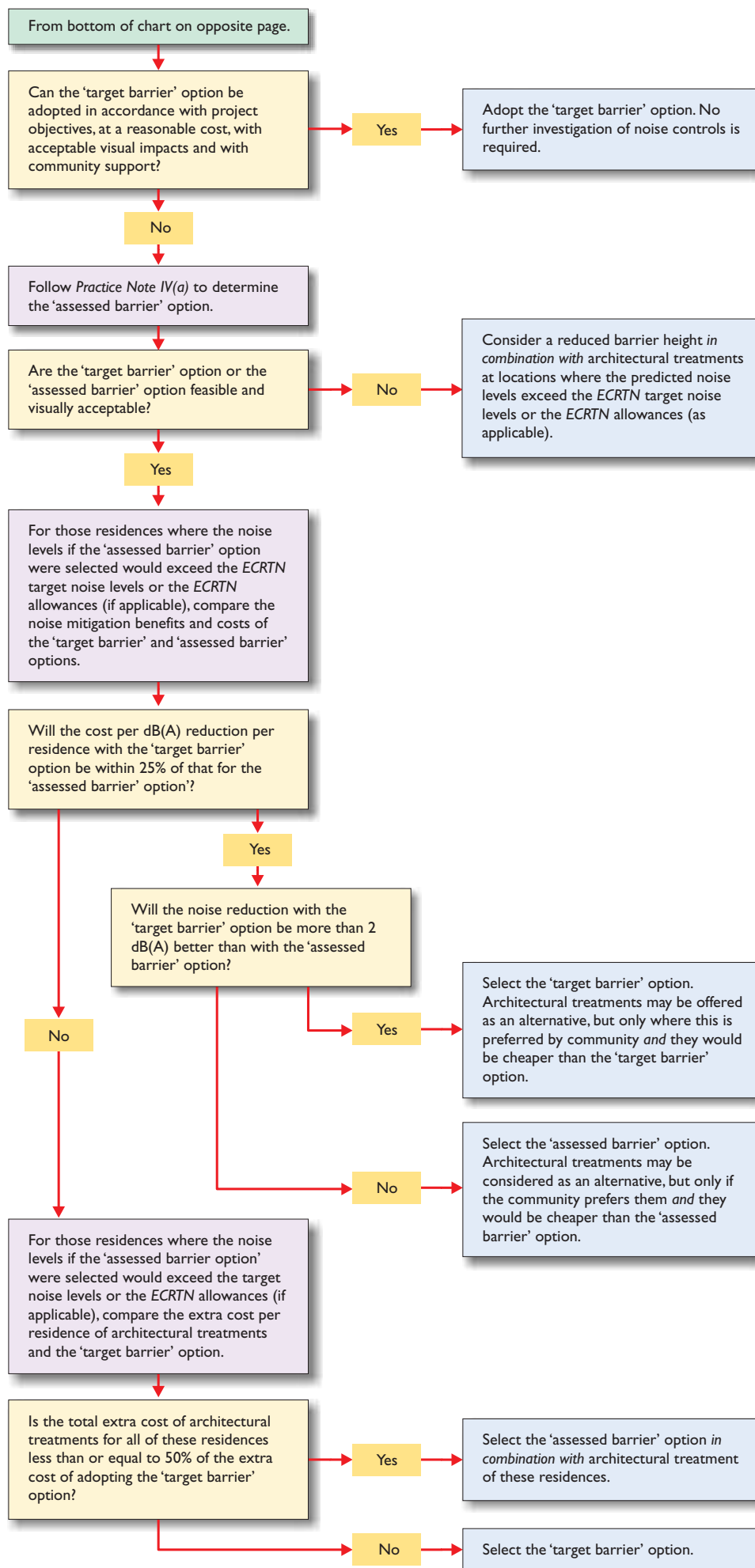
RTA (1998) *RTA Community Involvement Practice Notes and Resource Manual*

RTA (1999) *Beyond the Pavement: RTA Urban and Regional Design Practice Notes*

RTA (1999) *Economic Analysis Manual*.







Noise barrier heights

A way of analysing an acceptable balance between barrier height and effectiveness. A comparative cost-effectiveness methodology for noise mitigation options is provided in Practice Note IV for new and upgraded roads and Section 8 for existing roads.

Background

As discussed in *Section 6*, the *Environmental Criteria for Road traffic Noise* set noise level targets for specific types of projects but allow the acceptance of higher noise levels if it can be *demonstrated* that it is not feasible and reasonable to meet these targets.

The factors which must be considered in assessing the “reasonableness” of noise barriers and mounds include:

- Their benefits, in terms of the noise reductions achieved and the number of people protected, and
- Their costs, in terms of their total cost and the variation of this cost with variations in the benefits provided.

The analytical tools described in this *Practice Note* permit a consistent and robust approach to one aspect of these types of analyses: the identification of optimal noise barrier heights.

They are based on the interaction between barrier heights — and thus barrier areas and thus a significant component of barrier costs — and the resulting acoustic benefits within a defined area.

This methodology is applicable only to noise walls and mounds of a uniform type. It cannot be used, for example, to compare the cost-effectiveness of noise walls with alternatives such as quieter pavements, changes in vertical alignments or architectural noise-mitigation treatments.

It also ignores incidental factors such as variations in the costs of landscaping to mitigate the adverse visual impacts of noise walls of different styles and heights.

The methodology may, however, be used to explore the effectiveness of different noise wall heights *in combination with* other noise-mitigation techniques such as quieter pavement surfaces, especially when barrier heights are constrained for aesthetic reasons.

The methodology should not be applied for noise treatments at single dwellings, as barriers will not be a cost-effective treatment in these cases.

Design methodology

Step 1: Design a range of barrier options

Calculate the noise levels at all dwellings and other sensitive receptors within each segment of the catchment area, assuming there are no noise barriers.

- ☞ Refer to Steps 1 and 2 of the “Process” section of *Practice Note IV* (for new and upgraded roads) or Step 2 of the “Implementation” section of *Section 8* (for Noise Abatement Program assessments), as applicable.

Then explore the effectiveness, for each segment, of a barrier of varying height.

Compute the noise levels at all noise-sensitive receptors, starting, as a minimum, with the noise barrier height that will achieve a 5 dB(A) reduction in the noise level along the road section being examined.

Then increase the height of the barrier in steps of 0.5 m or 1 m, as appropriate, and calculate the new noise levels for each height.

The range of nominal noise level goals for which different barriers heights should be tested should extend from the maximum predicted “do nothing” noise level at the most affected residence down to the higher of:

- 50 dB(A) $L_{Aeq}(15 \text{ hour})$ or 45 dB(A) $L_{Aeq}(9 \text{ hour})$ (cumulative, from all road traffic noise sources), and
- The lowest noise level that can be achieved, taking into account the cumulative effect of all other road traffic noise sources.

If desired, repeat this process for noise walls of different heights in combination with other noise-mitigation techniques such as quieter pavements and changes in vertical alignments.

When considering quieter pavement surfaces in conjunction with noise barriers, it is reasonable to assume, for the purposes of this analysis, that there will be a linear additional noise benefit. On this basis, the noise reduction associated with noise barriers may be increased by the quieter pavement surface correction factor.

In some cases individual noise-sensitive receivers may be intuitively identified as having the potential to unduly “skew” or bias the barrier option analysis, because of their proximity or angle of view to the road alignment. In these circumstances these receivers may be excluded from the calculations and architectural acoustic treatments may be offered where this is feasible and reasonable.

In order to be considered cost-effective and therefore warrant consideration as a viable noise treatment option, noise barriers must provide an “insertion loss” — the actual noise reduction, taking account of the barrier’s reduction of noise from the proposal *and* noise from all other road traffic noise sources — of at least 5 dB(A) at the most affected residence. An exception to this may be reasonable, however, in the case of small barriers that are relatively cheap to install (such as “New Jersey”-style kerbs), at locations where even small noise reductions are important.

For noise barriers more than 3 m high, the insertion loss must be *more than* 5 dB(A) at the most affected residence.

For barriers which are 5 m high or higher, the insertion loss must be at least 10 dB(A) at the most affected residence.

Noise barriers more than 8 m high are generally considered visually unacceptable.

Step 2:

Calculate the total and marginal noise benefits for different barrier heights

The “**total noise benefit**” (TNB) for each barrier height option is the sum of the dB(A) reductions achieved (taking account of all road traffic noise sources) at all residences and other noise-sensitive receptors within each segment for the barrier height.

The “**marginal benefit value**” (MBV) for a particular barrier height option is the increase in “total noise benefit” (TNB) divided by the increase in barrier height or area. (The methodology assumes barrier costs are proportional to barrier areas and are hence proportional to barrier heights, even though other factors such as barrier material will also have an influence on costs.)

The “**total benefit per unit barrier area**” (TNBA) is the “total noise benefit” (TNB) divided by the total area of the barrier in the road section being examined.

Any convenient unit of area may be used.

For each barrier height option, the **highest noise level predicted at any dwelling** (taking account of all road traffic noise sources) should also be recorded.

Step 3:

Plot and evaluate the marginal and total noise benefits and the highest noise levels for different barrier heights

Plot the TNB, MBV, TNBA and highest noise level at any dwelling against barrier heights or barrier areas.

Peaks in the MBV curve correspond to barrier options with the greatest *marginal* cost-effectiveness, while peaks in the TNBA curve correspond to barrier options with the greatest *overall* cost-effectiveness, compared with the other barrier height options being considered.

The “**assessed barrier option**” is the barrier option selected after considering all of these parameters.

The “**target barrier option**” is the barrier option that results in the target noise levels’ being met at the most affected residence, or if these targets cannot be met because of traffic noise from other roads, the barrier option which results in the lowest feasibly achievable traffic noise levels.

The worked examples in *Practice Note IV(c)* include analyses of noise barrier heights.

Further reading

EPA (1999) *Environmental Criteria for Road Traffic Noise*

RTA (1999) *Beyond the Pavement: RTA Urban and Regional Design Practice Notes*

RTA (1999) *Economic Analysis Manual*.



Acoustic treatment of individual dwellings

These procedures should be followed when acoustic treatment of individual dwellings is being considered as a road traffic noise control option by the RTA.

Background

As discussed in *Section 4*, the provision of acoustic treatments to individual dwellings may be a viable road traffic noise treatment option for new, upgraded and existing roads, depending on factors such as cost-effectiveness, aesthetics and community and resident preferences.

For existing buildings these treatments are generally limited to acoustic treatment of the building elements and the installation of acoustic screen walls close to the dwelling.

The *Environmental Criteria for Road Traffic Noise* set external noise level targets which should be used as a design guide for external screen walls.

Architectural acoustic treatments should aim to achieve internal noise levels in habitable rooms 10 dB(A) below the external noise level targets. 10 dB(A) is equivalent to the traffic noise reduction that can be achieved for most building structures with the windows sufficiently open to satisfy minimum fresh air requirements.

Building element treatments are more effective when they are applied to masonry structures than light timber frame structures. Caution should be exercised before providing treatments for buildings in a poor state of repair, as they will be less effective in these cases.

The acoustic treatments provided by the RTA are limited to:

- Fresh air ventilation systems that meet Building Code of Australia requirements with the windows and doors shut
- Upgraded windows and glazing and solid core doors on the exposed façades of masonry structures only (these techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls)
- Upgrading window and door seals
- The sealing of wall vents, and
- The installation of external screen walls.

In most cases the limit per residence on the funding provided by the RTA for acoustic screen walls and/or building treatments for individual dwellings is:

- \$15,000 where the external noise level exceeds the target noise level by up to 10 dB(A), and
- \$20,000 where the external noise level exceeds the target noise level by more than 10 dB(A).

Additional funding may be provided, however, where site-specific circumstances prevail.

The RTA's funding is also subject to the execution of a Deed of Release in the standard form shown at the end of this *Practice Note*.

While due care must be taken in the design and selection of acoustic treatments for which funding is provided, the RTA makes no representations that any particular internal noise level will be achieved. There is therefore no need to verify that a particular internal noise level has been achieved, and post-treatment noise monitoring is not required.

Under the Deed of Release the RTA also accepts no legal responsibility to building owners for the quality of the treatments carried out, their maintenance, the owner's maintenance and operating costs or future noise treatments. As described below, however, the RTA must be satisfied about the treatment works carried out before it releases payment.

Upgraded windows and doors must have a minimum sound transmission class of 30 dB(A).

Processes

Step 1: Assess the practicality of treatments

- Identify the predicted external road traffic noise levels on which the design of acoustic treatments will be based.
- Assess the practicality of providing treatments where noise levels already exceed or are predicted to exceed the target noise levels in the *ECRTN*.
 - Obtain plans of the internal layouts of the affected buildings.
 - Normally this assessment is required only for the two most exposed levels of buildings.
- Consult with the affected building owners on their preferences for building treatments and/or the provision of external screen walls.
- Conduct a preliminary cost-effectiveness assessment to determine whether external screen walls, building treatments or both might be offered.

Screen walls and courtyard walls providing only localised protection should be assessed in terms of external noise levels, owners' preferences and their cost compared with other treatments.

Continuous fence walls protecting more than three closely grouped dwellings should be assessed as noise barriers, in the ways described in *Practice Notes IV and IV(a)*.

The available options for building treatments are:

- Fresh air ventilation systems and the sealing of wall vents (for any building construction type)
- Upgraded window and door seals (for any building construction type), and
- Upgraded windows, glazing and doors (for masonry structures for which the external noise levels exceed or are predicted to exceed the target noise levels by more than 10 dB(A)).

Upgraded windows, glazing and doors may also be provided, in lieu of fresh air ventilation systems, where noise levels are predicted to be equal to or less than 10 dB(A) above the target noise levels and the building owner(s) prefer this option. However, the owner(s) should be informed in writing that this option will require the windows to be kept open when fresh air is required to maintain healthy living conditions, and that when the windows are open no noise reduction benefit will be achieved.

Step 2: Initial cost estimates

- Obtain cost estimates for the installation of the identified practical treatment options.
- Review the options' cost-effectiveness, as described in *Practice Note IV* for new and redeveloped roads and *Section 8* for existing roads.
- If the cost of acoustic screen walls and/or building treatments for a residence would exceed the \$15,000/\$20,000 limit, as applicable, examine whether additional RTA funding would be warranted in the particular circumstances. The building's owner(s) might be willing to fund the installation of treatments beyond the normal limit themselves.

Step 3: Selection of treatments, council approvals, scope of works and quotations

- Verify the identity of the building's owner(s).
- Negotiate the design of external screen wall(s) and/or building treatments in consultation with the building owner(s).
- Consult with the local council regarding its approval requirements for the proposed works.
- Engage the services of an accredited certifier to manage the approval and building inspection process.

The treatments provided will usually be classified as exempt or (less commonly) complying development.

The "exempt development" classification allows works to proceed without the need to obtain construction and compliance certifications

or development consent and approval. The works must, however, comply with prescriptive “exempt development” requirements.

The “complying development” classification allows construction and compliance certificates to be issued by a private accredited certifier. In these cases the accredited certifier is responsible for submitting construction and compliance certificates and obtaining development consent and approval.

- In consultation with the building owner(s), prepare a broad scope of building works that reflects the findings of Steps 2 and 3 and the preferences of the owner(s). The scope of building works should clearly identify the products included (brand, model, colour, etc), the location of treatments, window opening regimes and the like.
- In consultation with the building owner(s), obtain at least two quotes for the supply and installation of the architectural treatments.

The quotes must be based on a detailed scope of works that satisfies the requirements of the accredited certifier and describes the fixing methods specific to the property in question.

This scope of works must also require the contractor to:

- Provide a 7-year labour warranty, and
- Provide evidence that the building components will be covered by a 5-year parts warranty (or, if they are procured on a supply-and-install basis, a 5-year parts and labour warranty).
- Negotiate the preferred quote with the building owner(s) and finalise the scope of works.

Step 4: Execution of contracts

- Execute a Deed of Release with the building owner(s), based on the standard form deed at the end of this *Practice Note*.
 - Attach the scope of works as a schedule to this deed.
- Enter into a contract for the delivery of the scope of works with the preferred contractor.

Step 5: Provision of RTA funds to the building's owner(s)

- The contractor must notify the RTA when the works have been completed.
- Seek written concurrence from the building owner(s) that the works have been completed to their satisfaction.
- The accredited certifier will then inspect the site for the purpose of certifying that the works have been completed in a workmanlike manner, in accordance with the scope of works, in consideration of any complaints by the building owner, and in accordance with any local council requirements.

- If rectification works are required, payment should not be made until these works have been completed and satisfactory certification has been obtained from the accredited certifier.

Step 6: Record the treatments

- Record the following information about the treatments on the RTA's regional *Noise Abatement Program* database (see *Section 8*):
 - The address of the property
 - A description of the treatments provided and their cost
 - The date the treatments were provided.
- Retain the following records on a permanent basis:
 - A description of the property, including title information
 - All correspondence between the RTA and the owner(s), contractor and certifier.
 - The Deed of Release
 - The scope of works
 - The building certificate, and
 - The cost of the treatments.

All architectural treatment records are to be stored on the property file for the affected site. Prospective building owners and their representatives may request information on whether the RTA has any interest in a particular property. As part of the RTA's investigation, all enquiries should be directed to the relevant region so that a review of architectural treatment records can be undertaken.

Further reading

EPA (1999) *Environmental Criteria for Road Traffic Noise*

Australian Building Codes Board, *Building Code of Australia*

Standards Australia, AS1170 *Minimum Design Loads on Structures*

Standards Australia, AS1288 *Glass in Buildings – Selection and Installation*

Standards Australia, AS2208 *Safety Glazing Materials for Use in Buildings (Human Impact Considerations)*

Standards Australia, AS3671 *Acoustics – Road Traffic Noise Intrusion – Building Siting and Construction*

Standards Australia, AS3700 *Masonry Structures*.

Standard form of Deed of Release for dwelling treatments

CONSENT AND AGREEMENT

THIS DEED is made the _____ day of _____

BETWEEN: The Roads and Traffic Authority of New South Wales (“the RTA”) on the one part

AND: [Insert the exact names of all registered proprietors of the land. This information must be obtained from a Land Titles search.] (“the Releasor”) on the other part

WHEREAS:

- A. The Releasor is the registered proprietor of property known as (hereinafter called “the premises”).
- B. The RTA proposes to carry out certain works in the vicinity of the premises.
- C. The proprietor requests the RTA to carry out or procure certain noise amelioration works (“the works”) to the proprietor’s premises as specified in the Schedule hereto [*or* as set out in Specification or Plan , a copy of which is annexed to this Deed].
- D. The RTA agrees to arrange for the works to be carried out to the premises.
- E. In consideration of the RTA’s procuring [third parties] to carry out the works the Releasor has granted his/her/its permission to the RTA and its contractors, servants and agents to enter the premises to carry out the works.

NOW THIS DEED WITNESSES THAT:

1. The Releasor grants the RTA and its contractors, servants and agents permission to enter the premises to carry out the works and to occupy the premises for the purposes of undertaking such works.
2. The Releasor will do all things reasonably necessary to facilitate the carrying out of the works on the premises.
3. In consideration of the works being carried out the Releasor:
 - (i) Releases unconditionally and forever all claims and causes of action against the RTA in respect of any need for noise amelioration works to be carried out as a result of the works, the carrying out of the works and the maintenance and costs of operating and maintaining the works, and
 - (ii) Agrees to indemnify and keep indemnified the RTA from and against all claims and causes of action that may be made against the RTA in respect of the aforesaid, including any claim by any person who has any other title or interest in the land, and
 - (iii) Agrees to obtain a release and indemnity in the same terms as this Deed from any successor in title.

IN WITNESS WHEREOF the Releasor and the RTA execute this Release and Indemnity as a Deed.

SIGNED SEALED AND DELIVERED for the RTA by its authorised delegate

In the presence of:

(Witness)

SIGNED SEALED AND DELIVERED by the Releasor and

In the presence of:

(Witness)

SCHEDULE

[Attach scope of works – see paragraph “C” of the recitals above]

Worked examples of the selection and design of treatment options

Worked examples are provided to assist with the practical application of Practice Notes IV, IV(a) and IV(b) in selecting and designing 'feasible and reasonable' treatment options for road traffic noise from 'new' and 'redeveloped' roads affecting residential land uses.

Example 1:

New motorway with predicted moderate road traffic noise levels, passing through a residential subdivision with low existing road traffic noise levels

The road considered in this example is a newly proposed dual carriageway motorway with two lanes each way. A noise model is used to predict noise levels with the following assumptions:

- Use of OGAC quiet pavement
- 90 km/h posted speed limit
- 8% heavy vehicles during the day and during the night.
- Source heights:
 - Car engine above road 0.5 m
 - Truck engine above road 1.5 m
 - Truck exhaust above road 3.6 m

From Table 1 in the *Environmental Criteria for Road Traffic Noise (ECRTN)*, the “base” road traffic noise criteria for residences near a new freeway or arterial road corridor are $L_{eq(15hr)} \leq 55$ dB(A) and $L_{eq(9hr)} \leq 50$ dB(A).

Practice Note IV

Step 1: Define the road traffic noise catchment area

The noise catchment is defined as the area of land within the 55 dB(A) $L_{eq(15hr)}$ / 50 dB(A) $L_{eq(9hr)}$ road traffic noise contour with no noise mitigation in place (the shaded areas in *Figure PNIV(c)-1*).

The noise modelling has shown that in this example the daytime *ECRTN* target noise level of 55 dB(A) $L_{eq(15hr)}$ is more stringent than the night-time

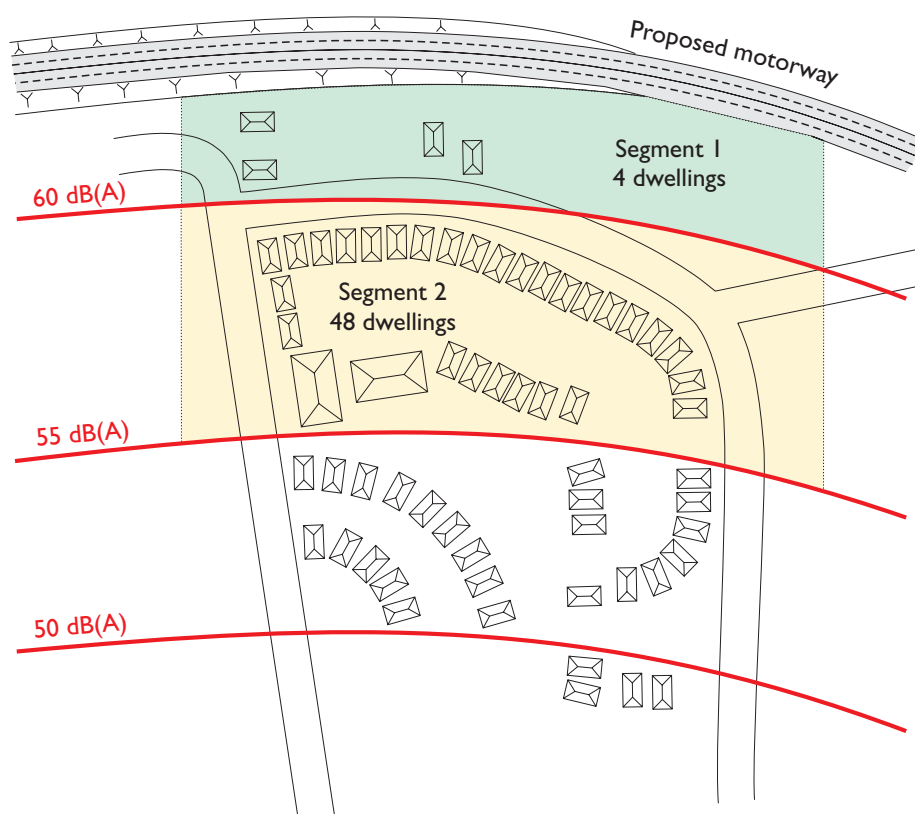


Figure PNIV(c)-1. Example 1: Site layout, $L_{Aeq(15hr)}$ noise contours before noise barrier or architectural treatment, and the noise catchment and its segments (shaded areas).

target noise level of 50 dB(A) $L_{eq(9hr)}$. In other words, the predicted exceedance of the daytime target noise level at residences in the noise catchment area, with no noise mitigation, is greater than the predicted exceedance at night.

Step 2: Identify all noise-sensitive receivers within the noise catchment area

As shown in *Figure PNIV(c)-1*, the noise catchment has been divided into sub-catchments intuitively thought to have similar noise exposures on the basis of similar topography, road design features, types of noise-sensitive receptors and existing road traffic noise sources.

There are two segments with dwellings that will be affected by similar noise levels (approximately within a 5 dB(A) range): Segment 1 is the area above the 60 dB(A) noise contour and Segment 2 is the area between the 55 and 60 dB(A) noise contour.

The remaining residences depicted in *Figure PNIV(c)-1* are outside the 55 dB(A) noise catchment contour and will therefore not be included in the analysis of costs and noise-reduction benefits.

There are 34 residential buildings in the catchment. Two of these buildings are apartment complexes containing ten residences each, so there are 52 residences in total in the noise catchment, four in Segment 1 and 48 in Segment 2.

As roadside noise treatments designed to meet the target noise level at the closest residence will also result in the target noise level's being met outside all

occupancies of the apartment complexes, the height of the apartment complexes will not cause an undue bias in barrier height design.

☞ *If an undue bias were likely, it might be appropriate to consider, for example, the first two levels of the apartment complexes in the barrier design, and adopt architectural treatments for the remaining levels.*

Step 3: Calculate existing and future noise levels, including changes in noise levels

Existing ambient road traffic noise levels (at the building façade most exposed to the motorway) are:

- Segment 1: 42 dB(A) $L_{eq}(15hr)$
- Segment 2: 44 dB(A) $L_{eq}(15hr)$.

For the purpose of this example it is assumed that all “feasible and reasonable” traffic management and other road design opportunities for reducing traffic noise have been exhausted. More specifically, there are no further traffic management opportunities for reducing noise impacts, and the alignment of the road cannot be adjusted, because of the location of existing developments along the route.

On the basis of initial traffic noise model predictions, without any additional noise mitigation measures, it *cannot* be shown in this case that:

- The noise levels for the proposal ten years after the project opening are predicted to be within 2 dB(A) of the “future existing” noise levels (the noise levels from existing sources of road traffic noise predicted for the time the motorway will open), and
- The predicted noise levels ten years after project opening are no more than 2 dB(A) above the *ECRTN* target noise levels.

Therefore, all available noise mitigation options need to be identified and evaluated.

Step 4: Identify all the options

The noise mitigation options which have not yet been utilised include noise walls, noise mounds and architectural treatments. A quieter pavement surface will not be sufficient on its own to mitigate traffic noise sufficiently to achieve the targets.

Step 5: Analyse the barrier height and other road treatment options

There are more than three affected residences grouped together, so noise barrier options need to be considered.

The methodology set out in *Practice Note IV(a)* is used to determine barrier heights for the “target barrier” and “assessed barrier” options.

Practice Note IV(a)

Step 1: Design a range of barrier options

The ranges of predicted daytime noise levels for dwellings in each segment ten years after project opening, assuming no barriers, are identified in *Table*

PNIV(c)-1 below, along with the corresponding representative noise levels (the noise levels at the most affected residences in each segment).

Table PNIV(c)-1
Example 1: Predicted daytime traffic noise levels without noise barrier or architectural treatment mitigation

Segment	Noise exposure range $L_{Aeq(15hr)}$ (dB(A))	Representative noise level $L_{Aeq(15hr)}$ (dB(A))
1	64 to 60	64
2	59 to 55	59

Noise barrier construction costs include the fixed costs of excavation and the installation of footings. The cost-effectiveness of small barriers is limited by these initial setup costs. Accordingly, a minimum noise reduction of 5 dB(A) is generally required before noise barriers are considered as a cost-effective mitigation option.

The range of nominal noise level goals for which different barrier heights should be tested should extend from the maximum predicted “do nothing” noise level (no barrier) at the most affected residence down to the *higher* of:

- (1) 50 dB(A) $L_{eq(15hr)}$ (It can usually be assumed that road traffic noise will not be a major contributor to environmental noise at levels below 50 dB(A) $L_{eq(15hr)}$.)

As the existing noise levels for Segments 1 and 2 are 42 and 44 dB(A) $L_{eq(15hr)}$ respectively, a noise barrier would need to be designed to reduce noise contribution from the proposed road to:

- Segment 1: $L_{eq(15hr)} = 50 \text{ dB(A)} - 42 \text{ dB(A)} = 49 \text{ dB(A)}$
- Segment 2: $L_{eq(15hr)} = 50 \text{ dB(A)} - 44 \text{ dB(A)} = 49 \text{ dB(A)}$

☞ *Note: The above noise level calculations are based on the principles of adding noise levels together described in Section 1.*

- (2) The lowest noise level that can be achieved, taking into account the cumulative effect of all other road traffic noise sources.

The lowest possible noise level will be achieved if the noise contribution of the proposed road is designed to be 10 dB(A) below the existing traffic noise level:

- Segment 1: $L_{eq(15hr)} = 32 \text{ dB(A)}$
- Segment 2: $L_{eq(15hr)} = 34 \text{ dB(A)}$.

In this example (1) is higher than (2) for both Segment 1 and Segment 2, so we shall use (1) for both segments.

Table PNIV(c)-2 shows, for each segment,

- Noise levels, including all road traffic noise sources, with no barrier
- Noise levels, including all road traffic noise sources, for a range of barrier heights, starting with the minimum barrier height required to achieve a 5 dB(A) insertion loss and increasing in 0.5 m increments to the height required to achieve the minimum of 50 dB(A) in Segment 1, and

- The corresponding representative barrier insertion loss for each incremental increase in barrier height.

Table PNIV(c)-2
Example 1: Effectiveness of noise barriers of varying heights

Barrier height (m)	Representative cumulative road traffic noise level (all sources) (dB(A))		Representative barrier insertion loss (all sources) (dB(A))	
	Segment 1	Segment 2	Segment 1	Segment 2
No barrier	64	59	0	0
1.0	58	54	6	5
1.5	56	53	8	6
2.0	55	52	9	7
2.5	54	51	10	8
3.0	53	50	11	9
3.5	52	49	12	10
4.0	51	48	13	11
4.5	50	47	14	12

Step 2: Calculate the total and marginal noise benefits for different barrier heights

Total noise benefit (TNB) = dB(A) insertion loss at the most affected residence in each segment × number of dwellings in each segment

Marginal benefit value (MBV) = increase in TNB / increase in barrier height (or area)

Total noise benefit per unit barrier area (TNBA) = TNB / total area of barrier

Table PNIV(c)-3
Example 1: Segment 1 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB)	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From <i>Table PNIV(c)-2</i>	= B × 4	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (42 dB(A))
0	0				64	64
0.5	4	16			60	60
1.0	6	24	1.6	0.8	58	58
1.5	8	32	1.6	0.7	56	56
2.0	9	36	0.8	0.6	55	55
2.5	10	40	0.8	0.5	54	54
3.0	11	44	0.8	0.5	52	53

Table PNIV(c)-3
Example 1: Segment 1 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB)	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-2	= B × 4	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (42 dB(A))
3.5	12	48	0.8	0.5	51	52
4.0	13	52	0.8	0.4	50	51
4.5	14	56	0.8	0.4	49	50

Table PNIV(c)-4
Example 1: Segment 2 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB)	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-2	= B × 48	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (44 dB(A))
0	0				59	59
0.5	3	144			56	56
1.0	5	240	19.2	8.0	54	54
1.5	6	288	9.6	6.4	52	53
2.0	7	336	9.6	5.6	51	52
2.5	8	384	9.6	5.1	50	51
3.0	9	432	9.6	4.8	48	50*
3.5	9	432	0	4.1	47	50*
4.0	9	432	0	3.6	46	50*
4.5	9	432	0	3.2	45	50*

* Cumulative noise levels of less than 50 dB(A) are assumed to be 50 dB(A), as lesser road traffic noise levels would most likely not be regarded as a dominant noise source.

Table PNIV(c)-5

Example 1: Segments 1 and 2 combined noise benefits

A	B	C	D	E	F
Barrier height (m)	Total noise benefit (TNB)	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	Segment 1 + Segment 2	Segment 1 + Segment 2	= [TNB ÷ total barrier area] × 10 = [B ÷ (A × 300)] × 10		= E + existing road traffic noise (42 dB(A) for Segment 1)
1.0	264	20.8	8.80	58	58
1.5	320	11.2	7.11	56	56
2.0	372	10.4	6.20	55	55
2.5	424	10.4	5.65	54	54
3.0	476	10.4	5.29	52	53
3.5	480	0.8	4.57	51	52
4.0	484	0.8	4.03	50	51
4.5	488	0.8	3.61	49	50

Step 3: Plot and evaluate the marginal and total noise benefits and the highest noise levels for different barrier heights

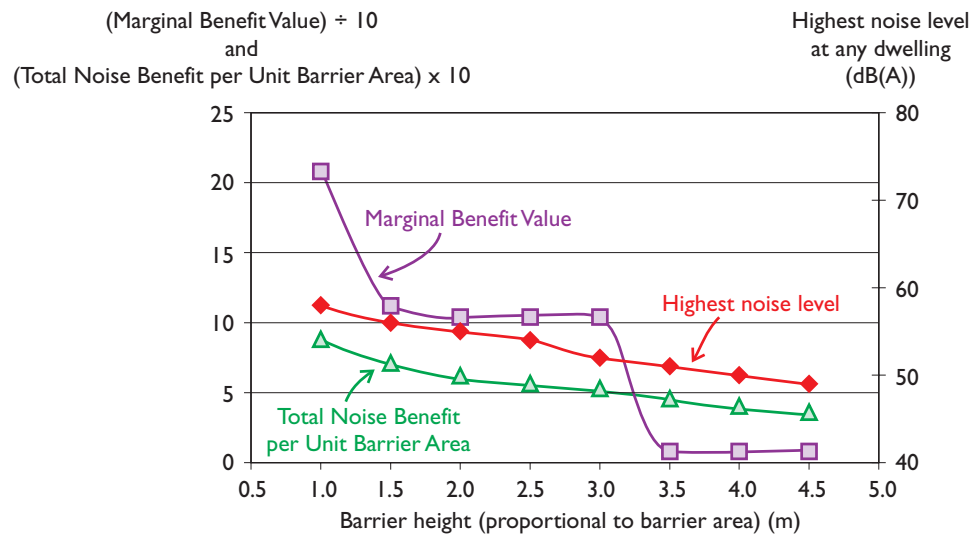


Figure PNIV(c)-2. Example 1: Barrier height effectiveness, Segments 1 and 2 combined.

The target noise level of $L_{eq}(15hr) = 55dB(A)$ would be met at the most affected residence if the 2 m barrier were adopted. This barrier is therefore the “target barrier” option.

The “total noise benefit per unit barrier area” (TNBA) curve shows a steady reduction in the total effectiveness per unit of barrier height (or area) as the barrier height is increased.

The only peak in the “marginal benefit value” (MBV) curve, corresponding with the maximum *rate of increase* in the noise benefit as the barrier height is increased, occurs when the barrier height is small.

So in this example the “assessed barrier” option is the 1 m high barrier, as this would maximise the TNBA and the MBV. From *Table PNIV(c)–2*, a 1 m high barrier would give a 6 dB(A) insertion loss, and from *Table PNIV(c)–3* the resultant noise level at the most affected residence would exceed the target noise level of 55 dB(A) $L_{eq(15hr)}$ by 3 dB(A).

Practice Note IV

Step 5: Analyse the barrier height and other road treatment options

For the purpose of this example it is assumed that the outcomes of the investigations to date into community preferences and visual impacts have had no further influence on the barrier option to be selected.

The next step is to determine whether the differences in effectiveness and costs between the “assessed barrier” and “target barrier” options (without architectural treatment) are significant.

The four residences in Segment 1 would experience noise levels above the 55 dB(A) $L_{eq(15hr)}$ target level if the “assessed barrier” (1 m high) option were adopted (from *Table PNIV(c)–3* and the noise modelling), but the 48 residences in Segment 2 would all experience noise levels below this target level if the “assessed barrier” option were adopted (*Table PNIV(c)–4*), so the Segment 2 residences are excluded from the comparison between the “assessed barrier” and “target barrier” options.

The maximum noise reductions and the barrier cost estimates for the “assessed barrier” and “target barrier” options, based on an installed cost of \$300 per square metre for noise barriers, are tabulated below.

Table PNIV(c)–6
Example 1: Comparison of noise reduction benefits and costs of the “assessed barrier” and “target barrier” options

		“Assessed barrier” option	“Target barrier” option
Insertion loss	Segment 1	6 dB(A)	9 dB(A)
Number of residences	Segment 1	4	4
Cost		\$90,000	\$180,000
Cost per dB(A) noise reduction per residence		\$3,750	\$5,000

In this example the “target barrier” option would provide a noise reduction benefit more than 2 dB(A) better than the “assessed barrier” option at the most affected residence, and the difference in cost per dB(A) reduction per residence between the two options is “significant” (i.e. equal to or greater than 25%), so further comparisons of the costs and effectiveness of the “target barrier” (on the one hand) and the “assessed barrier” in conjunction with architectural treatments (on the other) are warranted (Step 6 below).

☞ *Note that if the above calculations had shown that the difference in noise reduction benefit between the two options was more than 2 dB(A) but the difference in cost per dB(A) reduction per residence was not “significant” (i.e. was less than 25% of the cost per dB(A) reduction per residence for the “target barrier” option), the “target barrier” option would normally*

have been judged the most cost-effective option at this stage and no further cost analysis would have been warranted. However, in cases where the “significance” or otherwise of the cost difference is “lineball” (i.e. the difference is close to or equal to the 25% threshold, as in this example), other project objectives, community preferences and visual impacts should be taken into account before a decision is made not to proceed with any further analysis.

☞ *On the other hand, if the calculations had shown that the difference in noise reduction was less than 2 dB(A) and the difference in cost per dB(A) reduction per residence between the barrier options was not “significant”, the “assessed barrier” option would normally have been judged the most cost-effective option at this stage and again no further cost analysis would have been warranted.*

Step 6: Optimise the mix of road treatment and architectural treatment options

If the “assessed barrier” option were selected, the target noise level would be met at all residences within Segment 2 but not in Segment 1. The analysis of whether to offer architectural treatments is therefore confined to the four residences within Segment 1.

☞ *Note that even if a target noise level would be exceeded with an “assessed barrier” option, if the existing noise levels are already above the target noise levels but the future noise levels with the “assessed barrier” option would be within the ECRTN allowances set out in Column 4 of Table 1 in the ECRTN, architectural treatments would not need to be offered in conjunction with the “assessed barrier” option.*

Practice Note IV(b) lists the upper cost limits for architectural treatments that would generally be applied, based on the difference between the predicted external noise level and the target noise level.

In this example, the noise level difference for all residences within Segment 1 with the “assessed barrier” option would be less than 10 dB(A), so the extra cost per residence for architectural treatments should be assumed to be the upper cost limit for this situation, \$15,000 per residence, giving a total cost of \$60,000.

In the absence of architectural treatments, the extra cost per residence if the “target barrier” option were adopted in preference to the “assessed barrier” option would be $(\$180,000 - \$90,000) \div 4 = \$22,500$.

The cost per residence for architectural treatment (\$15,000) would therefore be substantially greater than 50% of the increase in cost per residence for the “target barrier” option (i.e. 50% of \$22,500, or \$11,250). Accordingly, on the basis of cost-effectiveness alone, the 2 m high “target barrier” option would be preferred over the combination of the 1 m high “assessed barrier” option and architectural treatment of the four dwellings in Segment 1.

This preference may need to be reviewed, however, in the light of later analyses of engineering feasibility and visual impact considerations, as described in Step 6 of *Practice Note IV*.

Example 2:

New motorway with predicted high road traffic noise levels, passing through a residential subdivision with low existing road traffic noise levels

The road considered in this example is a newly proposed dual carriageway motorway with two lanes each way. A noise model is used to predict noise levels with the following assumptions:

- Use of OGAC quiet pavement
- 90 km/h posted speed limit
- 12.3% heavy vehicles during the day and during the night.
- Source heights:
 - Car engine above road 0.5 m
 - Truck engine above road 1.5 m
 - Truck exhaust above road 3.6 m.

From the *Environmental Criteria for Road Traffic Noise (ECRTN)*, the “base” road traffic noise criteria for residences near a new freeway or arterial road corridor are $L_{eq(15hr)} \geq 55$ dB(A) and $L_{eq(9hr)} \geq 50$ dB(A).

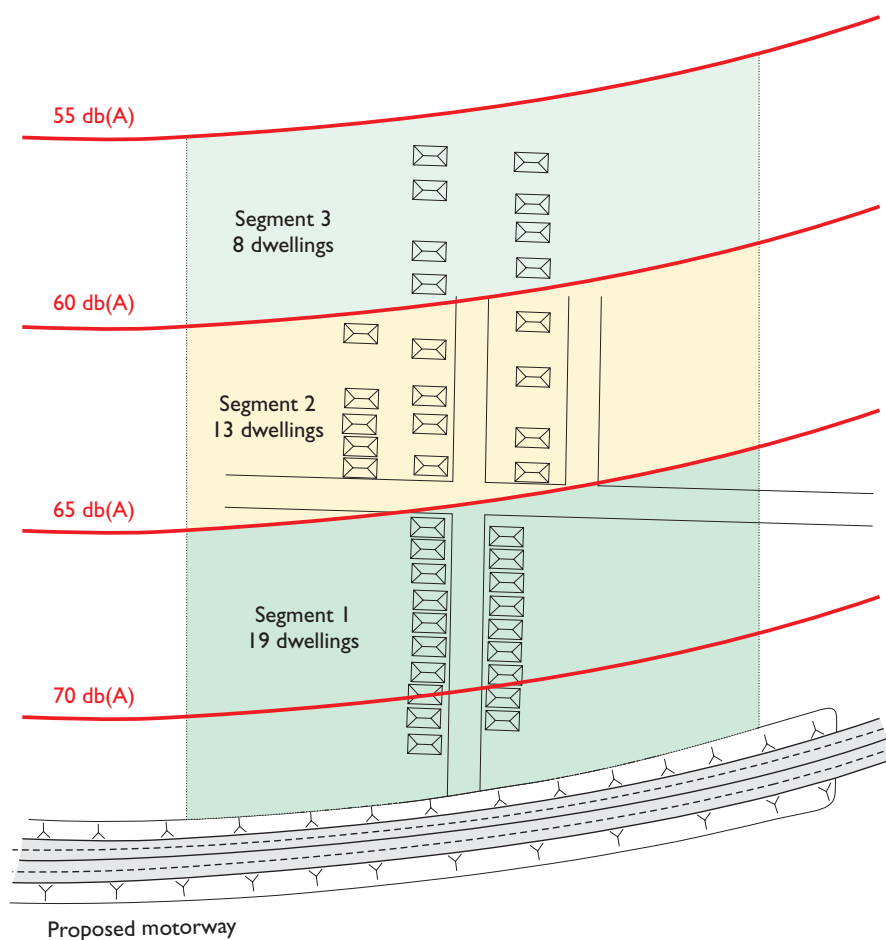


Figure PNIV(c)–3. Example 2: Site layout, $L_{Aeq(15hr)}$ noise contours before noise barrier or architectural treatment, and the noise catchment and its segments (shaded areas).

Step 1: Define the road traffic noise catchment area

The noise catchment is defined as the area of land within the 55 dB(A) $L_{eq(15hr)}$ / 50 dB(A) $L_{eq(9hr)}$ road traffic noise contour with no noise mitigation in place (the shaded areas in *Figure PNIV(c)-3*).

There are 40 residences in the catchment, all of them free-standing, single dwellings. A local road runs through the middle of the catchment.

The noise modelling has shown that in this example the daytime *ECRTN* target noise level of 55 dB(A) $L_{eq(15hr)}$ is more stringent than the night-time target noise level of 50 dB(A) $L_{eq(9hr)}$. In other words, the predicted exceedance of the daytime target noise level at residences in the noise catchment area, with no noise mitigation, is greater than the predicted exceedance at night.

Step 2: Identify all noise-sensitive receivers within the noise catchment area

As shown in *Figure PNIV(c)-3*, the noise catchment has been divided into sub-catchments intuitively thought to have similar noise exposures on the basis of similar topography, road design features, types of noise sensitive receptors and existing road traffic noise sources.

There are three segments with dwellings that will be affected by similar noise levels (approximately within a 5 dB(A) range): Segment 1 is the area above the 65 dB(A) noise contour, Segment 2 is the area between the 60 and 65 dB(A) noise contours and Segment 3 is the area between the 55 and 60 dB(A) noise contours.

There are 19 residences in Segment 1, 13 residences in Segment 2 and eight residences in Segment 3.

Step 3: Evaluate existing and future noise levels, including changes in noise level

Existing ambient road traffic noise levels (at the building facade most exposed to the proposed motorway):

- Segment 1: 43 dB(A) $L_{eq(15hr)}$
- Segment 2: 50 dB(A) $L_{eq(15hr)}$
- Segment 3: 45 dB(A) $L_{eq(15hr)}$.

For the purpose of this example it is assumed that all “feasible and reasonable” traffic management and other road design opportunities for reducing traffic noise have been exhausted. More specifically, there are no further traffic management opportunities for reducing noise impacts, and the alignment of the road cannot be adjusted, because of the location of existing developments along the route.

On the basis of initial traffic noise model predictions, without any additional noise mitigation measures, it *cannot* be shown in this case that:

- The noise levels for the proposal ten years after the project opening are predicted to be within 2 dB(A) of the “future existing” noise levels (the

noise levels from existing sources of road traffic noise predicted for the time the motorway will open), and

- The predicted noise levels ten years after project opening are no more than 2 dB(A) above the ECRTN target noise levels.

Therefore, all available noise mitigation options need to be identified and evaluated.

Step 4: Identify all the options

The noise mitigation options which have not yet been utilised include noise walls, noise mounds and architectural treatments. A quieter pavement surface will not be sufficient on its own to mitigate traffic noise sufficiently to achieve the targets.

Step 5: Analyse the barrier height and other road treatment options

There are more than three affected residences grouped together, so noise barrier options need to be considered.

The methodology set out in *Practice Note IV(a)* is used to determine barrier heights for the “target barrier” and “assessed barrier” options.

Practice Note IV(a)

Step 1: Design a range of barrier options

The ranges of predicted daytime noise levels for dwellings in each segment ten years after project opening, assuming no barriers, are identified in *Table PNIV(c)–7* below, along with the corresponding representative noise levels (the noise levels at the most affected residences in each segment).

Table PNIV(c)–7
Example 2: Predicted daytime traffic noise levels without noise barrier or architectural treatment mitigation

Segment	Noise exposure range	Representative noise level
	$L_{Aeq(15hr)}$ (dB(A))	$L_{Aeq(15hr)}$ (dB(A))
1	73 to 65	73
2	65 to 60	64
3	60 to 55	60

The range of nominal noise level goals for which different barrier heights should be tested should extend from the maximum predicted “do nothing” noise level (no barrier) at the most affected residence down to the *higher* of:

- (1) 50 dB(A) $L_{eq(15hr)}$.

As the existing noise levels for Segments 1, 2 and 3 are 43, 50 and 45 dB(A) $L_{eq(15hr)}$ respectively, a noise barrier would need to be designed to reduce noise contribution from the proposed road to:

- Segment 1: $L_{eq(15hr)} = 50 \text{ dB(A)} - 43 \text{ dB(A)} = 49 \text{ dB(A)}$
- Segment 2: $L_{eq(15hr)} = 50 \text{ dB(A)} - 50 \text{ dB(A)} = 40 \text{ dB(A)}$
- Segment 3: $L_{eq(15hr)} = 50 \text{ dB(A)} - 45 \text{ dB(A)} = 49 \text{ dB(A)}$

- (2) The lowest noise level that can be achieved, taking into account the cumulative effect of all other road traffic noise sources.

The lowest possible noise level will be achieved if the noise contribution of the proposed road is designed to be 10 dB(A) below the existing traffic noise level:

- Segment 1: $L_{eq}(15hr) = 33$ dB(A)
- Segment 2: $L_{eq}(15hr) = 40$ dB(A)
- Segment 3: $L_{eq}(15hr) = 35$ dB(A).

Therefore, for Segments 1 and 3 we shall use (1) and for Segment 2 we shall use (1) or (2) (for this segment they are identical).

Table PNIV(c)–8 shows, for each segment,

- Noise levels, including all road traffic noise sources, with no barrier
- Noise levels, including all road traffic noise sources, for a range of barrier heights, starting with the minimum barrier height required to achieve a 5 dB(A) insertion loss and increasing in 0.5 m increments to a maximum visually acceptable barrier height of 8 m, and
- The corresponding representative barrier insertion loss for each incremental increase in barrier height.

Note that barrier options have not been tested to a height that would achieve 50 dB(A) at the most affected residence in Segment 1, as barriers more than 8 m would be necessary. Note also that in this

Table PNIV(c)–8
Example 2: Effectiveness of noise barriers of varying heights

Barrier height (m)	Representative cumulative road traffic noise level (all sources) (dB(A))			Representative barrier insertion loss (all sources) (dB(A))		
	Segment 1	Segment 2	Segment 3	Segment 1	Segment 2	Segment 3
No barrier	73	64	60	0	0	0
1.0	68	61	57	5	3	3
1.5	67	60	55	6	4	5
2.0	65	60	55	8	4	5
2.5	64	58	54	9	6	6
3.0	63	57	53	10	7	7
3.5	61	56	52	12	8	8
4.0	60	55	51	13	9	9
4.5	59	55	50	14	9	10
5.0	58	54	50	15	10	10
5.5	58	54	49	15	10	11
6.0	57	53	49	16	11	11
6.5	56	53	49	17	11	11
7.0	55	53	48	18	11	12
7.5	55	52	48	18	12	12
8.0	54	52	48	19	12	12

example an 8 m high barrier would produce a noise reduction greater than the minimum requirement for a barrier of this height, 10 dB(A).

Step 2: Calculate the total and marginal noise benefits for different barrier heights

Total noise benefit (TNB) = dB(A) insertion loss at the most affected residence in each segment × number of dwellings in each segment

Marginal benefit value (MBV) = increase in TNB / increase in barrier height (or area)

Total noise benefit per unit barrier area (TNBA) = TNB / total area of barrier

Table PNIV(c)-9
Example 2: Segment 1 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-8	= (B × 19) ÷ 100	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (43 dB(A))
0	0				73	73
0.5	3	0.57			70	70
1.0	5	0.95	7.6	3.17	68	68
1.5	6	1.14	3.8	2.53	67	67
2.0	8	1.52	7.6	2.53	65	65
2.5	9	1.71	3.8	2.28	64	64
3.0	10	1.90	3.8	2.11	63	63
3.5	12	2.28	7.6	2.17	61	61
4.0	13	2.47	3.8	2.06	60	60
4.5	14	2.66	3.8	1.97	59	59
5.0	15	2.85	3.8	1.90	58	58
5.5	15	2.85	0.0	1.73	58	58
6.0	16	3.04	3.8	1.69	57	57
6.5	17	3.23	3.8	1.66	56	56
7.0	18	3.42	3.8	1.63	55	55
7.5	18	3.42	0.0	1.52	55	55
8.0	19	3.61	3.8	1.50	54	54

Table PNIV(c)-10
Example 2: Segment 2 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-8	= (B × 13) ÷ 100	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (50 dB(A))
0	0				64	64
0.5	2	0.26			62	62
1.0	3	0.39	2.6	1.3	61	61
1.5	4	0.52	2.6	1.16	60	60
2.0	4	0.52	0.0	0.87	59	60
2.5	6	0.78	5.2	1.04	57	58
3.0	7	0.91	2.6	1.01	56	57
3.5	8	1.04	2.6	0.99	55	56
4.0	9	1.17	2.6	0.98	54	55
4.5	9	1.17	0.0	0.87	53	55
5.0	10	1.30	2.6	0.87	52	54
5.5	10	1.30	0.0	0.79	51	54
6.0	11	1.43	2.6	0.79	50	53
6.5	11	1.43	0.0	0.73	50	53
7.0	11	1.43	0.0	0.68	49	53
7.5	12	1.56	2.6	0.69	48	52
8.0	12	1.56	0.0	0.65	48	52

Table PNIV(c)-11
Example 2: Segment 3 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-8	= (B × 8) ÷ 100	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (45 dB(A))
0	0				60	60
0.5	2	0.16			58	58
1.0	3	0.24	1.6	0.8	57	57
1.5	5	0.40	3.2	0.89	55	55
2.0	5	0.40	0.0	0.67	55	55

Table PNIV(c)-11
Example 2: Segment 3 noise benefits

A	B	C	D	E	F	G
Barrier height (m)	Representative barrier insertion loss (all sources) (dB(A))	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	From Table PNIV(c)-8	= (B × 8) ÷ 100	= [(increase in C) ÷ (increase in A)] ÷ 10	= [TNB ÷ total barrier area] × 10 = [C ÷ (A × 300)] × 10		= F + existing road traffic noise (45 dB(A))
2.5	6	0.48	1.6	0.64	53	54
3.0	7	0.56	1.6	0.62	52	53
3.5	8	0.64	1.6	0.61	51	52
4.0	9	0.72	1.6	0.60	50	51
4.5	10	0.80	1.6	0.59	49	50
5.0	10	0.80	0.0	0.53	48	50
5.5	10	0.80	0.0	0.48	47	50*
6.0	10	0.80	0.0	0.44	46	50*
6.5	10	0.80	0.0	0.41	46	50*
7.0	10	0.80	0.0	0.38	45	50*
7.5	10	0.80	0.0	0.36	44	50*
8.0	10	0.80	0.0	0.33	44	50*

Table PNIV(c)-12
Example 2: Segments 1, 2 and 3 combined noise benefits

A	B	C	D	E	F
Barrier height (m)	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	Segment 1 + Segment 2 + Segment 3	Segment 1 + Segment 2 + Segment 3	= [TNB ÷ total barrier area] × 10 = [B ÷ (A × 300)] × 10		= E + existing road traffic noise (43 dB(A) for Segment 1)
1.0	1.58	11.8	5.27	68	68
1.5	2.06	9.6	4.58	67	67
2.0	2.44	7.6	4.07	65	65
2.5	2.97	10.6	3.96	64	64
3.0	3.37	8.0	3.74	63	63
3.5	3.96	11.8	3.77	61	61
4.0	4.36	8.0	3.63	60	60
4.5	4.63	5.4	3.43	59	59
5.0	4.95	6.4	3.30	58	58
5.5	4.95	0	3.00	58	58
6.0	5.27	6.4	2.93	57	57

Table PNIV(c)-12

Example 2: Segments 1, 2 and 3 combined noise benefits

A	B	C	D	E	F
Barrier height (m)	Total noise benefit (TNB) ÷ 100	Marginal benefit value (MBV) ÷ 10	Total noise benefit per unit barrier area (TNBA) × 10	Highest noise level from proposal (dB(A))	Highest cumulative noise level (dB(A))
(300 m length)	Segment 1 + Segment 2 + Segment 3	Segment 1 + Segment 2 + Segment 3	= [TNB ÷ total barrier area] × 10 = [B ÷ (A × 300)] × 10		= E + existing road traffic noise (43 dB(A) for Segment 1)
6.5	5.46	3.8	2.80	56	56
7.0	5.65	3.8	2.69	55	55
7.5	5.78	2.6	2.57	55	55
8.0	5.97	3.8	2.49	54	54

Step 3: Plot and evaluate the marginal and total noise benefits and the highest noise levels for different barrier heights

(Marginal Benefit Value) ÷ 10
and
(Total Noise Benefit) ÷ 100

Highest noise level
at any dwelling
(dB(A))

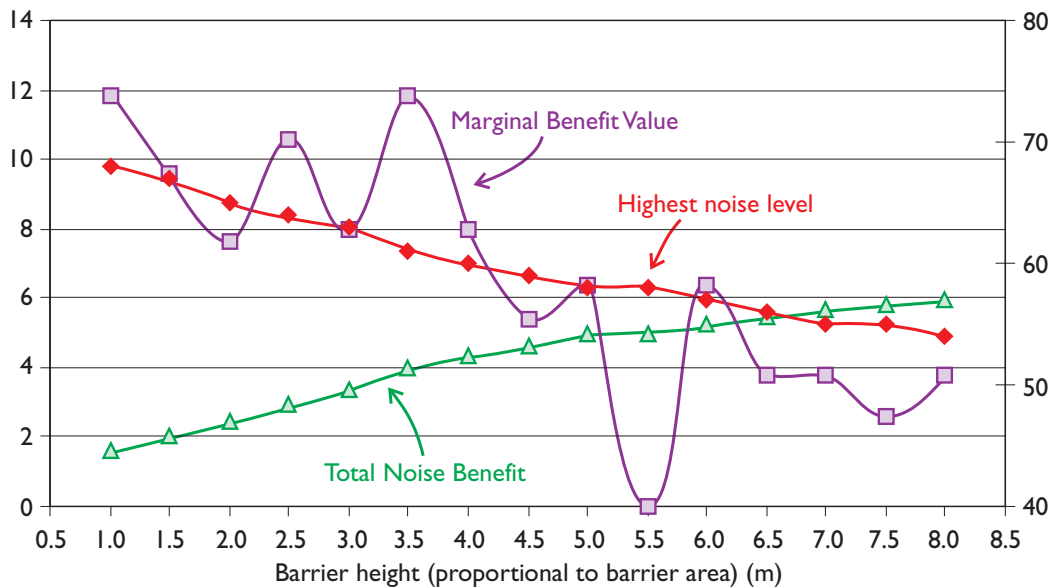


Figure PNIV(c)-4. Example 2: Barrier height effectiveness, Segments 1, 2 and 3 combined

In this example the “total noise benefit” (TNB) curve has been plotted, rather than the “total noise benefit per unit barrier area” (TNBA) curve. The TNB curve shows a steady increase in total noise benefit as the barrier height is increased.

The target noise level of 55 dB(A) $L_{eq}(15hr)$ would be met at the most affected residence if the 7 m barrier were adopted. This barrier is therefore the “target barrier” option.

The “marginal benefit value” (MBV) curve peaks at barrier heights of 1 m, 2.5 m and 3.5 m. The 1 m and 3.5 m barriers present the highest MBV, and a high MBV is also recorded for the 2.5 m barrier. (High MBV values for small

barrier heights are common where the road relative level (RL) is equal to or higher than the receiver level.)

As the difference in noise reduction between the 3.5 m barrier (on the one hand) and the 2.5 m and 1 m barriers (on the other) is significant, the “assessed barrier” option in this example is the 3.5 m high barrier.

This 3.5 m assessed barrier” option would result in an insertion loss at the most affected residence of 12 dB(A), achieving a road traffic noise level of 61 dB(A). This is well above the noise level objective of 55 dB(A), so if the “assessed barrier” option were selected the consideration of architectural treatments for further noise reduction would be warranted.

Practice Note IV

Step 5: Analyse the barrier height and other road treatment options

For the purpose of this example it is assumed that outcomes of the investigations to date into community preferences and visual impacts have had no further influence on the barrier option to be selected.

The next step is to determine whether the differences in effectiveness and costs between the “assessed barrier” and “target barrier” options (without architectural treatment) are significant.

The 19 residences in Segment 1 would experience noise levels above the 55 dB(A) $L_{eq}(15hr)$ target level if the “assessed barrier” (3.5 m high) option were adopted (from *Table PNIV(c)-9* and the noise modelling), so these residences need to be taken into account in the comparison between the “assessed barrier” and “target barrier” options.

Conversely, the eight residences in Segment 3 would all experience noise levels below this target level if the “assessed barrier” option were adopted (*Table PNIV(c)-11*), so the Segment 3 residences are excluded from the comparison between the “assessed barrier” and “target barrier” options.

The road traffic noise level at the most affected residence in Segment 2 would just exceed the target noise level if the “assessed barrier” option were adopted by a marginal 1 dB(A) (*Table PNIV(c)-10*). (Note, however, that the predicted noise level of 56 dB(A) at this most affected residence would nonetheless represent a substantial increase of 6 dB(A) on the existing noise level.)

For the purpose of this example two scenarios are investigated:

- *Scenario A:* Under this scenario, all 13 of the residences within Segment 2 would be affected by noise levels in excess of the target noise level if the “assessed barrier” option were adopted.

Under this scenario, all 13 residences in Segment 2 therefore need to be taken into account in the comparison between the “assessed barrier” and “target barrier” options.

- *Scenario B:* Only one of the 13 residences within Segment 2 would be affected by noise levels in excess of the target noise level if the “assessed barrier” option were adopted.

Under this scenario, this is the only residence in Segment 2 which needs to be taken into account in the comparison between the “assessed barrier” and “target barrier” options.

The maximum noise reductions for the “assessed barrier” and “target barrier” options and the numbers of residences to be taken into account under the two scenarios are tabulated below.

Table PNIV(c)-13

Example 2: Comparison of noise reduction benefits of the “assessed barrier” and “target barrier” options

	“Target barrier” option			“Assessed barrier” option		
	Maximum insertion loss (dB(A))	Number of residences		Maximum insertion loss (dB(A))	Number of residences	
		Scenario A	Scenario B		Scenario A	Scenario B
Segment 1	18	19	19	12	19	19
Segment 2	11	13	1	8	13	1

In this example the “target barrier” option would provide a noise reduction benefit more than 2 dB(A) better than the “assessed barrier” option at the most affected residence.

Based on an installed cost of \$300 per square metre for noise barriers, the cost estimates for the “target barrier” option and the “assessed barrier” option are \$630,000 and \$315,000, respectively.

The cost per dB(A) reduction per residence, for each scenario, is equal to the cost of each barrier option divided by the sum of the products, in each segment, of the noise reduction and the number of houses taken into account.

Under *Scenario A*, the cost per dB(A) reduction per residence for the 7 m high “target barrier” option would be

$$\$630,000 \div [(18 \times 19) + (11 \times 13)] = \$1,300$$

and the cost per dB(A) reduction per residence for the 3.5 m high “assessed barrier” option would be

$$\$315,000 \div [(12 \times 19) + (8 \times 13)] = \$949$$

So under this scenario the cost per dB(A) reduction per residence for the “assessed barrier” option would not be within 25% of the cost per dB(A) reduction per residence for the “target barrier” option, and further comparisons of the costs and effectiveness of the “target barrier” (on the one hand) and the “assessed barrier” in conjunction with architectural treatments (on the other) would be warranted (Step 6 below).

Similarly, under *Scenario B* the cost per dB(A) reduction per residence for the 7 m high “target barrier” option would be

$$\$630,000 \div [(18 \times 19) + (11 \times 1)] = \$1,785$$

and the cost per dB(A) reduction per residence for the 3.5 m high “assessed barrier” option would be

$$\$315,000 \div [(12 \times 19) + (8 \times 1)] = \$1,335$$

Again, under this scenario the cost per dB(A) reduction per residence for the “assessed barrier” option would not be within 25% of the cost per dB(A) reduction per residence for the “target barrier” option, so further comparisons of the costs and effectiveness of the “target barrier” (on the one hand) and the “assessed barrier” in conjunction with architectural treatments (on the other) would again be warranted (Step 6 below).

☞ Note that even if a target noise level would be exceeded with an “assessed barrier” option, if the existing noise levels are already above the target noise levels but the future noise levels with the “assessed barrier” option would be within the ECRTN allowances set out in Column 4 of Table 1 in the ECRTN, architectural treatments would not need to be offered in conjunction with the “assessed barrier” option.

Step 6: Optimise the mix of road treatment and architectural treatment options

Practice Note IV(b) lists the upper cost limits for architectural treatments that would generally be applied, based on the difference between the predicted external noise level and the target noise level.

In this example, the noise level difference for all residences within Segment 1 with the “assessed barrier” option would be less than 10 dB(A), so the extra cost per residence for architectural treatments should be assumed to be the upper cost limit for this situation, \$15,000 per residence.

Under *Scenario A*,

- The total cost of architectural treatments (for 32 residences, 19 of them in Segment 1 and 13 in Segment 2) would be $32 \times \$15,000 = \$480,000$, and
- In the absence of architectural treatments, the extra cost per residence if the “target barrier” option were adopted in preference to the “assessed barrier” option would be $(\$630,000 - \$315,000) \div 32 = \$9,844$.

Under this scenario the cost per residence for architectural treatment (\$15,000) would be substantially greater than 50% of the increase in cost per residence for the “target barrier” option (i.e. 50% of \$9,844, or \$4,922). Accordingly, on the basis of cost-effectiveness alone, the 7 m high “target barrier” option would be preferred over the combination of the 3.5 m high “assessed barrier” option and architectural treatment of the 19 dwellings in Segment 1 and the 13 dwellings in Segment 2.

This preference might need to be reviewed, however, in the light of later analyses of engineering feasibility and visual impact considerations, as described in Step 6 of *Practice Note IV*.

Similarly, under *Scenario B*,

- The total cost of architectural treatments (for 20 residences, 19 of them in Segment 1 and one in Segment 2) would be $20 \times \$15,000 = \$300,000$, and
- In the absence of architectural treatments, the extra cost per residence if the “target barrier” option were adopted in preference to the “assessed barrier” option would be $(\$630,000 - \$315,000) \div 20 = \$15,750$.

Under this scenario the cost per residence for architectural treatment (\$15,000) would again be substantially greater than 50% of the increase in cost per residence for the “target barrier” option (i.e. 50% of \$15,750, or \$7,875). Accordingly, on the basis of cost-effectiveness alone, the 7 m high “target barrier” option would be preferred over the combination of the 3.5 m high

“assessed barrier” option and architectural treatment of the 19 dwellings in Segment 1 and one dwelling in Segment 2. Again, however, this preference might need to be reviewed in the light of later analyses of engineering feasibility and visual impact considerations, as described in Step 6 of *Practice Note IV*.

Example 3:

Freeway widening that passes below an adjacent high-set subdivision where the existing freeway noise levels are high and there is only a low traffic noise contribution from other roads

This example is based on an existing freeway in an inner urban area, which is to be widened to allow for the incorporation of dedicated public transport lanes within the existing road corridor.

The assessment area is identified by a group of residences set back to the north of the existing freeway (*Figure PNIV(c)-5*). The dwellings are a combination of single and multiple unit buildings. The subdivision is serviced by a number of minor local roads. All of the ground floor levels are at least 10 m above the relative level (RL) of the freeway. There are no noise barriers adjacent to the existing freeway. The existing noise environment at the residences is dominated by noise from the existing freeway.

The *ECRTN* criteria for redevelopments of existing freeways/arterial roads will apply. The “base” road traffic noise criteria for affected residences will therefore be $L_{eq}(15hr) = 60$ dB(A) and $L_{eq}(9hr) = 55$ dB(A).

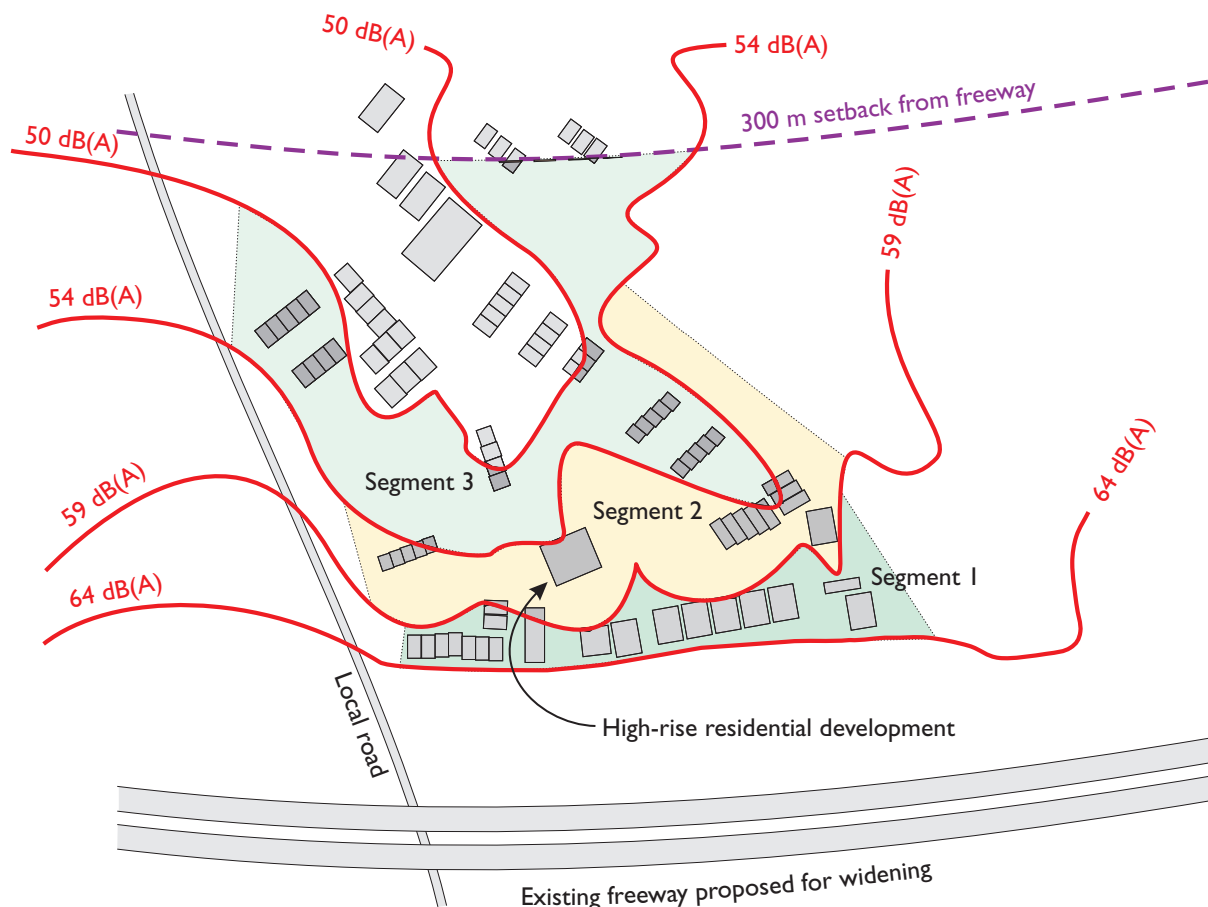


Figure PNIV(c)-5. Example 3: Site layout, $L_{Aeq(9hr)}$ noise contours before noise barrier or architectural treatment, and the noise catchment and its segments (shaded areas).

Table PNIV(c)-14
Example 3: Overview of road design parameters

	Future existing	10-year projection
AADT	76,000 southbound and 81,000 northbound	105,000 southbound and 117,000 northbound
Heavy vehicle content	4% of total traffic stream	
Average speed of vehicle stream	80 km/h – all scenarios	
Height differential residents to roadway	All residential dwellings at least 10 m above the RL of the freeway and have undisturbed line-of-sight	
Road traffic noise levels at most affected residences:		
night-time (L_{eq} (9hr))	62.4 dB(A)	63.9 dB(A)
daytime (L_{eq} (15hr))	65.7 dB(A)	67.6 dB(A)
Road surface	Open graded asphalt on the existing roadway and proposed for the new lanes	

Practice Note IV

Step 1: Define the road traffic noise catchment area

Detailed noise modelling has been undertaken for the period ten years after opening (the design year), taking account of the attenuation provided by the shielding associated with intervening rows of buildings. A review of the noise model has indicated that the night-time (L_{Aeq} (9hr)) period results in a higher exceedance level than the daytime (L_{Aeq} (15hr)) period. This has been confirmed by ambient noise surveys.

The predicted noise levels for the design year are as low as 50 dB(A) L_{eq} (9hr) within 300 m of the road alignment. The noise catchment area is therefore defined as the area bounded by the freeway and the 50 dB(A) L_{eq} (9hr) noise contour (the shaded areas in *Figure PNIV(c)-5*).

Step 2: Identify all noise-sensitive receivers within the noise catchment area

As shown in *Figure PNIV(c)-5*, the noise catchment has been divided into the following three segments, based similar noise exposure:

- Segment 1: An estimated 19 low-rise residences, predicted to experience L_{eq} (9hr) noise levels of between 59 and 64 dB(A)
- Segment 2: An estimated 12 low-rise residences plus one high-rise block (of 36 units, all of similar noise exposure, overlooking the freeway), predicted to experience L_{eq} (9hr) noise levels of between 54 and 59 dB(A), and
- Segment 3: An estimated 26 low-rise residences, predicted to experience L_{eq} (9hr) noise levels of between 50 and 54 dB(A).

These estimates of the number of discrete residential dwellings have been based on a combination of site inspection(s) and an examination of the catchment area using high-resolution aerial photography.

Step 3: Calculate existing and future noise levels, including changes in noise levels

For the purpose of this example it is assumed that all “feasible and reasonable” traffic management and other road design opportunities for reducing traffic noise have been exhausted. More specifically, a review has demonstrated that re-alignments of the roadway and more stringent limits on traffic flow speeds would have minimal effectiveness and cannot be considered either “feasible” or “reasonable” in the context of the project’s objectives.

Initial noise modelling for the design year indicates that the road traffic noise levels:

- Will not increase by more than the *ECRTN* allowance of 2 dB(A) over the “future existing” noise level (the noise levels from existing sources of road traffic noise predicted for the time the project will open)
- Will be greater than 60 dB(A) $L_{eq(9hr)}$ for the residences in Segment 1, and
- Will be less than 60 dB(A) $L_{eq(9hr)}$ for the residences in Segment 2 and Segment 3.

For the residences within Segments 2 and 3 the road development will result in an insignificant change from the “*future existing*” noise level and the design year noise level will not be acute. Accordingly, provided it can be established that all available road design and traffic management opportunities for reducing traffic noise have already been incorporated into the concept design, *additional* noise treatments such as noise barriers and architectural treatments for residences within Segment 2 and Segment 3, on their own, would usually be regarded as not warranted.

However, these treatments still need to be evaluated for Segment 1, and any consequential benefits to the owners and occupants of residences in Segments 2 and 3 will need to be considered in the design of treatment for residences in Segment 1.

Step 4: Identify all the options

A review of the remaining options capable of providing immediate results has shown these options are confined to noise moundings, other acoustic barriers and architectural treatments.

A noise-reducing road surface is already used on the existing freeway, and the same surface is to be used in the proposed redevelopment.

Step 5: Analyse the barrier height and other road treatment options

There are more than three affected residences grouped together, so noise barrier options need to be considered.

The methodology set out in *Practice Note IV(a)* is used to assess the effectiveness of various barrier heights.

Practice Note IV(a)

Step 1: Design a range of barrier options

A comparison of noise reductions for a range of barrier heights has been carried out for the most affected residences in Segment 1. *Figure PNIV(c)–6* shows the relation between barrier height and resulting noise levels for the design year. The height of the barrier has no noticeable effect on the predicted noise levels for the apartments in Segment 2.

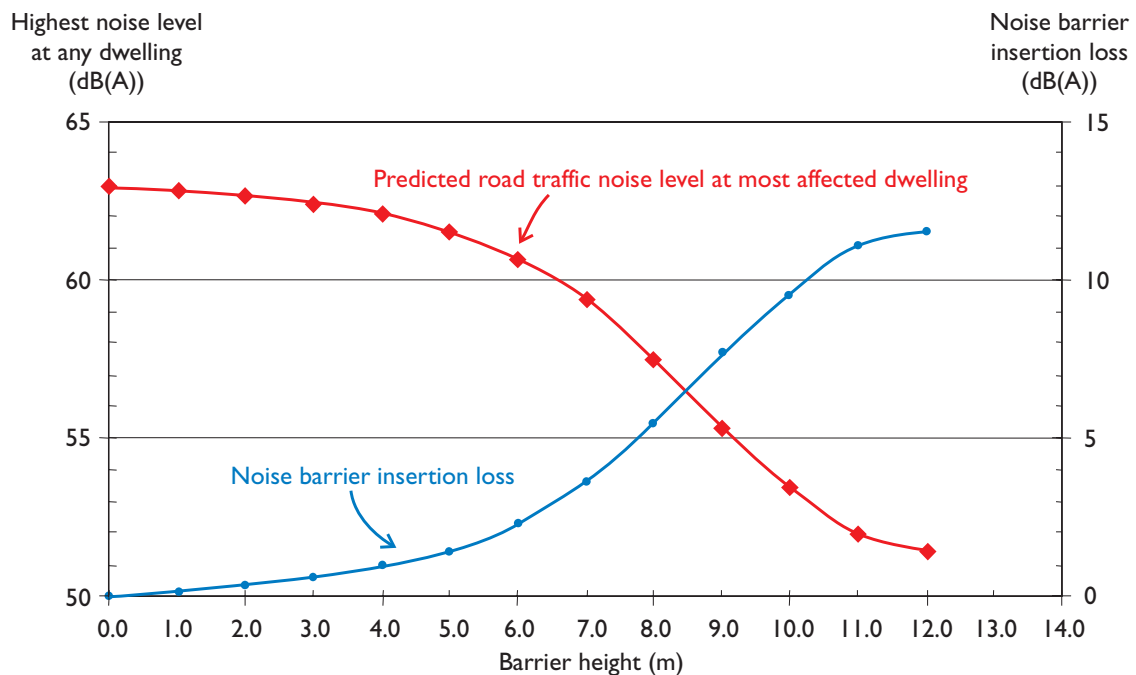


Figure PNIV(c)–6. Example 3: Noise barrier insertion loss

The target $L_{eq(9hr)}$ noise level of 55 dB(A) cannot be achieved without constructing barriers in excess of the 8 m height limit, and the insertion loss provided by an 8 m high barrier would be less than the permissible minimum reduction for barriers of this height, 10 dB(A). Both of these factors indicate that barriers are not a viable option for this assessment location.

The only remaining option is to examine architectural treatments.

Practice Note IV

Step 6: Optimise the mix of road treatment and architectural treatment options

The “future existing” noise level is higher than the target noise level, so architectural treatment — the only remaining treatment option — will need to be considered:

- For all residences where the noise levels will exceed the “future existing” noise level by more than the allowance of 2 dB(A) provided in column 4 of Table 1 in the *ECRTN*, and
- For all residences where the noise levels are predicted to be acute (i.e. in excess of 60 dB(A) $L_{eq(9hr)}$).

The *ECRTN* allowance will not be exceeded at any residence within Segments 1, 2 or 3. However, the residences in Segment 1 will be acutely affected by road traffic noise in excess of 60 dB(A) $L_{eq(9hr)}$.

The projected design year road traffic noise level of 64 dB(A) is within 10 dB(A) of the *ECRTN* target noise level of 55 dB(A). Consequently, from *Practice Note IV(b)*, the RTA may spend up to \$15,000 for architectural treatment of each of the 19 residences in Segment 1, if:

- It is reasonable to do so, in the context of the project's objectives, the predicted noise levels, the specific characteristics of the existing environment and the proposed route
- It is feasible to incorporate appropriate treatment(s) in these dwellings (e.g. they are not too dilapidated), and
- The owners of the dwellings are willing to sign the RTA's Deed of Release.

In accordance with *Practice Note IV(b)*, the RTA may offer to install local screen or courtyard walls or a combination of fresh air ventilation, acoustically treated wall vents and upgraded window and door seals.

☞ *If the *ECRTN* allowance had been exceeded in Segment 2, treatment would need to be evaluated for the exposed units within the high-rise apartment block. Architectural treatment of these units would be feasible only if:*

- *Provision had been made in the design of the building for a ducted fresh air ventilation system,*
- *There is "reasonable" accessibility for providing treatment, and*
- *Treatment can be provided within the cost limits set out in Practice Note IV(b).*

Example 4: Freeway widening producing a low noise contribution in an area where existing traffic noise levels from other roads are high

This example involves the proposed duplication of an existing freeway in an inner urban corridor.

The assessment area is identified by a group of residences fronting an adjacent arterial road which is a significant contributor to the existing road traffic noise (*Figure PNIV(c)-7*). The residences in the immediate area are predominantly single-level family dwellings. There are currently no noise barriers adjacent to the freeway.

The *ECRTN* criteria for redevelopments of existing freeways/arterial roads will apply. The "base" road traffic noise criteria for affected residences will therefore be $L_{eq(15hr)} = 60$ dB(A) and $L_{eq(9hr)} = 55$ dB(A).



Figure PNIV(c)-7. Example 4: Site layout, $L_{Aeq(15hr)}$ noise contours before noise barrier or architectural treatment, and the noise catchment and its segments (shaded areas).

Table PNIV(c)-15
Example 4: Overview of road design parameters

	Future existing	10-year projection
AADT	73,000 southbound and 65,000 northbound	108,000 southbound and 103,000 northbound
Heavy vehicle content	4% of total traffic stream (on freeway) 7% of total traffic stream on local roads	
Average speed of vehicle stream	80 km/h – all scenarios	
Road traffic noise levels at nearest affected dwellings:		
night-time ($L_{eq(9hr)}$)	54.5 dB(A)	58.4 dB(A)
daytime ($L_{eq(15hr)}$)	63.1 dB(A)	66.6 dB(A)
Road surface	Open graded asphalt on the existing roadway and proposed for the new lanes	

Practice Note IV

Step 1: Define the road traffic noise catchment area

Detailed noise modelling has been undertaken for the period ten years after opening (the design year), taking account of the attenuation provided by the shielding associated with intervening rows of buildings. A review of the noise model has indicated that the daytime ($L_{Aeq\ 15hr}$) period has the limiting criterion, so this will be used in this assessment.

The predicted noise levels for the design year are as low as 55 dB(A) $L_{eq(15hr)}$ within 300 m of the road alignment. The noise catchment area is therefore defined as the area bounded by the freeway and the 55 dB(A) $L_{eq(15hr)}$ noise contour (the shaded areas in *Figure PNIV(c)-7*).

Step 2: Identify all noise-sensitive receivers within the noise catchment area

As shown in *Figure PNIV(c)-7*, the noise catchment has been divided into the following two segments, based similar noise exposure:

- Segment 1: 29 low-rise residences, predicted to experience $L_{eq(15hr)}$ noise levels of between 60 and 67 dB(A), and
- Segment 2: 23 low-rise residences, predicted to experience $L_{eq(15hr)}$ noise levels of between 55 and 60 dB(A).

Step 3: Calculate existing and future noise levels, including changes in noise levels

For the purpose of this example it is assumed that all “feasible and reasonable” traffic management and other road design opportunities for reducing traffic noise have been exhausted.

Initial noise modelling for the design year indicates that the road traffic noise levels will increase by more than the *ECRTN* allowance of 2 dB(A) over the “future existing” noise level in Segment 1, so further evaluation of additional noise treatment options is warranted.

Step 4: Identify all the options

A review of potential treatment options has confirmed that the remaining noise control options are limited to noise barriers and architectural treatment of individual residences.

A noise-reducing road surface is already used on the existing freeway, and the same surface is to be used in the proposed redevelopment.

Step 5: Analyse the barrier height and other road treatment options

There are more than three affected residences grouped together, so noise barrier options need to be considered.

The methodology set out in *Practice Note IV(a)* is used to assess the *effectiveness of various barrier heights*.

Practice Note IV(a)

Step 1: Design a range of barrier options

In this example, it is not possible to place a noise barrier between the existing arterial road, which is adjacent to the freeway, and the residences along this road, because of the need to preserve access from the arterial road into these properties. This means the only feasible location for a noise barrier is between the freeway and the arterial road.

A comparison of noise reductions for a range of barrier heights for barriers along the freeway has been carried out for the most affected residences in Segment 1. *Figure PNIV(c)–8* shows the relation between barrier height and resulting noise levels for the design year.

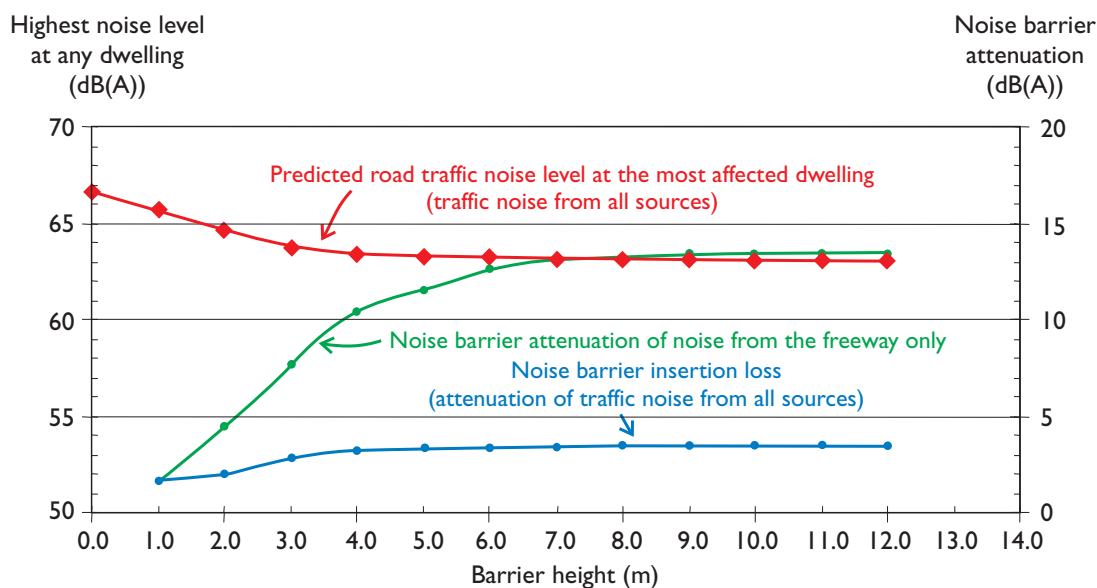


Figure PNIV(c)–8. Example 4: Noise barrier insertion loss.

It may be seen that noise *from the proposal* would be progressively reduced as the barrier height increased. However, the effectiveness of the barrier in reducing the *overall* traffic noise level (the insertion loss) would be severely limited by the high traffic noise levels from the adjacent arterial road, which already contributes 63 dB(A) to existing $L_{eq}(15hr)$ road traffic noise levels at the first row of residential dwellings in Segment 1.

The lowest noise level that could feasibly be achieved, taking account of noise from this and other roads which are not part of the proposal under investigation, would be achieved with a barrier height of 4 m or more.

Even though a 4 m or higher barrier would reduce the noise contribution from the proposal by a substantial 10 dB(A) or more, when the road traffic noise contribution from the adjacent arterial road is taken into account it may be seen that the barrier insertion loss would be limited to 3 dB(A).

Noise barriers would therefore not reduce noise sufficiently to be considered a cost-effective option.

Architectural treatment of individual dwellings is the only remaining noise reduction strategy.

Step 6: Optimise the mix of road treatment and architectural treatment options

At locations where the “future existing” noise level is higher than the target noise level, architectural treatment — the only remaining treatment option — will need to be considered:

For all residences where the noise levels will exceed the “future existing” noise level by more than the allowance of 2 dB(A) provided in column 4 of Table 1 in the *ECRTN*, and

For all residences where the noise levels are predicted to be acute (i.e. in excess of 65 dB(A) $L_{eq}(15hr)$).

Predictions for the design year indicate that:

- Road traffic noise levels will increase by more than the *ECRTN* allowance in Segment 1
- Contributed noise levels from the proposal will be 64 dB(A) in Segment 1, and the predicted noise level from all road traffic noise sources in this segment will be acute, at 67 dB(A), and
- Noise levels in Segment 2 will meet the target noise level.

Architectural treatment should therefore be offered only to the owners of the 29 residences within Segment 1.

The projected design year road traffic noise level of 67 dB(A) $L_{eq}(15hr)$ is within 10 dB(A) of the *ECRTN* target noise level of 60 dB(A). Consequently, from *Practice Note IV(b)*, the RTA may spend up to \$15,000 for architectural treatment of each of the 29 residences in Segment 1, if:

- It is reasonable to do so, in the context of the project’s objectives, the predicted noise levels, the specific characteristics of the existing environment and the proposed route
- It is feasible to incorporate appropriate treatment(s) in these dwellings (e.g. they are not too dilapidated), and
- The owners of the dwellings are willing to sign the RTA’s Deed of Release.

In accordance with *Practice Note IV(b)*, the RTA may offer to install local screen or courtyard walls or a combination of fresh air ventilation, acoustically treated wall vents and upgraded window and door seals.

☞ *Note that if the design year noise level (from all road traffic noise sources) had been predicted to exceed 70 dB(A) — i.e. more than 10 dB(A) above the target noise level — at residences of masonry construction, the RTA could have offered upgraded windows, glazing and doors in addition to the treatments described above (see Practice Note IV(b)).*



Selling RTA land exposed to road traffic noise

This Practice Note sets out the situations in which noise treatments do and do not need to be provided by the RTA before it sells any RTA land which is zoned to permit the development of a noise-sensitive land use but is exposed to road traffic noise.

Background

As discussed in *Section 6*, the *Environmental Criteria for Road Traffic Noise (ECRTN)* set noise criteria for specific types of road projects. *Section 7* describes the noise management framework for new and upgraded roads and the processes for establishing whether noise treatment of noise-sensitive land is required.

This *Practice Note* details the RTA's position on whether any such noise treatment needs to be provided by the RTA before it sells its properties.

Properties adjacent to existing roads not subject to road upgrading works

There is no obligation on the RTA to treat vacant land adjacent to existing roads which are not subject to road upgrading works.

Properties adjacent to new and upgraded roads

Practice Note II describes the responsibilities of different parties for treating land which is zoned for noise-sensitive development and which is affected by road traffic noise from new and upgraded roads. It adopts the philosophy of “proponent-mitigated development”, and accordingly places the responsibility for noise treatment on the proponent of development.

The RTA generally sells *vacant* land *after* the road development has been approved. Therefore, the responsibility for providing treatment will lie with the purchaser of the vacant land, when they subsequently apply for a development consent or a complying development certificate for the erection of a building.

In the case of RTA land with *existing* noise-sensitive buildings, a road traffic noise assessment may — after considering road treatment measures such as noise barriers and quieter pavement surfaces — identify architectural acoustic treatments as the most appropriate form of treatment. In this situation, architectural acoustic treatments will generally need to be installed by the RTA in accordance with *Practice Note IV(b)*, prior to the sale of the property.

Records

All records associated with the property and the treatments provided should be recorded on the RTA's *Noise Abatement Program* database (see *Section 8*) and permanently retained on the property file.



Noise and Vibration Management Plans

A guideline for preparing NVMPs. For larger projects and other projects likely to have significant noise and vibration impacts, the RTA's requirements for these plans must be specified in the PEMP and other tender documents prepared by the RTA early in Phase 4 (detailed design and construction) of the overall design process, and a NVMP must then form part of the CEMP prepared by the successful tenderer or the RTA.

Objective

To ensure NVMPs prepared by successful tenderers or the RTA as part of the CEMP are based on a consistent, sound methodology and framework.

Background

As part of the CEMP, the NVMP is a project-specific plan designed to ensure that all contractors and subcontractors comply with the RTA's design concepts and performance standards, including all relevant noise and vibration conditions of approval, and properly manage the project's noise and vibration risks. (See Sections 7 and 9 for more information on this overall context.)

The NVMP must incorporate details of the construction process, a summary of all noise and vibration impacts, details of operational and construction noise and vibration safeguards, details of all relevant design performance standards and specifications as developed by the RTA during the concept design development process, copies of approvals and licenses and specific details on all RTA commitments.

Further reading

Department of Public Works and Services (1998) *Environmental Management Systems Guidelines*, NSW Construction Policy Steering Committee, DPWS report number 97018

RTA (2001) *Environmental Impact Assessment Policy, Guidelines, Procedures*.

Model format and content for *Noise and Vibration Management Plans*

Noise and vibration management objectives

- Define and describe the objectives of the *NVMP*.
 - These objectives should reflect:
 - The final approved design concepts for the project
 - Design performance standards and/or specifications for the project, including urban and regional design standards, landscaping approaches, etc as well as noise and vibration standards
 - Planning approval and environment protection licence conditions, and
 - All other relevant standards and legislative requirements.

Noise and vibration impacts

- Identify the range of noise and vibration-generating activities to be conducted.
- Identify all areas potentially affected by noise or vibration from the road or transitway's operation and construction activities.
 - Include the findings of the traffic noise and construction noise and vibration assessments described in *Sections 7 and 9* and any subsequent investigations and design refinements.
- Wherever possible, define in detail the plant and equipment that will be used, where they will be used and the operational times for all equipment and any blasting activities.
- Set out predictions for noise, vibration and blasting levels based on clearly identified equipment usage and locations.
 - Include the predictions of the traffic noise and construction noise and vibration assessments described in *Sections 7 and 9* and any subsequent investigations and design refinements.
 - Compare the predictions with the appropriate targets, regulations and standards.
 - Review all noise and vibration management practices, including any management practices previously identified in the EIA and their effect in reducing noise and vibration impacts.
 - Include plan(s) of the road or transitway alignment, identifying the locations of sensitive receivers.
 - Justify any local exceedances in terms of the “feasibility and reasonableness” of noise and vibration management measures.

Legal and other requirements

- Identify all relevant legislative and regulatory requirements.
 - Include copies of the relevant approvals and licences.
 - Set out a procedure to keep track of any relevant changes.

Construction and operational noise and vibration targets

- Identify all relevant noise, vibration and blasting standards and targets.
- Identify the necessary mitigation measures to meet the objectives of the *NVMP*, while also meeting all other design standards for the project, including urban and regional design standards and other, wider environmental standards.
- Specify any project-specific noise and vibration design goals.

Accountability, responsibility and training

- Clearly define the responsibilities and accountabilities of all project participants in achieving the objectives of the *NVMP*.
- Identify the training needs and training programs required for achieving the objectives of the *NVMP*.

Activities to ensure compliance

- Specify activities and procedures to achieve compliance.
 - Include the use of suitable equipment, the relevant codes, the standards of workmanship required, the records required, procedures for responding to requests by and directions from regulators, and the necessary qualifications of personnel.
 - Include a schedule and map of activities and responsibilities.

Documentation

- Set out procedures to ensure that the documents and data used are readily available and are approved and current versions.
- Set out procedures for recording, identifying, retrieving and retaining all environmental records.
- Specify that RTA requirements for the archiving of records will apply.

Handling of complaints

- Specify procedures to handle complaints about noise, vibration or blasting activities.
 - Include:
 - A list of key personnel and responsibilities
 - 24-hour contacts and phone number for complaints
 - The actions to be taken on receipt of a complaint (see *Practice Note IX*)
 - Follow-up procedures to ensure that the complaint has been satisfactorily addressed (see *Practice Note IX*)
 - Procedures to record consequential noise and vibration management actions and findings.

Monitoring of performance

- Define noise, vibration and blast monitoring programs to routinely monitor environmental performance.

- Specify the reporting of the results of pre-construction, construction and post-construction monitoring and assessments.
 - Include map(s) of the monitoring locations and contact phone numbers of affected residences.

Audit and review

- Specify a system of internal audits and management reviews to verify that the *NVMP* is being adhered to and is effective.
 - This system must be consistent with the requirements of the *Project Environmental Management Plan (PEMP)* as a whole.

Communication

- Set out requirements and procedures for informing the community of proposed activities, especially those with significant risks of noise and/or vibration impacts, and any proposed changes in activities and timings.

Roadworks outside normal working hours

An outline of procedures for construction and maintenance works outside normal working hours. This Practice Note should be read in conjunction with Sections 9 and 10.

Background

From time to time local communities raise issues regarding noise and vibrations generated by roadworks outside normal working hours, and particularly works at night. These works are often unavoidable, because of the need to maintain full traffic capacity on the network during peak demand periods.

“Normal working hours” are defined in the EPA’s *Environmental Noise Control Manual* as 7 am to 6 pm Monday to Friday and 8 am to 1 pm on Saturdays (or 7 am to 1 pm on Saturdays if the noise is not audible on residential premises).

To minimise community concerns, effective community consultation is essential.

The involvement of affected communities should be sought in the selection and design of noise and vibration treatment measures, where possible.

Where practical, noise and vibration impacts should be minimised by applying stringent roadworks programming restrictions for work conducted outside normal working hours.

Minimum roadworks programming requirements

If roadworks are proposed and it is likely that sensitive receptors will be affected by noise and vibration above guideline levels, and/or receivers are within minimum distance setbacks set out in the *CEMP*,

- Program the work so that noise and vibration at night will not affect any single dwelling or group of dwellings, flats, units and other places of residence on more than two consecutive nights, or on more than a total of six nights over a period of one calendar month.
 - When night work is programmed in stages to comply with this requirement, the periods of work should be separated by not less than one week.

- If programmed night work is postponed for any reason, the work should be re-programmed and the programming requirements described above apply again.
- Very noisy activities should be programmed for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11:00 pm.
- Where practicable, work should be scheduled to avoid major student examination periods and times when students are studying for examinations, such as before and during the Higher School Certificate and at the end of higher education semesters.

If it is not practical to apply these minimum programming requirements, extra care will need to be taken in selecting and applying alternative and effective noise and vibration management measures.

The *CEMP* must be regularly revised to account for changes in noise and vibration management strategies.

Consultation and procedural requirements

- Evaluate all available, feasible and reasonable noise and vibration management measures and include the preferred management measures in the *CEMP*.
 - ◻ RTA environmental protection quality assurance specifications outline a range of measures, including minimum noise and vibration management requirements, that should be included in a *CEMP*. *Section 5* also outlines a range of construction and maintenance noise and vibration management measures which could be adopted. Source control is generally the most effective strategy.
- Apply for a *Road Occupancy or Road Development Licence* from the RTA's Transport Management Centre (Sydney region) or the Regional Traffic Commander (remainder of NSW).
 - ◻ Road construction or maintenance works must not commence until a *Road Occupancy or Road Development Licence* has been granted.
- On the *Road Occupancy or Road Development Licence* application form, include an "after hours" contact name and telephone number for the work. This person should have the power to issue directions concerning the commencement, performance or termination of the work. The "after hours" contact person must be accessible during the course of work.
- If the work is the subject of an Environment Protection Licence, contact the EPA and advise the work proposed to be undertaken, its location, the days and dates of the work, the hours involved and the "after hours" contact name and telephone number.
- Update the *CEMP* to include any additional noise and vibration management strategies and any additional EPA requirements.

- Contact the local community potentially affected by the proposed out-of-hours noise/vibration (residents, businesses, etc) and inform them by letter of the proposed work, the location and type of work, the day(s) and date(s) of work and the hours involved.
 - This contact should be made five days before the proposed commencement of the work.
 - It is preferable to over-estimate the hours of work, rather than aggravate people by extending the work hours for longer than anticipated.
 - A standard *Letter of Advice* can be found at the end of this *Practice Note* (below).
- If the night work will also involve significant disruption to traffic, a suitable advertisement should be placed in local papers. This advertisement should include a reference to night noise/vibration.
- Notify the TMC or Regional Traffic Commander, as applicable, prior to the commencement of work and again upon completion, in accordance with traffic management procedures.
 - It may also be beneficial to notify the affected community and other organisations (e.g. Police and Council), to assist effective complaint management.
- Notify the RTA Environmental Adviser for the region before the commencement of work.
- Manage any noise and vibration complaints in accordance with *Practice Note IX*.

Sample letter of advice

Dear resident,

[*Road name, suburb/town*]
Roadworks

The Roads and Traffic Authority (RTA) will soon be carrying out urgent road works on [*road name*] between [*point A*] and [*point B*], [*suburb/town*].

These works are programmed to commence on [*date*], weather permitting. It is expected that the work will take [*number*] nights to complete.

Unfortunately, because of the high traffic volumes in the area, the work must be carried out outside normal working hours, in order to limit traffic disruptions. It is therefore planned to work between the hours of [*state hours and relevant dates*].

The work will involve activities such as [*state nature of works e.g. the removal of failed pavement and its replacement*]. The effect on you is likely to be limited to noise [*and vibration, if relevant*] associated with this activity. Every attempt will be made to minimise the effect of this work on residents.

If you have any questions, please contact [*name*] on phone [*number*], or after hours the RTA Transport Management Centre on 131 700.

Yours faithfully,

[*Name*]

[*Position*]

[*Region/organisation*]

[*Date*]

Post-construction noise monitoring

A guide for post-construction noise monitoring and the evaluation of noise-control performance for “new” and “redeveloped” roads. Protocols for Noise Abatement Program post-treatment noise monitoring are included in Section 8.

Background

The noise level targets set by the *Environmental Criteria for Road Traffic Noise* for all “new” and “redeveloped” roads (see *Practice Note I*) apply not only immediately after the road opens but for the traffic volumes predicted for ten years’ time.

Post-construction monitoring is undertaken to determine whether the mitigation measures have been adequate for the predicted design noise levels to be met.

The “**Design Noise Level for Year 1**” is the noise level for the road development at project opening, after all feasible and reasonable mitigation strategies have been applied.

Provided traffic flows and mixes following the road’s opening are in line with those used for the predictions, it can be expected that if the predicted noise levels for Year 1 are achieved the predicted Year 10 noise levels will also be achieved.

It should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dB(A). In addition, when noise levels for a new road are being monitored short-term and uncharacteristic variations in traffic flow need to be taken into account when comparing the measured and predicted noise levels.

Process

Post-construction monitoring protocol

Noise monitoring is conducted once traffic flows have stabilised, usually two to 12 months after opening. The monitoring is generally conducted to give a minimum of seven consecutive days of data.

Classified traffic monitoring needs to be conducted simultaneously with the noise monitoring, to identify traffic flows and mixes.

Assessment of monitored data

If the post-construction monitoring indicates operational noise levels exceed the design noise level for Year 1, the following action is required:

- If the measured noise levels exceed the design noise level for year 1 by 2 dB(A) or less, the noise data should be examined, the prediction methodology and suitability of noise mitigation measures should be reassessed and the reasons for the marginal exceedance(s) should be identified and reported.
- If the measured noise levels exceed the design noise level for year 1 by more than 2 dB(A), the adequacy of the noise mitigation needs to be reviewed, and if problems are identified steps need to be taken to rectify the situation. Additional noise treatments may be required to achieve the design noise level, where this is feasible and reasonable.

Reviews of prediction methodology and noise treatments

If a prediction methodology review is required, it should

- Take into account all noise model inputs, including any traffic flow variations which can be attributed to temporary anomalous traffic flows, recent traffic-generating developments or Local Area Traffic Management (LATM) schemes
- Include a comparison of the traffic data used for the noise prediction model and monitored traffic volumes and compositions, and
- Evaluate and report on the post-construction noise monitoring methodology.

If the prediction methodology is found to be flawed, and the monitored noise levels and traffic volumes are considered to be representative, the noise treatments provided should be re-evaluated and upgraded where feasible and reasonable.

If the variation is attributable to factors beyond the RTA's control, such as LATM schemes or subsequent traffic-generating developments, examine the reasons why these proposals were not included in the predictions. Further amelioration may need to be evaluated by the responsible agencies. Please refer to *Practice Note X* for assistance in providing comments on proposals such as traffic-generating developments and LATM schemes.



Noise and vibration complaints

How to act on, investigate and respond to complaints about noise or vibration from individual vehicles, from road traffic more generally and/or from construction or maintenance activities.

Complaints about noisy vehicles

With the exception of complaints relating to noisy heavy vehicles, noisy vehicle complaints should be forwarded to the EPA's *Pollution Line* (131 555 State-wide) for further action.

Heavy vehicle noise complaints should be referred to the RTA Vehicle Regulation and Inspection section for further action. (See *Section 11* for information on the RTA's noisy heavy vehicle enforcement role. Note that the ADRs do not currently specify standards for engine brake noise.)

All complaints regarding noisy vehicles on private property should be referred to the appropriate local council or the Police.

Complaints should also be recorded in a regional vehicle noise complaints database.

Include the complainant's details, vehicle registration details, the observation time and location and vehicle details such as make, model, type of vehicle (e.g. sedan, heavy vehicle) and colour.

Traffic noise complaints

Upon receipt of a traffic noise complaint:

- Check to see if the location is already entered in the NAP database.
 - If not, enter the complaint details into the database.
- Conduct a preliminary evaluation of the validity of the complaint, to establish whether the site should be subjected to further investigation as described in Section 8.
 - Check whether noise monitoring has been conducted in the vicinity of the complainant.
 - Recent traffic volume data can be a reliable indicator of noise exposure.
 - Alternatively, conduct short-term monitoring over a minimum 15-minute sample period.

The time of day for this monitoring is usually quite flexible, as sites exposed to noise levels greater than 65 dB(A) $L_{eq}(15hr)$ or 60 dB(A) $L_{eq}(9hr)$ are usually noisy for most of the day. Generally the most suitable time is when traffic flows are at neither their highest nor lowest levels.

- Inform the complainant within three weeks, by phone or letter, of the status of the site in terms of the NAP and any other action to be taken.

Traffic vibration complaints

- Record the matter on the regional complaints database.
- Consider whether to undertake an architectural inspection of affected buildings, to identify the likelihood of structural damage arising from traffic vibration.
- Consider whether to commission a vibration study to assess the vibration levels being experienced.
 - An investigation of road traffic vibration or building damage impacts would not be warranted for sites more than 20 m from the road carriageway. It is most unlikely that building damage can be attributed to road traffic.
 - A model consultant brief for a vibration study is set out in *Appendix D*.

Complaints about construction or maintenance noise or vibration

- Refer all complaints about activities being conducted during normal working hours to the RTA representative and/or Contractor's representative with authority over the works, or to any project-specific complaints hotline, as soon as possible.
 - Complaints referred to a project-specific complaints hotline are in turn forwarded to the RTA representative and/or Contractor's representative with authority over the works.
- Refer out-of-hours complaints which have not been directed to any project-specific complaints hotline to the Transport Management Centre (TMC) Duty Chief as soon as possible.
 - The TMC Duty Chief will identify whether the activity relates to a road under the responsibility of the RTA or a local council.
 - In some circumstances, in regions outside Sydney, the TMC will not have sufficient information to establish which agency is responsible. In this situation the TMC Duty Chief will refer the complaint to the Regional Traffic Commander the following day, for further action.
 - Advise the EPA or the complainant, as applicable, if the complaint relates to activities that are under the control of the local council and are not the responsibility of the RTA.

- If management of the activity is a RTA responsibility, the TMC or the Regional Traffic Commander, as applicable, will obtain the project's contact details from its *Road Occupancy or Road Development Licence*. The complaint is then referred to this contact person (the RTA representative and/or the Contractor's representative having authority over the works) or to any project-specific complaints hotline, as applicable, as soon as possible.
- In all cases, the complaint is forwarded to the RTA representative and the details are logged into the regional complaint database. In addition, the Contractor's representative records the complaint details in accordance with the works' *CEMP*.
- The Contractor's representative must review the adequacy of the on-site noise and vibration safeguards and determine whether any variation from the planned work schedule or the safeguards in the *CEMP* has caused the problem.
 - This may necessitate compliance monitoring. Model consultant briefs for these types of investigations are in *Appendices C and D*.
- If appropriate, add extra on-site noise/vibration safeguards and revise the *CEMP*.
 - *Section 5* lists a range of techniques for controlling construction and maintenance noise and vibration.
 - If the works are the subject of an Environment Protection Licence, the noise and vibration safeguards should be selected in consultation with the EPA and the RTA representative.
 - Ensure that the Site/Works Supervisor is advised of the changes and send a copy of the revised *CEMP* to him or her for on-site reference.
- Notify the RTA representative.
- The RTA/Contractor's representative must then contact the complainant and/or the EPA representative, as appropriate, and inform them of the investigations and their outcomes.
- Notify the RTA Environmental Adviser for the region.



Land-use planning and Local Area Traffic Management schemes

This Practice Note describes the issues to consider when the RTA comments on:

- *Draft planning instruments (SEPPs, REPs and LEPs)*
- *Proposals to locate residential developments or other noise-sensitive developments adjacent to major roads*
- *Proposals for developments that are expected to have significant road traffic noise impacts*
- *Proposed Local Area Traffic Management (LATM) schemes.*

Commenting on draft planning instruments

As discussed in *Sections 2 and 4*, effective land-use planning can help to guard against high road traffic noise exposure.

Providing comments on draft planning instruments can therefore help to provide long-term, cost-effective benefits by ensuring the effects of road traffic noise are considered in the zoning of land and other provisions of these plans.

- Councils should be advised to include provisions relating to noise and vibration in relevant Local Environmental Plans (LEPs) and associated Development Control Plans (DCPs).
 - Sample comments for a draft comprehensive Local Environment Plan (LEP) are provided at the end of this *Practice Note*.
 - Appropriate noise targets should be set for noise-sensitive developments such as residences, schools, hospitals, places of worship and active and passive recreation areas.
 - The *ECRTN* encourage local approval authorities to develop their own internal noise level criteria (e.g. to prevent sleep disturbance in residences). In the absence of any local codes for new residential developments, the *ECRTN* recommend internal levels of 35–40 dB(A) at night. The *ECRTN* also set:
 - External noise level targets for new residential developments affected by traffic noise from different categories of roads
 - External noise level targets for land-use developments with a potential to generate additional traffic on different categories of roads, and

- External and internal noise level targets for certain particularly noise-sensitive land uses.
 - Planning instrument provisions relating to site layout, building design, building construction methods and building materials should demonstrate consideration of acoustic performance.

Commenting on noise-sensitive development proposals

- Whenever a potentially noise-sensitive development is proposed for a site near a major road, the RTA should seek an opportunity to comment and assist in reducing future traffic noise impacts.
 - If the RTA owns land adjacent to a proposed noise-sensitive development, the local Council should notify the RTA and provide an opportunity to comment.
- As planning approval authorities, local Councils must have sufficient information to make an assessment.
 - In some cases the RTA may need to provide information, where it is available, on likely future traffic volumes.
 - If insufficient information is available, Councils should be informed that it is important for the proponent to supply information about the expected external and internal noise levels for the building(s).
- To be effective, the RTA's comments should be provided to the Council or other relevant authority before building designs are finalised. Once designs are finalised, there are limited opportunities to include noise-reducing design features in construction.
- The Council or other relevant authority should also be advised that noise reduction measures for new developments should endeavour to meet the noise level targets set out in the *ECRTN* and that internal noise levels should meet the local Council's own criteria.
 - In the absence of any local internal noise level criteria, guidance is provided by the *ECRTN*.
- The design of multi-storey buildings provides scope for architectural modifications to reduce internal noise. Generally the lower apartments require more treatment than upper levels, and the underside of balconies can reflect noise into rooms below.
 - Comments on housing design and layout should include a reference to the *Australian Model Code for Residential Development* published by the Commonwealth Department of Housing and Regional Development in 1995.
- If appropriate and if space permits, earth embankments or noise walls could be erected on RTA land if the purpose, location and design of these barriers is acceptable to the RTA. An agreement with the developer regarding any such proposal would be required.

- The Council and the proponent should be made aware that the RTA will not be responsible for providing retrofitted noise controls, should residents seek assistance at a later date.
- The RTA should also emphasise existing and potential traffic noise impacts when responding to property enquiries.

Commenting on proposals for traffic-generating developments

The additional traffic generated by some types of development contributes to increased noise and vibration and therefore has clear potential to affect existing residential areas and other noise-sensitive land uses.

State Environmental Planning Policy 11, *Traffic Generating Developments*, requires development applications for certain traffic-generating developments to be forwarded to the RTA for comment. This applies to:

- Traffic-generating developments of the types specified in Schedule 1 to SEPP 11, and
- Any development of the types specified in Schedule 2 of SEPP 11 if they are proposed to be located on or near an arterial road.

This provides an opportunity for the RTA to comment on a number of environmental and amenity impacts, including those associated with noise.

- In commenting on these development applications, ensure that the matters relating to noise set out in the Planning NSW publication *Guide to Section 79C* have been adequately addressed.
 - Section 79C of the Environmental Planning and Assessment Act requires consideration of whether the proposed development will generate offensive noise pollution or vibration, taking account of ambient noise levels in the locality and prevailing meteorological conditions (wind speed and direction and temperature inversions), noise generated from the development, vibration from the development and its effect on the surrounding area, and noise and vibration mitigation measures and management.
- The development application should also demonstrate how the proposal will meet the noise level criteria for traffic-generating developments set out in the *ECRTN*.
 - The *ECRTN* require all feasible and reasonable noise control strategies to be applied in endeavouring to meet noise goals.
 - The *ECRTN* list a number of strategies that should be applied in minimising any noise impacts associated with developments defined as traffic-generating developments in SEPP 11.
 - If the *ECRTN* goals are already exceeded and all feasible and reasonable noise control strategies have been applied, the *ECRTN* require that “in all cases, traffic arising from the development should not lead to an increase in noise levels of more than 2 dB(A)”.
 - If several separate traffic-generating developments are proposed in an area and each is expected to contribute to an overall cumula-

tive noise impact, these developments should be considered both individually and as a group for the purposes of assessing their impacts and deciding mitigation measures.

As a guide, a cumulative noise impact assessment should take account of the contributions from all traffic-generating developments which are currently proposed or which have been approved or have commenced operation within the last five years. Increases in road traffic noise levels attributable to other contributors to changing traffic flows will usually not be significant within this timeframe.

Commenting on Local Area Traffic Management schemes

- Local Traffic Committees considering local Council Local Area Traffic Management (LATM) schemes should assess whether the potential noise impacts of all devices and changes in road paving have been adequately investigated, and if necessary make recommendations to the Council.
 - ◻ Each Local Traffic Committee comprises the local State Member of Parliament (or his or her delegate) and representatives of the Council, the Police Service and the RTA. It provide advice to the Council on the appropriateness of any proposal, prior to the Council's exercising of its delegated power.
 - ◻ The use of traffic management schemes and traffic calming devices is discussed in *Section 3*.
- The available types of devices and other constraints on vehicle operation are outlined in *Towards Traffic Calming: A Practitioner's Manual of Implemented Local Area Traffic Management and Blackspot Devices*. Useful examples of before and after noise studies are presented for some LATM devices and implemented schemes.
- A research study commissioned by the RTA, *Traffic Calming Devices Part 1: Effects on Attitudinal Behaviour and Roadside Noise Levels* and *Part 2: Community Attitudinal Survey, Background, Methodology and Data Analysis* (Renzo Tonin & Associates Pty Ltd 1996), discusses the effects of a number of traffic calming devices on both speed and maximum noise levels, and presents the results of annoyance surveys, including an analysis of correlations of annoyance with maximum and L_{Aeq} noise levels.
- A paper presented at the Roads 96 Conference, *The Acoustical Attributes of Some Traffic Calming Devices* (Karachlis N, Pontifix G and Samuels S E), presents information on individual vehicle noise and overall traffic noise associated with some traffic calming devices.
- The *ECRTN* set target noise levels for local roads.
- An acoustic assessment of each LATM proposal should be undertaken before the RTA's concurrence is sought.

Further reading

Austrroads (1988) *Guide to Traffic Engineering Practice, Part 10 Local Area Traffic Management*

Commonwealth Department of Housing and Regional Development (1995) *Australian Model Code for Residential Development*

Planning NSW (formerly the NSW Department of Urban Affairs and Planning) (1998) *Guide to Section 79C, Environmental Planning and Assessment Act 1979*

EPA (1999) *Environmental Criteria for Road Traffic Noise*

EPA and RTA (1991) *Reducing Traffic Noise: A Guide for Homeowners, Designers and Builders*

Karachlis N, Pontifix G and Samuels S E (1996) *The Acoustical Attributes of Some Traffic Calming Devices*, Proceedings, Roads 96 Conference, Part 6

Renzo Tonin & Associates (1996) *Traffic Calming Devices: Part 1, Effects on Attitudinal Behaviour and Roadside Noise Levels and Part 2, Community Attitudinal Survey, Background, Methodology and Data Analysis*

RTA (1991) *Noise Barriers and Catalogue of Selection Possibilities*

RTA (1991) *Statutory Planning Guidelines*

RTA (1995) *Guide to Traffic Generating Developments*

Standards Australia (1987) AS 2107 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors*

Standards Australia (1989) AS 3671 *Acoustics – Road Traffic Noise Intrusion, Building Siting and Construction*

Standards Australia (1991) AS 1742.13 *Manual of Uniform Traffic Control Devices – Local Area Traffic Management*

WSROC (1993) *Towards Traffic Calming: A Practitioner's Manual of Implemented Local Area Traffic Management and Blackspot Devices*.

Sample comments on a draft comprehensive LEP

Minimising road traffic noise impacts

It is recognised that road traffic noise is a serious issue for many residents living close to the State Road network. While the RTA and Council cannot eliminate such conflicts between *existing* land uses and roads, the opportunity exists to implement measures to minimise conflicts for *future* developments and redevelopment along existing and identified future road corridors. Accordingly, when considering residential or other noise sensitive development along these road corridors, Council needs to assess the potential impacts of road traffic noise on the development and ensure suitable abatement treatments are incorporated in the design.

The NSW Environment Protection Authority's *Environmental Criteria for Road Traffic Noise* ("the *ECRTN*") identify sites as being noise-affected when existing noise levels exceed external noise target levels for residential developments and internal and external noise target levels for other selected noise sensitive developments. The *ECRTN* recognise that it is preferable for residential internal noise target levels to be set by Council and that the internal noise level goals may vary depending on the type of development the planning authority wants to encourage for an area. In the absence of any local policy or code, the *ECRTN* recommend internal noise goals for residential developments.

Landowners and developers need to be made aware of the potential for significant road traffic noise impacts resulting from the placement of noise sensitive development in the vicinity of State and National Roads. It is considered appropriate that the LEP should identify land within a (*300 m setback – modify setback distance on the basis of available noise and/or traffic volume and mix*) from the road alignment as being potentially affected by road traffic noise. The LEP should be supported by a local policy or DCP that sets criteria describing when land is noise-affected and internal noise levels to be achieved through appropriate subdivision design and building design and treatment. Section 149 certificates issued by Council should state whether the LEP identifies the subject land as potentially noise-affected and then refer to the relevant Council policy or code.

Engine brake signs

A guide for determining whether the installation of standardised engine brake signs is warranted, to help reduce the use of engine brakes in urban areas.

Background

Noise from heavy vehicle engine brakes is a major source of community annoyance in urban areas. Currently there are no regulations specifically restricting the use of engine brakes, although ADR 28/01 is being revised to include limits for engine brake noise.

Driver education can be an important way of reducing road traffic noise at the source. The installation of “engine brake signs” is part of this education strategy and it is targeted raising awareness and encouraging behavioural change throughout the industry. The signs should not be installed in the hope of achieving immediate noise reductions at a specific site.

For background information on the NSW vehicle noise management framework, see *Section 11*.

Engine brake signs should be installed at strategic truck route locations identified on a regional basis that maximises their exposure and effectiveness. Proliferation of these signs should be avoided and they should not be installed simply as a response to local complaints or as a local noise control measure for a specific road development or upgrade projects.

The use of engine brake signs is subject to a “sunset clause” of three years, until in-service engine brake noise limits and tests are established.

Engine brake signs may be useful for both defined and undefined truck routes through urban areas. For each proposed sign, however, a case justifying the installation of the sign needs to be developed.

Actions

- Conduct a regional strategic study of truck routes and potential sign installation locations.
- Establish whether the proposed installation site is consistent with the findings of the regional strategic study.
- Assess the traffic composition. As a guide, signs would generally not be warranted on routes used by fewer than 40 heavy vehicles between 10 pm and 6 am.



- Assess the potential disturbance caused by engine braking.
 - ◻ Assess the prevalence of residential areas within 100 m of the road alignment.
 - ◻ Assess the likely extent of engine brake use, taking account of road gradients, traffic devices and the road design.
- Assess the practicality of installing the sign.
- Install the sign.
 - ◻ Standardised signs must be used, as shown at left.
 - ◻ Signs must not be less than 1 km apart, and there should be no more than two signs in any 10 km section of a defined route.
- Monitor the effectiveness of the signs in collaboration with the community and evaluate heavy vehicle operator attitudes and behaviour.



Roads and Traffic Authority
www.rta.nsw.gov.au

Appendices

Model briefs

for consultants

MODEL CONSULTANT BRIEFS

These “model” briefs are designed to assist you in obtaining noise and vibration monitoring and assessment services.

They are not intended as comprehensive guides to contracts and do not attempt to set out all the matters that might be relevant to consultants’ proposals.

Similarly, the model briefs may refer to issues that are not relevant to every project.

Please treat these briefs as guides only, and modify them to suit each project.

Model consultant brief for assessing likely traffic noise from new and upgraded roads

Scope

This brief applies to the preparation of traffic noise assessment reports associated with the route strategy development, option investigation and concept design development, including the project's EIA. It should be read in conjunction with *Section 7* of the *RTA Environmental Noise Management Manual* and the EPA *Environmental Criteria for Road Traffic Noise*.

Objective

To measure, model and assess road traffic noise impacts and potential mitigation/attenuation measures for the proposal.

RTA inputs

The RTA will provide the following materials, information and resources to the consultant, where available:

- Previous noise monitoring results, where available.
- Aerial photographs, where available.
- Road design data as PC readable (IBM format) files in AutoCAD DXF format, MOSS GENIO format or as delimited (or fixed width) ASCII files of *x*, *y* and *z* coordinates suitable for direct input into a spreadsheet.
- Traffic volumes (AADT) and percentages of cars, medium trucks and heavy trucks for the specified year(s). Hourly data will be provided where available.
- The intended (or actual) speed limit(s) and pavement surface(s) for the road.

Minimum outputs

The number of copies of the report to be provided is shown in Schedule A, Item 1.

Electronic copies of all noise monitoring data must be provided in IBM PC format.

Timing

Timing of output shall be in accordance with Schedule A, Item 2.

A variation may be requested if there is interference with monitoring equipment, inclement weather or a change in the scope of work.

Route strategy development

Broadly and strategically evaluate potential noise issues and noise impacts associated with the strategy options in terms of populations affected/benefited and cumulative contributions from other sources, such as heavy industry and aircraft flight paths.

(Noise monitoring and modelling is generally not required during this “scoping” stage.)

Route selection

Following development of the route strategy, broadly evaluate potential noise impacts associated with the various route options:

- Review existing information and use broad descriptors to assess potentially high noise locations that may arise as a result of both construction and anticipated traffic noise for each of the proposed road options.
- Indicative setbacks from the road alignment where noise criteria could be met may be calculated based on simple road traffic noise modelling that takes into account the proposed vehicle speed, projected traffic volume and mix and intuitive effects of significant topographical features.
- Noise monitoring is not required at this stage (delete if appropriate).
- Include in the assessment a comparison of the potential noise impacts of the proposed route options and conduct a cost-benefit analysis in terms of noise impacts and the number of noise sensitive receivers within noise criteria setbacks. The RTA’s *Economic Analysis Manual* describes cost-benefit analysis methodologies that may be applied in the selection of the most cost-beneficial route.

Option investigation for the preferred route

Noise monitoring

General specification

Measurements must be carried out in accordance with AS 2702 Acoustic Methods of Measurement of Road Traffic Noise and this Brief.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

Consultant staff carrying out noise measurements must be courteous and tactful in dealing with members of the public. Staff may enter properties only after consultation with the Project Manager and with the permission of the occupier.

Instrumentation

All instrumentation utilised must comply with the requirements of AS 1259.2 Sound Level Meters and carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

Continuous noise monitoring is to be undertaken using noise-logging instrumentation that samples continuously over each 24-hour period. Generally, the instrumentation must be set up to record the relevant environmental noise parameters in 15-minute time intervals.

The minimum noise parameters recorded should include L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period.

If this brief requires specific monitoring to be undertaken for the purpose of a maximum noise assessment, a chart recorder may be used. Alternatively, noise logging instrumentation may be used, but must be set up to record instantaneous sound pressure levels at intervals of about ¼ second. The storage of longer period noise levels, such as 1-second sound levels, may be appropriate but should be justified.

Monitoring periods, extraneous noise, traffic conditions and noise data analysis

The duration of noise monitoring must be in accordance with Schedule A, Item 3.

Noise monitoring may not be undertaken during periods of atypical traffic flows, including school holidays.

Noise monitoring may not be undertaken during periods of extraneous noise (for example, nearby construction activity).

Events identified as extraneous are to be excluded from the computation of the noise parameters.

All data considered to be affected by adverse weather conditions, including rain and wind, are also to be excluded from the computation of the noise parameters.

If it is not possible to exclude noise from sources other than road traffic, these sources must be documented and their contribution to the measured noise levels estimated. In these circumstances, noise level reporting should also include noise levels adjusted by subtracting any extraneous contributions.

As a minimum, the noise parameters in Schedule A, Item 4 shall be computed from the monitored data.

If this brief requires specific monitoring to be undertaken for the purpose of a maximum noise assessment, external L_{Amax} and L_{Aeq} noise levels should be computed from the monitoring data for each hour between 10 pm and 7 am. This computation must include:

- The L_{Amax} noise levels greater than 65 dB where $L_{Amax} - L_{Aeq} \geq 15$ dB, and
- The number and distribution of the $L_{Amax} - L_{Aeq}$ emergence events.

Road traffic noise monitoring locations

Identify the noise catchment areas for all options under investigation and all possible sensitive locations within the catchment areas.

Site plans indicating the location of monitoring points need to be included, using the same co-ordinate system as that used in the road design data.

Road traffic noise monitoring should be conducted at all the locations nominated in Schedule A, Item 5.

Noise monitoring should be conducted 1 m from the building façade that is most exposed to traffic noise and at a height 1.5 m above the floor level. If monitoring is in the free-field (for example, before a dwelling is built), a 2.5 dB(A) façade reflection correction should be added to the measured L_{Aeq} noise levels.

Similarly, if there is risk of interference from extraneous noise sources located near the subject building, noise measurements may be conducted in the free-field and a 2.5 dB(A) façade correction added to the measured L_{Aeq} noise levels.

In the case of multi-level residential buildings, noise monitoring should be at either of the two floors of the building that are most exposed to traffic noise (generally the ground and first floors).

Noise modelling

Noise modelling algorithms

The noise model selected to calculate the road traffic noise levels is to be justified according to the circumstances of the particular project, prior to commencement of works and in the noise assessment report.

Noise model selection should take into account low traffic volumes/speed and variations to the acoustic centre of the traffic stream attributable to varying traffic mixes. The consideration given to this should be documented in the consultant's report, particularly when the predictions involve significant heavy vehicle percentages or terrain features, road cuttings or noise barriers which screen the traffic stream from the noise-sensitive properties.

Where the heavy vehicle component of the traffic flow is 10% or greater during the day or the night, the model selected should be capable of segregating source height and noise components for the exhaust and engine and/or tyres of heavy vehicles or alternatively, adopt a "split-height" of energy for vehicles of different classifications.

Consideration may also be given to models that can directly predict or be adapted to predict maximum noise levels from an individual source.

Documentation supporting the conversion of the output from the selected programs to the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ parameters must be provided.

Modelling considerations

The consultant must consider at least the following parameters when conducting the calculations or computer modelling:

- Percentage of cars on the roadway(s)
- Percentage of trucks on the roadway(s)
- Posted speed limit(s)
- Pavement surface
- Gradient of roadway
- Topographic features
- Receiver/source distances and heights
- Intervening ground cover
- Roadside or topographic barriers
- Reflections from buildings or roadside barriers, including multiple reflections
- Assessment heights
- Contributed noise from other traffic sources likely to influence the overall noise environment, and
- Façade reflections.

Verification of the noise model

The objective of verification is to demonstrate that the particular computer noise model being employed for the study is capable of generating correct outputs.

The nature of the verification process will depend on the circumstances of the particular project and site (flat or hilly terrain, presence of noise barriers, etc).

The consultant must identify the key issues relating to verification for the specific project and implement the required verification process with approval of the RTA project manager.

Reporting

The report must include the following, as a minimum:

- A brief description of the options under investigation
- A brief description of the prevailing ambient noise environments
- Documentation of the location of the noise monitors relative to each option being investigated, including an indication of the distance to the nearest road, if a road is located close to the noise monitors
- A site plan showing the locations of the noise monitoring
- Aerial photographs (provided by the RTA, if available) showing the locations of the noise monitoring
- Using 15-minute intervals, charts of noise parameters, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , for each 24-hour period of the monitoring survey
- A table summarising the noise parameters detailed in Schedule A, Item 4 at each location
- Tabulations of Average Annual Daily Traffic (AADT) results and predictions for the day and night periods:
 - If hourly traffic data are available, the report should include tabulations of the number of cars (including light trucks with four tyres), medium trucks (2 axles, 6 tyres) and heavy trucks (3 axles) for each measurement hour
 - If classified traffic counts were conducted as part of the noise model verification or maximum noise assessment, the report should include a summary of the traffic volumes and percentages
- Summaries of the computational algorithms used and justification for their selection, the location of noise-sensitive dwellings and how the issues identified under “Modelling considerations” were addressed
- The calculated $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ levels for each identified noise-sensitive dwelling/location, in tabular format
- The noise environment predicted at the times listed in Schedule A, Item 5 at each location
- The noise criteria applying to the project and the locations where noise levels are predicted to exceed the target noise levels of the *Environmental Criteria for Road Traffic Noise*
- An evaluation of prevailing maximum noise level impacts and changes in impacts attributable to the proposed options. This evaluation should include the tabulation of representative predicted maximum noise levels, showing maximum noise levels, the value of $L_{max} - L_{Aeq}$ and the number of noise events (refer to *Practice Note III* in the *RTA Environmental Noise Management Manual*)
- Noise contours, generally for intervals of 5 dB(A), clearly identified with the contour value. The contours should extend to a noise level at least 5 dB(A) (and preferably 10 dB(A)) below the noise target applicable to the project (*strike out if not required for this brief*)
- All available options for reducing noise impacts, and a preferred option(s), based on assessment of likely effectiveness, costs, practicality, any community preferences, aesthetics, project objectives and equity issues.

The RTA's *Economic Analysis Manual* provides advice on cost-benefit methodologies that could be used in the development of a preferred option.

Concept design and environmental impact assessment of the preferred route option

The report must include the following, as a minimum:

- A brief description of the project and the objectives of the report
- Justification for selection of the preferred route option
- Details of the noise investigation and impact assessment for the preferred route option conducted during the “option investigation” stage
- All possible noise control options for reducing noise impacts, and a set of preferable options, based on assessment of likely effectiveness, costs, practicality, any community preferences, aesthetics, project objectives and equity issues.

Practice Note IV in the RTA's *Environmental Noise Management Manual* describes a procedure for carrying out a comparative cost-effectiveness analysis of noise control options.

All monitoring data should be included as an appendix.

Schedule A

Item 1: Required number of reports

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing of outputs

e.g. final report within 6 weeks of commissioning

e.g. draft report within 6 weeks of commissioning, followed by the final report 2 weeks after the receipt of RTA comments.

Item 3: Duration of noise monitoring

e.g. 7 days of valid data (default)

e.g. 3 days of valid data

e.g. 1 day of representative valid data (default for a maximum noise assessment)

e.g. other

Item 4: Computed noise parameters

e.g. $L_{Aeq(1hour)}$: the highest level for any hour between 7:00 am and 10:00 pm or if relevant between 10:00 pm and 7:00 am

e.g. $L_{Aeq(1hour)}$: for each hour between 10:00 pm and 7:00 am (maximum noise assessment only)

e.g. $L_{Aeq(15hour)}$: for the 15-hour day period from 7:00 am to 10:00 pm

e.g. $L_{Aeq(9hour)}$: for the nine-hour night period from 10:00 pm to 7:00 am

e.g. $L_{Aeq(24hour)}$ averaged over 24 hours

Item 5: Ambient noise monitoring locations

e.g. potentially most affected and representative locations to be selected by the consultant (default)

e.g. 5 locations to be selected by the consultant

e.g. 31 James Street, 41 Norton Street, etc.

Item 6: Environment predicted

e.g. at project opening (default)

e.g. 10 years after project opening (default)

e.g. at design capacity

Model consultant brief for assessing the likely noise and vibration impacts of construction works

Scope

This brief applies to the preparation of a construction noise and vibration assessment report associated with road concept design development, including the project's EIA. It should be read in conjunction with *Sections 9 and 10* of the RTA *Environmental Noise Management Manual*.

This brief has been formulated on the basis that a detailed construction work plan is not yet available and that accordingly it is only possible to conduct an indicative assessment of construction impacts.

Objective

To assess construction site noise and vibration impact and potential mitigation/attenuation measures for the proposal.

RTA inputs

The RTA will provide the following materials, information and resources to the consultant, where available:

- Previous noise monitoring results
- Aerial photographs
- Hard copies of the road design showing noise-sensitive receiver locations, and
- An indicative description of the expected construction activities and plant/equipment to be used.

Minimum outputs

The number of copies of the report to be provided is shown in Schedule A, Item 1.

Electronic copies of all noise monitoring data must be provided in IBM PC format.

Timing

Timing of output shall be in accordance with Schedule A, Item 2.

A variation may be requested if there is interference with monitoring equipment, inclement weather or a change in the scope of work.

General specification

Measurements must be carried out in accordance with AS 1055 Acoustic – Description and Measurement of Environmental Noise and this Brief.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

Consultant staff carrying out noise measurements must be courteous and tactful in dealing with members of the public. Staff may enter properties only after consultation with the Project Manager and with the permission of the occupier.

Instrumentation

All instrumentation utilised must comply with the requirements of AS 1259.2 Sound Level Meters and carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

Continuous noise monitoring is to be undertaken using noise-logging instrumentation that samples continuously over each 24-hour period. The instrumentation must be set up to record the relevant environmental noise parameters in 15-minute time intervals.

The minimum noise parameters recorded should include L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period.

Monitoring periods, extraneous noise and noise data analysis

The duration of noise monitoring must be in accordance with Schedule A, Item 3.

Noise monitoring may not be undertaken during periods of extraneous noise (for example, nearby unrelated construction activity).

Events identified as extraneous are to be excluded from the computation of the noise parameters.

All data considered to be affected by adverse weather conditions, including rain and wind, are also to be excluded from the computation of the noise parameters.

In situations where it is not possible to exclude noise sources that are not representative of the ambient noise environment, these sources must be documented and their contribution to the measured noise levels estimated. In these circumstances, noise level reporting should also include noise levels adjusted by subtracting any extraneous contributions.

As a minimum, the noise parameters in Schedule A, Item 4 are to be computed from the monitored data.

Ambient noise monitoring locations

Identify all possible construction noise sensitive locations surrounding the construction area.

Site plans indicating the location of monitoring points are to be included with monitoring points identified using the same co-ordinate system as that used in the provided RTA road design data.

Ambient noise monitoring should be conducted at all locations nominated in Schedule A, Item 5.

Reporting

The report must include the following, as a minimum:

- A brief description of the project and the objectives of the report
- A brief description of the prevailing ambient noise environment
- Documentation of the location of the noise monitors, including an indication of the distance to the nearest road, if a road is located close to the noise monitors
- A site plan showing the locations of the noise monitoring
- Using 15-minute intervals, charts of noise parameters, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , for each 24-hour period of the monitoring survey
- A table summarising the noise parameters detailed in Schedule A, Item 4 at each location
- An assessment of potential construction noise and vibration impacts in accordance with *Section 9* of the RTA *Environmental Noise Management Manual*
- An indicative description of the types of plant, equipment and construction activities to be included in the project construction, their estimated noise and vibration levels, and the distance of operations from noise-sensitive locations
- The noise and vibration environment predicted during the course of road construction
- The noise and vibration guidelines applying to the project and the locations where these guidelines are predicted to be exceeded, and
- The range of best economically and technically available options that could be considered in managing construction noise and vibration impacts.

Schedule A

Item 1: Required number of reports

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing of outputs

e.g. final report within 6 weeks of commissioning

e.g. draft report within 6 weeks of commissioning, followed by the final report 2 weeks after the receipt of RTA comments

Item 3: Duration of noise monitoring

e.g. 7 days of valid data (default)

e.g. 3 days of valid data

e.g. other

Item 4: Computed noise parameters

e.g. L_{A90} (7:00 am to 6:00 pm).

e.g. L_{A90} (7:00 am to 10:00 am; 10:00 am to 2:00 pm; 2:00 pm to 6:00 pm).

e.g. LA90(6:00 pm to 10:00 pm).

e.g. LA90(10:00 pm to 7:00 am).

Note: The background noise needs to be determined on the basis of the lowest tenth percentile noise level (LA90 (15min)) for each time segment during the entire measurement period

Item 5: Ambient noise monitoring locations

e.g. potentially most affected and representative locations to be selected by the consultant

e.g. 5 locations to be selected by the consultant

e.g. 31 James Street, 41 Norton Street, etc.

Model consultant brief for construction and/or maintenance noise monitoring

Scope

This brief applies to the monitoring and reporting of noise from road construction and maintenance works, including any blasting activities. It should be read in conjunction with *Section 9* of the RTA's *Environmental Noise Management Manual*.

The noise monitoring report and data may be used to:

- Review the adequacy of current works practices and noise-management procedures
- Identify a need for more detailed monitoring and investigation to minimise noise impacts, and/or
- Identify a need to implement further noise management strategies.

Objectives

To establish and document the impacts of construction and maintenance noise emissions at sensitive receivers potentially affected by the works.

RTA inputs

The RTA will provide the following materials, information and resources to the consultant, where available:

- Hard copies of the road design showing noise-sensitive receiver locations
- A schedule of construction activities and a description of plant/equipment to be used
- Pre-construction ambient noise monitoring results.

Minimum outputs

The number of copies of the report to be provided is shown in Schedule A, Item 1.

Timing

Timing of output shall be in accordance with Schedule A, Item 2.

A variation may be requested if there is interference with monitoring equipment, inclement weather or a change in the scope of work.

General specification

Measurements must be carried out in accordance with AS 1055 Acoustic – Description and Measurement of Environmental Noise and this Brief.

The assessment of construction/maintenance noise must be carried out in accordance with the construction noise guidelines presented in the EPA's *Environmental Noise Control Manual* and/or project-specific requirements, including those contained in the project's *EIS/REF* and *EMP*.

The blasting airblast overpressure assessment must be carried out in accordance with project-specific requirements, including those contained in the project's *EIS/REF*, *EMP*, any conditions of approval and the ANZECC *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

Consultant staff carrying out noise measurements must be courteous and tactful in dealing with members of the public. Staff may enter properties only after consultation with the Project Manager and with the permission of the occupier.

Instrumentation

All instrumentation utilised must comply with the requirements of AS 1259.2 Sound Level Meters and carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

Continuous noise monitoring is to be undertaken using noise-logging instrumentation which samples continuously over each 24-hour period. The instrumentation must be set up to record the relevant environmental noise parameters in 15-minute time intervals.

The minimum noise parameters recorded should include L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period.

If blasting is carried out, the linear (peak noise) parameter must be recorded for blasting airblast overpressure assessment.

Noise monitoring regime

The activities to be monitored and the duration of noise monitoring must be in accordance with Schedule A, Item 3. In any case other than blasting overpressure monitoring, the monitoring must be conducted over a minimum period of fifteen minutes.

Construction noise monitoring may not be undertaken during periods of extraneous noise (for example, nearby unrelated construction activity).

Events identified as extraneous are to be excluded from the computation of the noise parameters.

All data considered to be affected by adverse weather conditions, including rain and wind, are also to be excluded from the computation of the noise parameters.

Monitoring should normally be conducted at a time when the maximum impact is likely. Pre-construction ambient noise monitoring data (supplied by the RTA) may be used as an indicator of when the maximum impact for a particular activity is most likely to occur.

When short-term operator attended construction/maintenance noise monitoring is undertaken, short-term ambient background noise monitoring must also be conducted as part of the same monitoring regime.

Long term unattended construction/maintenance noise monitoring results may be compared to background noise levels identified through the environmental impact assessment.

For blasting airblast overpressure assessment, ambient background noise monitoring is not required.

Noise monitoring locations

Monitoring of site noise emissions must be conducted at the locations nominated in Schedule A, Item 4.

Frequency of noise monitoring and reporting

Noise monitoring and reporting during the works must be conducted at the frequency nominated in Schedule A, Item 5.

Reporting

The report must include the following, as a minimum:

- A brief description of the project and the objectives of the report
- Documentation of the noise monitoring locations
- For construction/maintenance noise assessments only, a description of the ambient noise environment and the lowest tenth percentile $L_{A90(15min)}$ background noise level(s) calculated during pre-construction ambient noise surveys (supplied by the RTA)
- A brief description of the works adjacent to each noise monitoring location and the normal hours of works
- Documentation of the noise assessment criteria
- A description of the work site activities during the course of noise monitoring at each location
- Documentation of typical noise emissions from the work site, including the sources of noise emissions, where these are identifiable
- Noise parameters, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , charted for each 24-hour period of the construction/maintenance noise monitoring survey, if long term unattended monitoring has been specified
- The results of operator-attended noise monitoring during construction/maintenance works, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} noise levels
- The results of operator-attended short-term ambient background noise monitoring conducted at the time of construction/maintenance activities, including L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} noise levels
- The results of operator-attended noise monitoring during blasting activities, using the linear (peak) noise descriptor
- An assessment of the noise impacts, and
- Noise management options. These may include alternative equipment or work methods, engineering noise controls such as enclosures and noise screens, and management methods such as the re-scheduling of works during low-impact times, the use of additional plant to reduce the duration of exposure, etc.

Schedule A

Item 1: Reporting

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing of outputs

e.g. final report within 1 weeks of noise measurements

e.g. draft report within 3 weeks of commissioning followed by the final report 1 week after the receipt of RTA comments on the draft

Item 3: Noise monitoring regime

Activities to be monitored:

- e.g. excavation, compacting, blasting, etc.

Noise monitoring periods:

- e.g. operator-attended on one occasion only
- e.g. operator-attended on one occasion on 2 consecutive days
- e.g. operator-attended on one occasion plus 1 day of valid data unattended
- e.g. operator-attended on one occasion plus 2 days of valid data unattended

Item 4: Noise monitoring locations

e.g. potentially most affected or representative locations to be selected by the consultant

e.g. 2 locations to be selected by the consultant

e.g. 31 James Street, 41 Norton Street, etc.

Item 5: Frequency of noise monitoring and reporting

e.g. once only for specified activities

e.g. once only for specified activities on date(s) to be advised

e.g. once per two weeks for specified activities

e.g. once per month for specified activities

e.g. once per two months for specified activities

e.g. other.

Model consultant brief for vibration monitoring and impact assessments

Scope

This brief applies to vibration measurement and reporting to assess whether there is significant risk of vibration damage or annoyance caused by roadway operations or road construction or maintenance activities.

Objectives

- To create a record for future reference should vibration characteristics subsequently increase or decrease.
- To quantitatively assess a possible or perceived risk of vibration-induced annoyance or damage.
- To determine whether vibration levels are within accepted guideline values concerning vibration-induced annoyance or damage.

RTA inputs

The RTA will provide the following materials, information and resources available to the consultant:

- Hard copies of the road design showing vibration-sensitive receiver locations, where available, and
- Any previous vibration monitoring results.

Minimum outputs

The number of copies of the report to be provided is shown in Schedule A, Item 1.

Timing

Reports must be submitted within the timing shown in Item 2 of Schedule A, or at such other time(s) as mutually agreed with the RTA client.

Extensions of time will normally be granted only in the event of interference with monitoring equipment, inclement weather or a change in the scope of work.

General specification

The consultant must at all times act in a courteous and considerate manner towards the general public and the owners/occupiers of any property on which the consultant has cause to work.

The consultant must obtain permission from the owners/occupiers prior to installing instrumentation on any property.

The consultant must ensure that no damage is caused to any property during the course of the vibration monitoring. Particular attention must be paid to the method of attaching transducers.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

The assessment of vibration levels must be carried out in accordance with the project's *EIS/REF, EMP* and any conditions of approval.

Instrumentation

The instrumentation for vibration monitoring must be capable of measuring vibration velocities in three orthogonal axis, with a linear range of at least 2 Hz to 200 Hz.

The instrumentation must measure the Peak Particle Velocity (PPV) in all three axis and print or store the values on a continuous basis, using sampling periods as specified in Item 3 of Schedule A.

The instrumentation must carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

For the investigation of activities with a potential to generate PPV events at frequencies which will have an influence on vibration goals, the instrumentation must be capable of giving an indication of the frequency content of each PPV event.

Monitoring sites and locations

Vibration monitoring must be carried out at the site(s) listed in Item 4 of Schedule A.

Unless otherwise indicated, one vibration monitoring location is required at each site. The location(s) at each site are as described in Item 5 of Schedule A.

When assessing the potential for structural damage, the triaxial vibration transducer must be coupled to the ground to faithfully measure vibration in the frequency range 2 Hz to 200 Hz.

When assessing the potential for annoyance, the triaxial vibration transducer must be attached rigidly to the floor (or other rigid structure close to the ground) in the room of the building where the potentially excessive vibration is occurring.

Monitoring periods

Monitoring of vibration attributable to road traffic must be carried out under normal traffic conditions.

Weekends and holidays are to be avoided, except in the context of long-term monitoring or as necessary if the vibration activity is expected to impact on weekends and/or holidays.

Monitoring of vibration attributable to construction activities must be carried out at times and locations of likely maximum construction impact (e.g. when construction activity is closest to nearest residential locations).

Monitoring of blasting must be carried out at the most sensitive receiver locations.

The required period of monitoring is shown in Item 6 of Schedule A, and in any event must be long enough to characterise the vibration impact. If necessary, repeated measurements must be taken to characterise the variations that may be anticipated in measured vibration levels.

Data analysis and professional opinion

The data obtained from the monitoring must be analysed to check compliance with the relevant continuous vibration criteria.

The consultant must review the data to check for any anomalies and present the data in graphical form, one day to a page.

If required in Item 7 of Schedule A, the consultant must provide a professional opinion regarding the risk of vibration damage and/or annoyance at the measured vibration levels.

Reporting

The report shall include:

- A brief description of the project and the objectives of the report
- The name of the consultant
- The name of the RTA client
- The address of the property on which the measurements were made
- A site plan indicating the measurement location(s) and nearby roads
- For road traffic vibration, details of the traffic flow, percentage of heavy vehicles, average traffic speed, road structure characteristics and road surface condition
- For construction activity vibration, complete details of the type of plant, models and any other identifying information, and the distances of the construction sources from the vibration transducer
- For blasting ground vibration, the charge size(s) and distance(s) of the blast source(s)
- The date(s) and times of the measurements
- A description of the road traffic, if applicable
- A description of any other known vibration sources that could influence the measurements
- Details of any anomalies noted in the data
- A site description, including any known geotechnical and/or structural features and including water table heights, if known
- Photographs showing the measurement instrumentation and the locations of relevant features
- A description of the instrumentation, including attachment methods and the orientation of axis
- A description of analysis
- A tabulated summary of vibration levels
- Indicative plot(s) of PPV vibration level against time, in total and/or for each axis
- Plot(s) of typical measured vibration level vs frequency also showing criteria
- A statement indicating compliance or otherwise with relevant criteria, and
- If required, the consultant's professional opinion on the risk of vibration-induced damage and/or annoyance.

Schedule A

Item 1: Reporting

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing

e.g. draft report 4 weeks after engagement, final report 1 week after the receipt of comments on the draft (*default*)

e.g. no draft required, final report 4 weeks after engagement

Item 3: Sampling periods

e.g. maximum instantaneous (default for blasting activities)

e.g. continuous monitoring using representative sample periods (default for non-blasting activities)

Item 4: Site(s)

e.g. 131 Smith Street, Uptown

e.g. Pacific Highway, Downtown, between Smith Street and Jones Street

Item 5: Location(s)

e.g. most suitable location to be determine by the consultant (*default*)

e.g. northeast corner of residence

Item 6: Monitoring periods

e.g. attended representative spot monitoring (default for blasting and non-blasting activities)

e.g. 24 hours monitoring, mid-week (default for monitoring of ambient conditions for environmental impact assessment)

e.g. other

Item 7: Data analysis and professional opinion

e.g. profession opinion not required

e.g. professional opinion required.

Model consultant brief for post-construction road traffic noise monitoring

Scope

This brief applies to post-construction road traffic noise monitoring and reporting for nominated locations for the NAP and new roads/road upgrades.

Objectives

- To determine whether post-construction noise levels are consistent with the appropriate design limits at the nominated location(s).
- To identify whether additional noise mitigation treatment should be evaluated, and the degree of mitigation required.

RTA inputs

The RTA will make the following materials, information and resources available to the consultant:

- Previous noise monitoring results and assessments, where available
- Aerial photographs, where available
- Specific noise-sensitive receiver locations to be assessed
- Predicted traffic growth rates.

Minimum outputs

- The number of copies of the report to be provided is shown in Schedule A, Item 1.
- Electronic copies, in IBM PC format, of all noise monitoring data.

Timing

The timing of output shall be in accordance with Schedule A, Item 2.

A variation may be requested if there is interference with monitoring equipment, inclement weather or a change in the scope of work.

General specification

Measurements must be carried out in accordance with AS 2702 *Acoustic Methods of Measurement of Road Traffic Noise* and this *Brief*.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

Consultant staff carrying out noise measurements must be courteous and tactful in dealing with members of the public. Staff may enter properties only after consultation with the Project Manager and with the permission of the occupier.

Instrumentation

All instrumentation utilised must comply with the requirements of AS 1259.2 *Sound Level Meters* and carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

Continuous noise monitoring is to be undertaken using noise-logging instrumentation that samples continuously over each 24-hour period. The instrumentation must be set up to record the relevant environmental noise parameters in 15-minute time intervals.

The minimum noise parameters recorded should include L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period.

Monitoring periods, traffic conditions extraneous noise and noise data analysis

The duration of noise monitoring must be in accordance with Schedule A, Item 3.

Noise monitoring may not be undertaken during periods of atypical traffic flows, including school holidays.

Noise monitoring may not be undertaken during periods of extraneous noise (for example, nearby construction activity).

Events identified as extraneous, including insect noise, lawn mowers and wall-mounted air-conditioners, are to be excluded from the computation of the noise parameters.

All data considered to be affected by adverse weather conditions, including rain and wind, are also to be excluded from the computation of the noise parameters.

If it is not possible to exclude noise from sources other than road traffic, these sources must be documented and their contribution to the measured noise levels estimated. In these circumstances, noise level reporting should also include noise levels adjusted by subtracting any extraneous contributions.

As a minimum, the noise parameters in Schedule A, Item 4 are to be computed from the monitoring data.

The monitored traffic volumes and predicted traffic growth rates are to be utilised as a basis for comparison with the project's planning and environmental approval conditions for future design year(s), if applicable. *Practice Note VIII* of the RTA's *Environmental Noise Management Manual* outlines protocols for post-construction noise monitoring for new and upgraded roads. *Section 8* includes a post-treatment monitoring protocol for works completed under the Noise Abatement Program (NAP) for existing roads.

Noise monitoring locations

Noise monitoring should be conducted at all locations nominated in Schedule A, Item 5.

Noise monitoring should be conducted 1 m from the building façade that is most exposed to traffic noise and at a height 1.5 m above the floor level. If monitoring is in the free-field (for example, before a dwelling is built), a 2.5 dB(A) façade reflection correction should be added to the measured L_{Aeq} noise levels.

Similarly, if there is risk of interference from extraneous noise sources located near the subject building, noise measurements may be conducted in the free-field and a 2.5 dB(A) façade correction added to the measured L_{Aeq} noise levels.

In the case of multi-level residential buildings, noise monitoring should be at the two floors of the building most exposed to traffic noise (generally the ground and first floors).

Road traffic volume monitoring

Simultaneous classified traffic counts must be carried out for the duration of noise monitoring as specified in Schedule A, Item 6. [*Delete if brief applies to NAP projects.*]

Reporting

The report must include the following, as a minimum:

- A brief description of the prevailing ambient noise environment
- Documentation of the location of the noise monitors, including an indication of the distance to the nearest road, if a road is located close to the noise monitors
- A site plan showing the locations of the noise monitoring
- Using 15-minute intervals, charts of noise parameters, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , for each 24-hour period of the monitoring survey
- A table summarising monitored average weekday and average weekly traffic volumes, including the number of heavy vehicles
- For new and upgraded roads, a table summarising the relevant noise parameters computed at the monitoring location(s) and comparing them with the design noise objectives, the target noise levels and, in cases where pre-construction noise levels already exceeded the target levels, the pre-construction noise level plus allowances as provided for by the *Environmental Criteria for Road Traffic Noise*
- For new and upgraded roads, an assessment of whether the noise levels are within the project's design goals and applicable noise criteria, and
- For treatments provided under the NAP, a table summarising the relevant noise parameters computed at the monitoring location(s) and comparing them with the design noise levels, followed by an assessment of whether monitored noise levels are within design goals.

All noise and traffic monitoring data should be included as appendices.

Schedule A

Item 1: Required number of reports

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing of outputs

e.g. final report within 6 weeks of commissioning

e.g. draft report within 6 weeks of commissioning, followed by the final report 2 weeks after the receipt of RTA comments

Item 3: Duration of noise monitoring

e.g. 7 days of valid data (default)

Item 4: Computed noise parameters

e.g. $L_{Aeq}(1hour)$: the highest level for any hour between 7:00 am and 10:00 pm or if relevant between 10:00 pm and 7:00 am

e.g. $L_{Aeq}(15hour)$: for the 15-hour day period from 7:00 am to 10:00 pm

e.g. $L_{Aeq}(9hour)$: for the nine-hour night period from 10:00 pm to 7:00 am

e.g. $L_{Aeq}(24hour)$ averaged over 24 hours

e.g. in accordance with the noise parameters used in the EIA

Item 5: Noise monitoring locations

e.g. potentially most affected and representative locations to be selected by the consultant

e.g. 5 locations to be selected by the consultant

e.g. 31 James Street, 41 Norton Street, etc.

Item 6: Requirements for traffic counts *[Delete if brief applies to NAP projects.]*

e.g. full classification counts immediately adjacent to 13 James Street, approximately 50 m from the intersection, for the duration of the noise survey

e.g. at an appropriate location determined by the consultant, for the duration of the noise survey

e.g. to be provided by the RTA

Model consultant brief for assessing road traffic noise from existing roads

Scope

This brief applies to the preparation of a noise assessment report associated with the RTA's *Noise Abatement Program* (NAP) for existing roads. It should be read in conjunction with *Section 8* of the *RTA Environmental Noise Management Manual*.

Objective

To measure, model and assess road traffic noise impacts and recommend appropriate mitigation/attenuation measures.

RTA inputs

The RTA will make the following materials, information and resources available to the consultant:

- Previous noise monitoring results, where available.
- Aerial photographs, where available.
- Road design data as PC readable (IBM format) files in AutoCAD DXF format, MOSS GENIO format or as delimited (or fixed width) ASCII files of x , y and z coordinates suitable for direct input into a spreadsheet.
- Traffic volumes (AADT) and percentages of cars, medium trucks and heavy trucks for the specified year(s). Hourly data will be provided where available.

Minimum outputs

- The number of copies of the report to be provided is shown in Schedule A, Item 1.
- Electronic copies, in IBM PC format, of all noise monitoring data.

Timing

Timing of output shall be in accordance with Schedule A, Item 2.

A variation may be requested if there is interference with monitoring equipment, inclement weather or a change in the scope of work.

General specification

Measurements must be carried out in accordance with AS 2702 *Acoustic Methods of Measurement of Road Traffic Noise* and this *Brief*.

The consultant must have an AS/NZS/ISO 9001 Quality System in place and must carry out all work in accordance with this system.

Consultant staff carrying out noise measurements must be courteous and tactful in dealing with members of the public. Staff may enter properties only after consultation with the Project Manager and with the permission of the occupier.

Instrumentation

All instrumentation utilised must comply with the requirements of AS 1259.2 *Sound Level Meters* and carry current NATA or manufacturer calibration certificates, with certification at intervals not exceeding two years.

Continuous noise monitoring is to be undertaken using noise-logging instrumentation which samples continuously over each 24-hour period. The instrumentation must be set up to record the relevant environmental noise parameters in 15-minute time intervals.

The minimum noise parameters recorded should include L_{Amax} , L_{A10} , L_{A90} and L_{Aeq} for each 15-minute time period.

Monitoring periods, extraneous noise, traffic conditions and noise data analysis

The duration of noise monitoring must be in accordance with Schedule A, Item 3.

Noise monitoring may not be undertaken during periods of atypical traffic flows, including school holidays.

Noise monitoring may not be undertaken during periods of extraneous noise (for example, nearby construction activity).

Events identified as extraneous are to be excluded from the computation of the noise parameters.

All data considered to be affected by adverse weather conditions, including rain and wind, are also to be excluded from the computation of the noise parameters.

If it is not possible to exclude noise from sources other than road traffic, these sources must be documented and their contribution to the measured noise levels estimated. In these circumstances, noise level reporting should also include noise levels adjusted by subtracting any extraneous contributions.

As a minimum, the noise parameters in Schedule A, Item 4 shall be computed from the monitored data.

Road traffic noise monitoring locations

Identify the catchment area and all possible noise sensitive locations with the catchment area. Site plans indicating the location of monitoring points need to be included with monitoring points identified in accordance with the data requirements of the NAP database.

Road traffic noise monitoring should be conducted at all locations nominated in Schedule A, Item 5.

Noise monitoring should be conducted 1 m from the building façade that is most exposed to traffic noise and at a height 1.5 m above the floor level. If monitoring is in the free-field (for example, before a dwelling is built), a 2.5 dB(A) façade reflection correction should be added to the measured L_{Aeq} noise levels.

Similarly, if there is risk of interference from extraneous noise sources located near the subject building, noise measurements may be conducted in the free-field and a 2.5 dB(A) façade correction added to the measured L_{Aeq} noise levels.

In the case of multi-level residential buildings, noise monitoring should be at the two floors of the building most exposed to traffic noise (generally the ground and first floors).

Noise modelling algorithms

The noise model selected to calculate the road traffic noise levels is to be justified according to the circumstances of the particular project, both prior to commencement of works and in the noise assessment report.

Noise model selection should take into account low traffic volumes/speeds and variations to the acoustic centre of the traffic stream attributable to varying traffic mixes. The consideration given to this should be documented in the consultant's report, particularly when the predictions involve significant heavy vehicle percentages or terrain features, road cuttings or noise barriers which screen the traffic stream from the noise-sensitive properties.

Where the heavy vehicle component of the traffic flow is 10% or greater during the day or the night, the model selected should be capable of segregating source height and noise components for the exhaust and engine and/or tyres of heavy vehicles or, alternatively, should adopt a "split-height" of energy for vehicles of different classifications.

Consideration may also be given to models that can directly predict or be adapted to predict maximum noise levels from an individual source.

Documentation supporting the conversion of the output from the selected programs to the $L_{Aeq(15\text{hour})}$ and $L_{Aeq(9\text{hour})}$ parameters must be provided.

Modelling considerations

The consultant must consider at least the following parameters when conducting the calculations or computer modelling:

- Percentage of cars on the roadway(s)
- Percentage of trucks on the roadway(s)
- Posted speed limit(s)
- Pavement surface
- Gradient of roadway
- Topographic features
- Receiver/source distances and heights
- Intervening ground cover
- Roadside or topographic barriers
- Reflections from buildings or roadside barriers, including multiple reflections
- Contributed noise from other traffic sources likely to influence the overall noise environment, and

- Façade reflections.

Verification of the noise model

The objective of verification is to demonstrate that the particular computer noise model being employed for the study is capable of generating correct outputs.

The nature of the verification process will depend on the circumstances of the particular project and site (flat or hilly terrain, presence of noise barriers, etc).

The consultant must identify the key issues relating to verification for the specific project and implement the required verification process with approval of the RTA project manager.

Reporting

The report must include the following, as a minimum:

- A brief description of the project and the objectives of the project
- A brief description of the prevailing ambient noise environment
- Documentation of the location of the noise monitors, including an indication of the distance to the nearest road, if a road is located close to the noise monitors
- A site plan showing the locations of the noise monitoring
- Aerial photographs of a scale of 1:1000 (provided by the RTA, if available) showing the locations of the noise monitoring
- Site photographs identifying the noise logger and position
- Using 15-minute intervals, charts of noise parameters, including the L_{Amax} , L_{A10} , L_{Aeq} and L_{A90} , for each 24-hour period of the monitoring survey
- A table summarising the noise parameters detailed in Schedule A, Item 3 at each location
- Tabulations of Average Annual Daily Traffic (AADT) results and predictions for the day and night periods.
 - If hourly traffic data are available, the report should include tabulations of the number of cars (including light trucks with four tyres), medium trucks (2 axles, 6 tyres) and heavy trucks (3 axles) for each measurement hour.
 - If classified traffic counts were conducted as part of the noise model verification, the report should include a summary of the traffic volumes and percentages.
- Summaries of the computational algorithms used and justification for their selection, the location of noise-sensitive dwellings and how the issues identified under 'Modelling Considerations' were addressed
- The calculated $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ levels for each identified noise-sensitive dwelling/location, in tabular format
- The noise environment predicted at the times listed in Schedule A, Item 4 at each location
- Well-presented noise contour maps for the predicted noise environment (with and without noise mitigation measures being considered), identifying all noise-sensitive locations in the study area. (These contour maps should generally be presented for intervals of 5 dB(A), and the contour values should be clearly identified. The contours should extend to a noise level at least 5 dB(A) — and preferably 10 dB(A) — below the noise goal.)

- A range of options for reducing noise impacts towards the goals for existing roads described in the *Environmental Criteria for Road Traffic Noise*, based on an assessment of cost-effectiveness, practicality, any community preferences, aesthetics, other urban and regional design issues and equity.

All monitoring data should be included as an appendix.

Schedule A

Item 1: Required number of reports

e.g. 3 copies of final report

e.g. 1 copy of draft and 3 copies of final report

Item 2: Timing of outputs

e.g. final report within 6 weeks of commissioning

e.g. draft report within 6 weeks of commissioning, followed by the final report 2 weeks after the receipt of RTA comments

Item 3: Duration of noise monitoring

e.g. 7 days of valid data (default)

Item 4: Computed noise parameters

e.g. $L_{Aeq(1hour)}$: the highest level for any hour between 7:00 am and 10:00 pm or if relevant between 10:00 pm and 7:00 am

e.g. $L_{Aeq(15hour)}$: for the 15-hour day period from 7:00 am to 10:00 pm

e.g. $L_{Aeq(9hour)}$: for the nine-hour night period from 10:00 pm to 7:00 am

e.g. $L_{Aeq(24hour)}$ averaged over 24 hours

Item 5: Ambient noise monitoring locations

e.g. potentially most affected and representative locations to be selected by the consultant

e.g. 5 locations to be selected by the consultant

e.g. 31 James Street, 41 Norton Street, etc.

Item 6: Environment predicted

e.g. existing environment [*insert year*] (default)



Roads and Traffic Authority

New South Wales, Australia

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