Transportation and noise: land use planning options for a quieter New Zealand

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Contents

Executive summary

Noise arising from land transport is an increasing problem. This research, carried out in Christchurch in 2004 and 2005, examines the effects of noise and options for reducing those effects.

New Zealand's small population coupled with a relatively large land mass has resulted in a reliance on motor vehicles, with vehicle numbers and vehicle use on the increase. The decline in passenger rail has also added to increases in road transportation. Rail noise is less of a concern in New Zealand but will need to be considered during possible future rail expansion.

New Zealand's transport noise trends are consistent with international trends.

Purpose of this report

Various options are available to address the problems associated with transport noise. These include technical options that focus on vehicle, rail and infrastructure design, legal parameters for noise limits, and land use planning. This report focuses on land use planning options.

In the past, action to reduce environmental noise has had a lower priority than many other environmental issues, such as air, biodiversity and water. Noise has previously been regarded as an acceptable result of development. As the impacts of noise are better understood, transport noise has become a key environmental and social issue.

This report uses international and national experiences to assess potential land use planning options for reducing transport noise in New Zealand. The report is primarily written for local authorities and road controlling authorities as an aid in the implementation of sustainable transport development as it relates to transport noise. However, it is likely to be of interest to some Government departments and other people involved in transport and land use planning in New Zealand.

What are the effects of noise?

Transportation noise can cause a range of impacts on people and communities from general interference with everyday activities through to more significant health issues. Rail noise is considered to be less annoying than road noise of the same level. Excessive noise creates stress-type responses, and sleep disturbance is a common complaint from people affected.

When developing solutions to noise the receiving environment and the types of activities that are occurring need to be considered. Activities that are regarded as sensitive to noise include education centres, hospitals, healthcare facilities, elderly care facilities, residential activities and traveller accommodation. These are the key targets of noise management objectives.

Noise above 65 dBA[1] is highly undesirable. More specifically, the World Health Organisation (WHO) recommends maximum noise levels of ≤ 30 dBA in sleeping areas. For outdoor living areas, in residential areas, exposure levels should not exceed 50 – 55 dBA. Some local planning authorities include design levels and performance standards in local plans but considerable variation exists.

International approaches

International strategies for addressing transport noise have a long history. Each has evolved as a result of the increased understanding of the effects of noise on health.

The World Business Council for Sustainable Development (WBCSD), the Organisation for Economic Co-operation and Development (OECD) and the United Nations Economic Commission for Europe (UNECE) have each developed consistent solutions to transportation issues, including noise, in a bid to achieve more sustainable outcomes for transport.

In each of the countries researched, noise is addressed at a strategic level. Although land use planning tools for dealing with noise vary considerably, abatement technologies are relatively consistent. A general consensus also exists on what constitutes acceptable noise levels, mirrored by the WHO guidance. Most countries that have implemented noise abatement plans are currently in the process of re-evaluation to improve them.

The Netherlands has one of the most sophisticated approaches to noise. Transport planning is central to environmental policy making in the Netherlands and the integration of noise abatement measures and land use planning is a key element of this. The Netherlands first addressed noise abatement in the 1970s and central government policies and legislative instruments encompassing noise have evolved over the past 25 years.

A number of lessons arise from the Dutch experience. The most fundamental is the centralisation of noise strategies. This has proved effective for setting and applying common goals at regional and local levels. The Netherlands demonstrates that land use planning and urban design can provide effective solutions to transport impacts. The integration of transport and planning policies has proven necessary to provide consistency and address issues effectively.

Mixed development and a concentration of commercial areas around transport nodes have been central to Dutch policies. Policy aims have been achieved in some cities through urban planning, controlling vehicle use and providing suitable alternatives. However, the approach is not without problems. Cities continue to be inherently noisy, making them less attractive to residents, with wealthier citizens continuing to move to rural areas.

[1] dBA is an abbreviation for the A frequency weighted decibel as per IC651, a scale of sound measurement which emulates the human auditory response.

In contrast, Australia's federal government has approached transportation issues by delegating responsibility to State authorities. Australia's transport noise strategy has been divided into two categories, road design and management, and vehicle design, specification and emissions testing. In recent years, efforts have focused on centralising vehicle emission controls to achieve greater consistency. Efforts to centralise land use planning are less advanced.

In the absence of an integrated transport policy as a means of addressing noise issues, Australia has placed emphasis on building codes and design. They encourage early design to avoid noise. Home owners and developers are responsible for implementing acoustic protection in new building and renovations. The Building Code of Australia establishes a baseline for noise levels. Orientation and layout of homes are considered important to avoid noise and renovation is considered an opportunity to introduce acoustic insulation.

In the United States a change in policy direction has been from controlling noise through mitigation at each stage of a development, to encouraging an integrated approach to transport and land use planning. This is more consistent with the direction taken in the Netherlands.

Land use planning

Land use planning has been identified as a key tool for addressing land transport noise. Approaches range from dealing with localised problems to the wider application of planning tools across entire urban areas. In New Zealand, land use planning is primarily implemented through the Resource Management Act 1991. The land use planning options are applicable to both road and rail noise.

Land use planning may occur at national, district or local level. Good land use planning allows for participation by land users, planners and decision-makers. It is a precautionary approach and is most effective when applied at the initial planning and development stage. Good land use planning requires foresight so that methods can be implemented to achieve long-term, strategic goals.

Local approaches to land use planning include implementing noise barriers to reduce the transmission of noise from vehicles to sensitive receivers. They may also include building design and orientation away from the noise source.

At a regional level land use planning can be applied to district planning documents. A common approach is to make land use, growth and transport projections for an area and develop land use plans that assist noise avoidance. This might include, for example, placing restrictions on sensitive developments along road corridors or requiring setbacks from roads.

National level land use planning tools can be applied using national standards for noise, building control standards or urban design strategies. The aim of these documents is to develop policies and tools for preventing noise in sensitive areas. Both regional and national approaches represent long-term approaches to addressing noise.

The research concludes that the key consideration in applying land use tools is predicting current and future noise levels, potential transport growth and development trends. New Zealand's legal framework provides an opportune format for implementing noise management including national environmental standards, local authority plans and building standards. The key to achieving effective outcomes is co-operation and consistency under a framework of national-level guidance.

Recommendations

- Implement a National Environmental Standard (NES).
- Integrate land transport noise controls at a national level.
- Use the WHO maximum noise standards as a start-point for New Zealand policy.
- Establish the preferred noise criteria.
- Develop effective land use planning objectives, policies and rules in plans.
- Undertake noise measuring and monitoring.

Abstract

This research carried out in Christchurch in 2004 and 2005 looks at the problem of land transport noise in New Zealand and examines the effects of noise, and the options for its reduction.

Lessons from international examples show that land use planning methods can be applied to New Zealand to ensure sustainable transport and development outcomes. Land use planning is most effective as a preventive tool while technical options may be more effective for existing noise problems.

A key lesson from international case studies is the need for integration of policies within different government departments to achieve sustainable outcomes. An approach that integrates traditional land use planning measures with transport planning has proved effective in many European countries and is being used by state planning authorities in Australia and the United States.

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1. Introduction to transportation noise

Noise from transportation is an increasing problem. New Zealand's small population coupled with a relatively large land mass has resulted in a reliance on motor vehicles, with vehicle numbers and vehicle use on the increase. The decline in shipping and passenger rail has also added to the increase in road transportation.

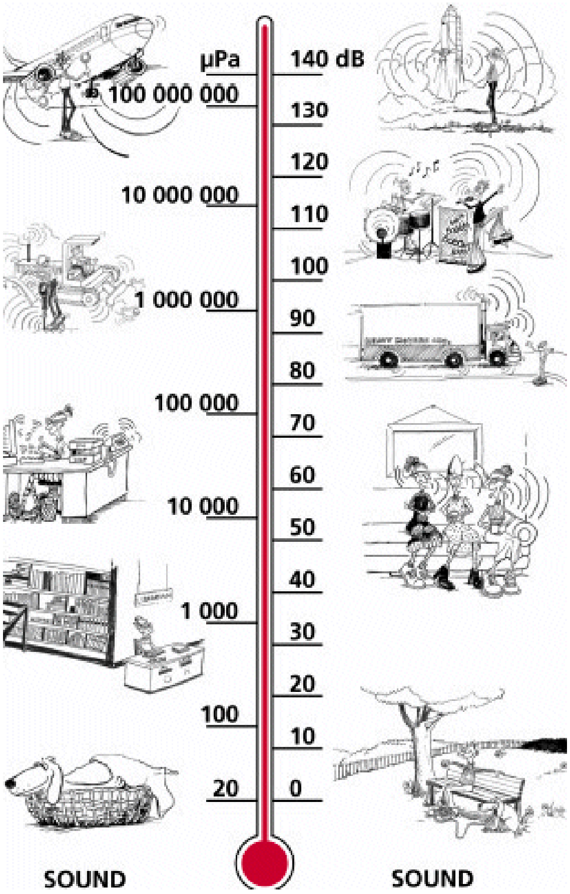
Transportation noise can cause a range of impacts on people and communities from general interference with everyday activities through to more significant health impacts. Action to reduce environmental noise has had a lower priority than many other environmental issues, such as air, biodiversity and water, as noise has previously been regarded as an acceptable result of development (EC 1996). As the impacts of noise have been better understood transportation noise has become a key environmental and social issue.

1.1 What is noise?

Noise is simply unwelcome sound. Sound is made up of pressure variations detected by the ear which have been transmitted in longitudinal waves. The number of pressure variations per second, or cycles per second, is called the frequency of the sound and is measured in Hertz (Hz). The frequency of sound or the Hz rating, determines the tone of the sound. The audible frequency range of the human ear is between 20,000 Hz, a high pitched tone, and 20 Hz, a very low bass tone. The human ear is most sensitive to sounds between 2000 and 5000 Hz (WHO 1995).

The loudness or intensity of sound is measured in Pascals (Pa). Because the Pascal scale is so large it is more useful to express the loudness of sound on a logarithmic scale as decibels (dB) (WHO 1999a). Sounds which are audible to people range from the threshold of hearing at 0 dB to the threshold of pain at levels over 130 dB (Brüel & Kjær 1984).

Exposure to sound is expressed as a weighted measurement dBA, which provides an indication of the loudness and duration of exposure. As a measure it has limitations, including underestimating the impact of the low-frequency components of noise and assessing sounds exceeding 60 dB, but is widely cited as acceptable in practice (WHO 1995).



Threshold of pain, 130 dB

Aircraft takeoff at 300mm, 120dB

Very busy street, 90 dB

Vacuum cleaner, 80 dB

Street, 70 dB

Conversation, 60 dB

Library, 40 dB

Bedroom, 30dB

Hearing threshold, 0 dB

(Illustration from: Brüel & Kjær 2000 p.8; data: WHO 1999a)

Figure 1.1 Sound scale.

1.2 What are the characteristics of transport noise?

Sound from transport radiates from its source in waves. As sound contacts with surfaces and objects it is refracted, reflected or absorbed in much the same way as light (Alington 1987). Where it does not come into contact with an object, the level of sound is approximately halved for every doubling of distance from the source (Caltrans 1998a, WHO 1999a). These characteristics determine the levels and effects of noise arising from transport.

1.3 How is transportation noise measured?

Transportation noise is measured in terms of exposure. Exposure to transportation noise is often expressed as the average reading over a given period, for example 24 hours. This is known as the equivalent continuous sound pressure level (L_{eq}) and is an acceptable scale for the measurement of long-term noise exposure (EC 1996, WHO 1999a, Malcolm Hunt Associates 2004, AUSTROADS 2005).

The average equivalent continuous sound pressure level over 24 hours would be expressed as $L_{eq\ 24hr}$. L_{eq} has been adopted by the International Organisation for

Standardisation (ISO) for the measurement of both environmental noise exposure and hearing damage risk (EC 1996, WHO 1999a, Rylander & Björkman 2002). Different countries use different measures, such as L_{dn}, L_{10} and L_{den}.

1.4 The impacts of noise on human health

The impacts of noise on human health have been widely researched, see:

- *Impacts of Transport on Health – An Overview* – A summary prepared by the Public Health Advisory Committee, April 2003 (http://www.nhc.govt.nz/PHAC/publications/SummaryofTransport&HealthPapers.pdf)
- *The health effects of environmental noise – other than hearing loss* – a summary prepared by The enHealth Council, a subcommittee of the Australian National Public Health Partnership, May 2004
- *The influence of night-time noise on sleep and health*, Health Council of the Netherlands, 2004
- *Health aspects of extra-aural noise research.* Wolfgang Babish. Noise and Health Journal 2004
- *Updated review of the relationship between transportation noise and cardiovascular risk.* Wolfgang Babisch, 2005. Proceedings of 12th ICSV, Lisbon

Noise affects people in different ways and creates various reactions depending on the level of noise and the activities individuals are engaged in.

Most commonly, noise creates stress-type responses. No significant impacts on health are thought to occur at noise levels under 40 dBA during the day or 20 dBA at night. The effects rise in tandem with the level of noise and length of exposure. It is widely accepted that noise above 65 dBA is highly undesirable.

Sleep disturbance is a common complaint from people affected by noise. Sleep deprivation can have cumulative effects caused by impairment of the rest and recovery functions of sleep. WHO maintain that this can impact on daytime functioning and lead to mood effects (WHO 1999a, Passchier-Vermeer & Passchier 2000).

Noise exposure has been shown to have temporary and permanent impacts on psychological and physiological functions (WHO 1995, 1999a). Acute noise exposure activates the nervous and hormonal systems leading to increased blood pressure, increased heart rate and the narrowing of blood vessels. After prolonged exposure, susceptible individuals may develop permanent effects such as hypertension and coronary heart disease. These responses are indicative of the scale of impacts that can arise from acute and persistent exposure. Cardiovascular effects tend to arise from long-term exposure to levels above 60-70 dBA (WHO 1999a).

1.5 Recommended noise levels

The WHO *Guidelines* (1999a) co-ordinated international research on the health impacts of noise and developed guidelines for protecting communities and individuals from non-industrial noise including road and rail transport. The WHO guidelines for noise are widely cited as a baseline for establishing acceptable or maximum noise levels. They are also used as a basis for establishing noise levels under the OECD *Environmentally Sustainable Transport Project* which was established in 1998 and updated in 2000 (OECD 2000).

The WHO guidelines provide direction with regard to the impacts of noise but standards for noise continue to be researched. The WHO European Centre for Environment and Health is developing guidelines for night-time noise in partnership with the European Commission Directorate General Health and Consumer Protection and numerous member states.

1.5.1 Night-time exposure

As discussed, the WHO guidelines define acceptable noise levels for various situations. Night-time disturbance from rail noise is considerably lower than road traffic noise (Kurze 1996, Moehler et al. 2000). However, no noticeable difference has been found in the *reaction* of individual exposed to road and rail noise while sleeping.

Night noise level limits are usually subject to a 10 dB penalty from accepted daytime levels, and often supplemented with a single event noise measure. The single event noise measure is a means of ensuring sleep protection, and is depicted as L_{max}, which defines short duration, high level sounds such as audible single passing vehicles[2].

WHO recommend maximum noise levels of ≤ 30 dBA L_{eq} in sleeping areas. For non-continuous noise an L_{max} level of 45 dBA is recommended (WHO 1999a). Externally this sets levels of approximately 50 dBA L_{eq} and 65 dBA L_{max} respectively (dependent on building construction). These levels assume that it should be possible to sleep with a window ajar. However, lower values may be necessary for more sensitive recipients.

Night-time levels are commonly described as occurring between 2200h and 0700h. This differentiation between day and night has been adopted in Europe with night-time commencing at 2300 hours. Australian authorities also consider differentiating between daytime and night-time levels useful, as it provides consistency with other nations (AUSTROADS 2004b). New Zealand guidelines on noise apply average design criteria of 24 hours and make no differentiation between day and night levels (Transit 1999, 2004).

1.5.2 Daytime exposure

The most common issue arising from exposure to noise during the day and evening is interruption to speech and concentration. With a raised voice sentences may be 100% intelligible for noise levels of up to 55 dBA and sentences spoken with straining vocal effort can be 100% intelligible with noise levels of about 65 dBA (WHO 1999a).

For outdoor living areas in residential areas exposure levels should not exceed 50 – 55 dBA L_{eq} (WHO 1999a).

2 For further information see Appendix 1 and WHO 1995, 1999a.

Table 1.1 WHO guideline values for noise in specific environments.

Specific environment	Critical health effect(s)	LAeq [dB]	Time base [hours]	LAmax, fast [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility and moderate annoyance, daytime and evening Sleep disturbance, night-time	35 30	16 8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoors	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/ earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservation areas	Disruption of tranquillity	#3		

#1: as low as possible;

#2: peak sound pressure (not LAmax, fast), measured 100 mm from the ear;

#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;

#4: under headphones, adapted to free-field values Source: WHO 1999a

1.5.3 Sensitive activities

When developing solutions to noise the receiving environments and the types of activities that are affected need to be considered. Sensitive activities can be described as activities that are sensitive to noise interference, for example teaching, which requires communication and interaction through speech.

Generally, sensitive daytime activities such as learning and patient care are disrupted at levels similar to those applicable at night-time. Where vulnerable groups are involved, such as the elderly and young children, even lower levels may be required (WHO 1999a).

Guidelines for noise in hospitals have been established to avoid communication intrusion and warning signal interference in addition to sleep disturbance in wards. The recommended levels are 30 dBA L_{eq} and 40 dBA L_{max} at night, and 35 dBA L_{eq} during the day.

1.5.3.1 Case law: Sensitive receivers

An Environment Court decision on the definition of sensitive activities was made in 2004[3]. Parties sought a definition of noise-sensitive activities in the Christchurch City Plan in relation to airport noise. The definition is consistent with international approaches and includes:

- residential activities,
- education activities including pre-school but excluding industry related training within the Special Purpose (Airport) zone,
- travellers' accommodation that has not been mitigated against aircraft noise,
- hospitals, healthcare facilities and elderly persons accommodation.

1.6 Transportation noise exposure in New Zealand

New Zealand transport trends are consistent with international trends of increasing vehicle numbers, vehicle movement and heavy vehicle freight. Urban centres are experiencing growth and a geographical spread of residential development into previously semi-rural and rural areas is occurring. With the growth in transportation comes increase in noise.

Rail noise is less of a concern in New Zealand as the rail network is not extensive and high speed trains are not used. Rail noise is considered to be less annoying that road noise (Kurze 1996, Moehler et al. 2000, Malcolm Hunt Associates 2004). People also become accustomed to railway noise exposure and annoyance appears to decrease over time (Brons et al. 2003). However, rail noise will need to be considered for possible future rail expansion.

[3] Board of Airlines Representatives of New Zealand Incorporated, Christchurch International Airport Limited, Commodore Airport Hotel Limited, Robinsons Bay Trust, National Investment Trust v Christchurch City Council. Dated 6 August 2004.

Very little data exist on the noise impacts from transportation in New Zealand. A number of local authorities report that noise monitoring occurs as part of wider state of the environment reporting, but no national monitoring or data collection is undertaken.

Noise has been identified as an issue in Auckland city (B. Waghorn pers.comm.). From a survey of 500 residents in medium to high density housing, 82% considered noise an issue and 32% considered that it had an impact on sleep. For the same number surveyed in stand-alone dwellings, 69% considered noise an issue, with 24% feeling that it had an impact on sleep. The main source of noise identified in the study was transportation (Lyne & Moore 2004).

1.7 Land use planning and noise

Land use planning has been identified as a tool for addressing land transport noise. Land use planning approaches range from dealing with localised problems to wider application of planning tools across entire urban areas. In New Zealand, land use planning is primarily implemented through the Resource Management Act 1991(RMA).

Land use planning may occur at national, district or local level. Good land use planning allows for participation by land users, planners and decision-makers, as provided for by the RMA.

Local approaches to land use planning include implementing noise barriers to reduce the transmission of noise from vehicles to sensitive receivers. They may also include building design and orientation away from the noise source.

At a regional level land use planning can be applied to district planning documents. A common approach is to make land use, growth and transport projections for an area and develop land use plans that assist noise avoidance. This might include, for example, placing restrictions on sensitive developments along road corridors or requiring setbacks from roads.

National level land use planning tools can be applied using national standards for noise, building control standards or urban design strategies. The aim of such documents would be to develop policies and tools for preventing noise in sensitive areas. Both regional and national approaches represent long-term approaches to addressing noise.

Each of these areas will be explored in greater detail throughout the following sections.

1.8 Limitations and delimitations

1.8.1 Rail noise

As noted, land transport noise arises from both road and rail corridors. This report will focus on options for addressing road noise. There are two reasons for this.

First, the research indicates that solutions for managing rail noise are often technical in nature, meaning that they are best served by management of the rolling stock and railway line design. Technical options are summarised in Chapter 2 of this report but are not the focus of this research.

Land use planning may be applied to address new rail tracks and reconstruction. The design and planning stage of new rail would provide an opportunity to implement appropriate land use planning options. Land use planning options for rail are generally consistent with road options, e.g. setbacks from buildings, acoustic insulation or noise barriers.

Second, road noise is the predominant issue in New Zealand. The existing rail network is long established and little benefit would be gained by implementing land use planning solutions to existing rail corridors. Changes to existing rail corridors would also result in excessive cost. Benefits may outweigh the costs for high volume rail routes, such as an expanded commuter network in Auckland, with frequent train movements.

This report includes some references to rail. Overall, the reader should be mindful that the principles of land use planning and anticipated outcomes are relatively consistent for all forms of land transport. However, it is recommended that rail noise issues be revisited for specific new rail projects.

1.8.2 Definition of noise

Under the RMA, the definition of noise includes vibration. For the purposes of this research noise is defined as ‘unwanted sound’, and does not include vibration. A number of generally accepted national and international standards exist that define both annoyance levels and thresholds when damage to buildings is likely. Vibration levels are dependent on many factors, including soil types and building design, and are often very location-specific. It would be difficult to implement a land use planning regime that accounted for this variability.

2. Technical options for decreasing transport noise

A number of technical options are available for decreasing transport noise. Technical options fall into three categories:

- dealing with noise at the source,
- controlling the transmission of noise,
- decreasing noise at the receiving end.

This chapter provides a brief overview of technical options for dealing with noise. Further and more detailed information on technical options can be found in the following references:

- Hendriks R. 1998. Guidelines for studying the effects of noise barriers on distant receivers. *Technical Advisory TAN-98-01-R9701* California Department of Transportation Environmental Program, Sacramento, California, USA. (Information on testing noise barrier noise efficacy on distant receivers.)
- Hubner, P. 2000. The action programme of UIC, CER and UIP ''Abatement of railway noise emissions on goods trains". *Journal of sound and vibration 231(3):* 511-517. (Discussion of various technical options for addressing rail carriage and track noise.)
- Hothersall, D.C., Salter, R.J. 1977. *Transport and the environment*. Granada Publishing Limited: St Albans, Hertfordshire, UK. (Overview of transport effects assessment; includes method for calculating efficacy of noise mitigation including acoustic insulation.)
- Kotzen, B., English, C. 1999. *Environmental noise barriers: A guide to their acoustic and visual design*. E & F.N. Spon: London. (Detailed overview of noise barrier technology, design and testing options.)
- Malcolm Hunt Associates. 2004. *Noise impacts of land transport – stage 3: Development of policies for the management of noise from land transport*. Malcolm Hunt Associates: Wellington, New Zealand. (Comprehensive overview of noise policy and abatement options for New Zealand.)
- Samuels, S., Ancich, E. 2002. Recent developments in the design and performance of road traffic noise barriers. *Noise & vibration worldwide 33(3):* 16-23(8). (Review of developments in the design and performance of noise barrier, undertaken for the road transport authority in New South Wales, Australia.)
- Sandberg, U. 2001b. *Noise emissions of road vehicles: Effect of regulations.*, *Final report of I-INCE working party on noise emissions of road vehicles (WP–NERV)*. International Institute of Noise Control Engineering. (Global view of the effect of the vehicle noise regulations on road traffic noise over the past 30 years; includes overview and critique of vehicle noise abatement measures.)

Table 2.1 illustrates approximate noise reductions arising from the implementation of sample noise abatement measures.

Table 2.1 Noise abatement measures and noise emission reductions.

Measure	Reduction (dBA)	Source
'Silent' tyres	4	*Nijland et al. 2003a*
	3-5	*Malcolm Hunt Associates 2004*
Low-noise road surface. Latest technology, including dual-layer pavements, may increase this potential reduction further.	6-8	*Nijland et al. 2003a*
	4-6	*van den Berg undated*
	4-7	*Malcolm Hunt Associates 2004*
	2-4	*FHWA 1995*
Noise barriers	5-15	*Kotzen & English 1999*
Acoustic insulation - Open window - Closed window (4 mm thick)	 5-15 20	 *Hothersall & Salter 1977* *Hothersall & Salter 1977*
Vehicle speed reduction for high speed roads	5-7	*WHO 1999a*
	5-6	*Malcolm Hunt Associates 2004*
Traffic volume reduction (50%)	3	*Malcolm Hunt Associates 2004*
Replacement of tread brakes with discs on trains	5-10	*Kurze 1996, Hubner 2000*
Rail track grinding	5-10	*Kurze 1996*
Sound absorptive rail track beds	5	*Kurze 1996*

2.1 At source options

Road transport noise consists of two key components: engine noise and tyre/road noise. Vehicle noise arises from various mechanisms including the cooling fan, vehicle transmission and exhaust system. Faulty or modified exhausts and vehicle-braking systems in heavy vehicles are also a common source of noise.

Noise can vary with the road and vehicle type. Larger vehicles and engines generally produce more noise. Road vehicles with exhausts placed higher up on the vehicle create more intense and broader noise levels.

Road/tyre interaction and air turbulence contribute to noise at higher speeds. The interaction of the tyre and road surface generally produces more noise than the engine at speeds exceeding about 50 km/h (WHO 1999a).

Rail noise is created in a similar manner to road transport. Rail wheels, track vibration and engine mechanisms are the key components. Rail noise is also influenced by auxiliary equipment such as brakes and ventilation systems. Train frequency, speed, train type and infrastructure (such as curves and turbulence) also determine noise emissions (Brons et al. 2003).

2.1.1 Noise emission controls on vehicles

Vehicle emission standards are common throughout the world. Vehicle manufacturers and government groups have both played a role in implementing acceptable limits on vehicles. Controls on noise emitted from vehicles reduce the need for control at other stages.

In New Zealand, vehicle noise is covered by the Traffic Regulations, 1976. The regulations place restrictions on 'excessively' noisy vehicles. They apply only to new vehicles which currently leaves the high numbers of imported second hand cars unregulated. They are compared with European levels in Table 2.2. International standards on noise have been in place since the introduction of Regulation 51 (UNECE 1996) and are consistent with the European limits outlined in Table 2.2. Vehicles must comply with all the relevant European Community directives in order to be placed on the market.

Australian Design Rules (ADRs) set out requirements for all vehicles types in Australia. The ADR levels were reviewed in 2003 by the National Transport Commission and were updated to reflect UNECE standards. The new rules will be phased in from January 2005 under ADR 83/00. One concession exists under the new standards, for large trucks with >320kw engine output: the noise limits for these vehicles is set at 83 dBA (National Transport Commission 2004). The new standards require noise levels to be recorded. These records will form the basis for enforcement of noise standards in the future. The aim is to minimise excessive noise caused by poorly maintained or modified exhausts. This is similar to the approach used in Norway (Malcolm Hunt Associates 2004).

In New Zealand, vehicles must have an exhaust system and silencer in effective and 'good working order' (LTSA 2003a). A basic noise test forms part of warrant of fitness (WoF) testing undertaken by inspectors during warrant renewal. Police also have powers to address excessively noisy vehicles. Police issue green stickers which automatically cancel WoFs to vehicles for noisy exhaust systems (LTSA 2003a). However, the permitted noise levels are considered out of date compared with international levels. There are no restrictions on rail noise.

Table 2.2 New vehicle limit values and restrictions.

New Zealand Traffic Regulations 1976 Specifications	dBA	European (EC 92/97/EC); UNECE Regulation N°51; and Australian Design Rule 83/00 Specifications	dBA
Power cycle	77	**Mopeds**	
		≤ 25km/h	66
		> 25km/h	71
		3-wheeled mopeds	76
Motor cycles		**Motor cycles**	
- engine capacity ≤ 125 cm³	82	- engine capacity ≤ 80cm³	75
- engine capacity > 125 cm³	86	- engine capacity > 80cm³, ≤ 175cm³	77
		- > 175 cm³ or 3-wheeled	80
Motor vehicles		**Passenger vehicles**	
≤ 3500 kg	84	- ≤ 8–9 seats including the driver	
>3500 kg, engine		- > 8–9 seats including driver > 3.5 tons	74
- engine power ≤ 150 kw	89	▪ engine power < 150 kW	78
- engine power > 150 kw	92	▪ engine power > 150 kW	80
		Passenger >nine seats and goods vehicles	
		≤ 2 tons	76
		2–3.5 tons	77
		Goods vehicles > 3.5 tons	
		engine power < 75 kW	77
		engine power 75–150 kW	78
		engine power ≥ 150 kW	80
		engine power > 320 kW (Australia only)	83

2.1.2 Tyre/road noise

Noise from tyres arises from the friction between the tyre and road surface and increases with speed. Tyre and road interaction is a significant source of transport noise and is the main source of road noise at speeds above about 50 km/h (WHO 1999a).

The semi-closed space formed between the tyre and the road surface amplifies the sound pressure level. This is known as the 'horn effect'. Vibrations in the area are converted into sound and determined by the shape and size of the horn (Iwao & Yamazaki 1996). The vibrations create the roar or rumble that is associated with vehicle noise. Iwao & Yamazaki conclude that the main cause of the tyre/road noise is vibration from the exiting force of the tyre as it rotates, and is dependent on the road surface roughness, the driving torque and vertical load.

The parameters affecting tyre noise are vehicle speed, wheel rim dimension, tyre width and tread pattern, width and depth. Noise increases with the size of the rim and tyre width. When the vibrating spot is located exactly at the 'throat' of the horn effect area, noise levels reach their maximum. Reducing the vibration may be achieved by modifying this area of the tyre during manufacture and design (Iwao & Yamazaki 1996).

Despite extensive literature on tyre-generated noise little consensus exists on how overall sound is produced. Tyre/road interaction consists of a number of components[4]. The only clear fact is that road and tyre texture influence vibration and sound radiation. This is described as 'texture induced vibrations'. The importance of air-pumping as the tyre interacts with the road is less well understood and modelling tyre/road interaction has proved complex (Kuijpers 2001).

Tyre noise has not decreased significantly over time. This is in part because the testing of noise from tyres is limited to new passenger car tyres in laboratory situations. As a result, tests do not reflect what occurs in actual traffic or the noise from heavy truck tyres (Sandberg 2001a, Kuijpers 2001). Noise levels also change over the life of the tyre and differ from laboratory tests (Sandberg 2001b). Vehicle numbers continue to increase as does the trend towards larger, four wheel drive vehicles.

In Europe, a commitment to introducing additional noise abatement measures on vehicles was expressed in Directive 92/97/EEC. Directive 2001/43/EC on tyres on motor vehicles and trailers was introduced in 2001[5]. Increased tyre widths, more widespread use of sports utility vehicles (SUVs) and diesel vehicles has negatively impacted on desired outcomes (van Blokland 2004). Research is now underway to better match laboratory testing with 'real-world' situations.

2.1.3 Rail noise

Rail noise stems from the rolling noise of carriages as the wheels and track interact. Like road noise, the source of noise varies with the speed. Up to 50 km/h engine noise is the predominant source; at speeds between 50 and 300 km/h rolling noise becomes the principal source (Brons et al. 2003).

As rolling noise is the major source of train noise, technical options focus on this aspect. They include the modification of freight trains and improvements of track condition. The latter includes providing for smooth, flat rails and wheels and using brakes made from less noisy materials (Brons et al. 2003)

The upgrade and maintenance of rolling stock provides an ideal opportunity to address rail noise at source. The replacement of tread brakes with disc brakes has achieved reductions of 5-10 dBA in high speed passenger trains (Kurze 1996, Hubner 2000). Freight train noise can also be addressed by the choice of brake shoe material. For example, disc brakes create significantly less noise than cast iron brake shoes (Hubner

4 For a detailed description see Kuijpers 2001.

5 Council Directive 2001/43/EC amended Council Directive 92/23/EEC relating to tyres for motor vehicles and their trailers and their fitting.

2000). Regular grinding of tracks keeps the rails smooth and helps to reduce noise (Malcolm Hunt Associates 2004).

Methods for managing of the transmission or rail noise are relatively consistent with road noise. Land use planning options, discussed in Chapter 5, will become increasingly relevant as passenger rail is considered as part of regional land transport planning in urban areas. For example noise barriers may be implemented where new tracks are built or existing lines reconstructed.

2.1.4 Quieter road surfaces

Although advances in tyre technology for noise reduction have been relatively unsuccessful, road surfaces can have a marked effect on noise emissions. A number of countries including the Netherlands, Germany and the United States (US) have advanced the use of quieter road surfaces.

Noise emitted from road surface varies from 9-15 dBA depending on the type (AUSTROADS 2005). Road texture influences noise level with smoother road surfaces generating less noise. Concave shaped surface 'chip' results in a decrease in noise (Kuijpers 2001). Open graded asphalt is considered the quietest of road surface type while concrete surfaces are the noisiest. This is illustrated in Table 2.3.

Road surfaces are normally described as 'macro' or 'micro' in texture. Microtexture describes the spacing between stones in the chip seal and macrotexture the surface defects such as cracks and potholes. Both macro- and micro-factors influence noise emission when in contact with tyres (AUSTROADS 2005).

Table 2.3 Noise emissions from a range of road surfaces.

Country	Surface Type	Noise Level Variation (dBA)		
		Traffic Noise	Cars	Trucks
Aus/NZ	14 mm chipseal	+4	+4	+4
NZ	10–14 mm chipseal	+3	?	?
NZ	7–10 mm chipseal	+3	?	?
Aus	Portland cement concrete	0 – +3	+1 – +3.5	−1 – +1
Aus	Cold overlay	+2	+2	+2
Aus	Portland cement concrete – exposed aggregate	−3	−0.1	−6.7
Aus/NZ	Open graded asphalt	−3 – −4	−0.2 – −4.2	−4.9
US	Open graded asphalt concrete	−4	?	?
NZ/US	Dense graded asphalt	?	?	?

Adapted from AUSTROADS (2004a), additional data from Transit NZ (1999) and Caltrans (2004).

Current research on road surfacing focuses on a 'new generation' of road surface technology. Dutch research aims to improve road surface noise abatement to achieve noise reductions of 6 dBA. The Dutch research programme involves the application of dual layer porous asphalt on highways to improve the acoustic and structural properties of road surfaces.

Noise reduction from quieter road surfaces decreases over the life of the road surface. Part of the Dutch research deals with retaining the noise benefits over a longer period. The longevity of quieter road surfaces is an important factor in assessing the cost benefit analysis of abatement options.

2.1.5 Managing road traffic

Noise can also be controlled by managing road traffic, e.g. lowering speed limits, restricting heavy vehicles in specific areas, and reducing the volume of traffic.

Large speed reductions are required to make a difference to noise. Significantly lowering speeds can also reduce the efficiency of the transport network (Malcolm Hunt Associates 2004). In contrast, there are positive spin-offs from speed reduction such as improved safety and reduced fuel consumption. Reducing speed levels to 30 km/h in built-up residential areas has proved successful in Dutch cities (M. van den Berg pers.comm.).

Heavy vehicle routing is a further option and involves redirecting heavy commercial vehicles to less sensitive areas. This approach may form part of land use planning options where sensitive activities are restricted from certain land transport routes (Malcolm Hunt Associates 2004).

Traffic congestion occurs with peak travel hours and bottle necks in roading systems (Stopher 2004). Controlling congestion and noise by reducing traffic volume can be achieved by restricting vehicle access at certain times of the day, introducing congestion taxing, or car sharing schemes. Vehicle restrictions have limitations, e.g. commuters may drive to the edge of the congestion zone, increasing traffic volumes and the need for parking in those areas. Alternative forms of transport are also required for entry into the restriction zones.

2.2 Options for decreasing the transmission of noise

The main options for decreasing the transmission of noise are distance, or separation, and the obstruction of noise by natural and artificial barriers.

2.2.1 Distance separation / setbacks

This approach involves siting noise-sensitive activities away from sources of transport noise using distance. For example, houses may only be permitted at a distance of more than *x* metres from a road or rail corridor. Setbacks may be difficult to implement because of competing land use interests. Along existing road and rail networks, land may simply be unavailable.

Ground surface also affects noise propagation. Grass and natural surfaces are more sound absorbent than hard surfaces like concrete or water bodies. Hard surfaces tend to reflect noise; this may lead to the transfer of unwanted noise to the surrounding area (Main Roads 2000a).

Setbacks will be covered in detail in the land use planning section.

2.2.2 Noise barriers

A noise barrier, or acoustic shield, reduces noise by interrupting the propagation of sound waves. With proper design and selection of materials, noise barriers prevent noise reaching sensitive receivers. Any remaining noise would be primarily through diffraction over the top of the barrier and around its ends. The acoustical 'shadow zone' created behind the barrier is where noise levels are substantially lowered.

To be effective barriers need to be continuous and high enough to block the line of sight between the source and receiver (Kotzen & English 1999, Main Roads 2000a). The barrier material determines whether noise is reflected, absorbed or dispersed. Material selection needs to consider the surrounding topography. For example, in a built-up area reflective barriers may create noise in previously unaffected areas.

Some typical noise barriers include:

- timber – palings, plywood sheets,
- reinforced concrete,
- cement panels,
- masonry,
- acyclic, i.e. transparent,
- earth mounds, with or without planting,
- siting roads or rail tracks below ground level,
- lowering roads or rail tracks into cut-and-cover tunnels.

Earth mounds require more land than barriers but also allow space between the road and housing. Main Roads (2000a) suggests that a 2 m-high mound requires a 10 m base on a 1:2 slope but a shallower slope (1:3) is recommended to allow ease of access for planting and weeding. A combination of barriers and mounds is common.

Noise barriers that are designed and constructed as part of an overall project proposal, and which suit the surrounding environment, are considered most effective (Kotzen & English 1999).

2.3 Dealing with noise at the receiving end

A range of methods are currently implemented to address the issue of noise at the receiver including retrofitting of noise barriers, acoustic insulation and urban design.

2.3.1 Acoustic insulation

Acoustic insulation addresses the internal noise of dwellings. Acoustic insulation can be added to wall cavities or ceilings. Noise-resistant materials, such as thicker external walls and double glazing, are also widely used. Air conditioning provides an indirect method for addressing noise by reducing the need to open windows (AUSTROADS 2005).

2.3.2 Urban design

Urban design incorporates design elements to address or prevent noise. The orientation of buildings can be used to reduce noise in new developments. Noise-sensitive areas, such as bedrooms and living areas, may be positioned away from the road or railway.

Urban design standards can be used to ensure less noise-sensitive activities or designs occur next to a transport corridor. For example, noise barriers will prove ineffective at controlling noise levels in buildings that look over the top of the barrier, such as a two-storey house.

Urban design will be discussed in more detail under land use planning.

2.4 Comment

Technical noise abatement options can be applied at different stages. Their selection is dependent on a number of factors including cost-effectiveness and practicality.

Noise abatement measures can result in rising returns as they are progressively implemented. Measures such as low-noise road surface and railway tracks bring declining returns as implementation increases while low-noise tyres bring increasing returns (Nijland et al. 2003a). Malcolm Hunt Associates (2004) note that technical measures for addressing rail noise may be less efficient than technical measure for controlling road transport noise.

Technical options form part of a wider set of tools for addressing noise. Using a combination of technical approaches achieves the greatest reduction in noise. Where retrofitting is necessary to address existing noise, options may be more limited.

Table 2.4 Summary of technical options.

Option	Implementation method	Advantages	Disadvantages[6]
Quiet road surfacing	• Highway Authority Guidance • Rules in District Plans	• Easy to implement • Can be retrofitted	• Cost (Approx $150,000/km) (Annualised cost: $10,250/km) • Relatively low noise reduction • Lifespan of road surfaces
Vehicle noise standards	• Traffic Regulations • WOF/COC	• Sets specific levels for noise at source • Theoretically easy to test	• Cost of implementation and testing • Exhaust can be altered for testing by owners • Enforcement has proven difficult in other countries
Congestion charging	• Bylaws • Regional Land Transport Strategies • Urban Growth Strategies	• Increases public transport use • Increases revenue from private vehicles for transfer to research • Less stop-start traffic	• Parking on peripheries • Need to supply private vehicle alternatives • Requires marked drop in traffic volumes
Speed	• Bylaws	• Reduces noise at source	• Lower speeds can frustrate drivers • Requires a considerable speed reduction
Restricting traffic volumes	• Bylaws • Regional Land Transport Strategies • Urban Growth Strategies	• Reduced noise levels at source	• Requires a dramatic reduction in volume 50% reduction to achieve 3 dBA drop (Malcolm Hunt Associates 2004)
Heavy vehicle restrictions	• Bylaws • Regional Land Transport Plans	• Addresses heavy vehicle issues	• Does not address overall traffic volumes where this is a concern, • Drivers may be reluctant, or it may be impractical, to use alternative routes
Upgrading train brakes **Rail track gliding**	• Rail operators • District Plans • Regional Land Transport Strategies	• Good level of noise reduction (5-10 dBA)	• Not cost-effective given the number of people affected by rail noise in New Zealand (0.6% as of 1994), (Uniservices, quoted in Malcolm Hunt Associates 2004)

6 For more detailed analysis see: Malcolm Hunt Associates (2004). *Noise impacts of land transport – stage 3: Development of policies for the management of noise from land transport*. Malcolm Hunt Associates: Wellington.

3. International approaches to land transport noise and its abatement

International strategies on transport noise have evolved as a result of the increased understanding of the effects of noise on health. Transport and noise are global issues and now form part of sustainable transport planning considerations. The World Business Council for Sustainable Development (WBCSD), the Organisation for Economic Co-operation and Development (OECD) and the United Nations Economic Commission for Europe (UNECE) are each developing solutions to transportation issues, including noise, in a bid to achieve more sustainable outcomes for transport globally.

In assessing options available to New Zealand it is useful to look at examples from other countries and successful and unsuccessful methods of transport noise control. Before considering individual countries or states it is helpful to provide an overview of the OECD goals, particularly as the New Zealand Government envisages a return to the top half of OECD nations in terms of capita per income, while sustaining a high quality environment (Ministry of Transport 2002). The European Union's approach will also be outlined to provide a background to the Netherlands case study.

In each of the countries researched, noise is addressed at a strategic level. Land use planning tools for dealing with noise vary considerably. However abatement technologies are gaining consistency and a general consensus exists on what constitutes acceptable noise levels. Many countries have implemented noise abatement plans with varying degrees of success. Most are in the process of re-evaluation to improve those policies.

3.1 OECD

The OECD investigates and reports on environmental issues among member countries. Work on the environmental issues relating to transport includes addressing noise. The OECD established the *Environmentally Sustainable Transport (*EST) project in response to growing concerns with the impacts of transport and the realisation that current transportation approaches are unsustainable (OECD 2002).

The OECD's desired outcomes for future noise levels are consistent with WHO recommendations, although specifically they identify appropriate outdoor noise levels as not exceeding 55 dBA during the day and 45 dBA at night.

European Member States have also signed a Charter on transport, environment and health which is endorsed by the OECD. The Charter promotes the incorporation of environmental and health aims with transport and land use policies (WHO 1999b). The EST guidelines are in Appendix 2.

3.2 Europe

Transport is the most prevalent source of noise pollution in Europe (Dora 1999, WHO 2000). It is estimated that 80 million Europeans are exposed to noise levels that cause sleep disturbance and 170 million people live in 'grey areas' where serious noise annoyance occurs during the day (EC 1996). European noise legislation has a long history of abatement attempts. Restrictions on vehicle noise emissions were first introduced in 1970. Measures to reduce transport noise such as noise barriers to restrict transmission and treating buildings with noise insulation are also widespread. Land use planning is used in a number of countries to address road noise and new rail network noise. Technical options are more commonly used for addressing existing rail noise (Hubner 2000).

Despite policy variation across states, consensus exists about what constitutes acceptable noise levels. These values are based largely on the WHO and OECD levels illustrated in Table 3.1. European Union Member States accept that significant interference with normal, daytime activities occurs at levels above 55 dBA (EC 1996). Noise descriptors are also consistent. Day (L_{day}), Day-evening-night (L_{den}) and night (L_{night}) descriptors are commonly used in Europe

Table 3.1 Noise levels and responses to noise as accepted in Europe.

Level	Response
50 – 60 dBA	Creates annoyance
60 – 65 dBA	Annoyance increases significantly
Over 65 dBA	Constrained behaviour patterns occur, symptomatic of serious damage

Source: EC 1996

A Green Paper outlining potential methods for developing a framework for noise at the European Community level was circulated in 1996. The Green Paper assessed member state approaches to noise policy and outlined their commitment to achieving a unified approach to noise management, common assessment methods, noise descriptors and improved information exchange.

Directive 2002/49/EC relating to the assessment and management of environmental noise was introduced in 2002. The directive applies to noise impacts as perceived by people and communities in built-up areas and sensitive places such as schools, public parks and hospitals. It promotes a common approach to avoidance and mitigation of noise using noise-mapping[7] to identify day-evening-night and night levels. The first noise maps are required by 2007 and will be reviewed every five years. Data from noise maps will assist the development of action plans for dealing with major roads and rail corridors; the first action plans are required by 2008. A review of the directive's implementation is scheduled for 2009. The findings will form the basis for developing community measures to address noise emissions.

[7] More information on noise mapping can be found in Appendix 3 Data collection and monitoring noise exposure.

European Union (EU) strategies place emphasis on regional consistency and spatial planning. Spatial planning is considered central to achieving integrated transport networks and environmentally sound outcomes. Integration is also a key element of EU noise policies[8]. The Amsterdam Treaty, 1997 makes a clear link between integration and sustainability (Geerlings & Stead 2003). This has been passed on to the noise directive where the emphasis is on a 'harmonisation' of policies[9]. European policy recognises that transport planning will not achieve sustainable outcomes if used in isolation and the Directive provides the umbrella policy to allow for that.

In addition to existing guidance for noise standards, described in Chapter 1, WHO's European division is developing environmental health indicators specific to European countries as part of an *Environment and Health Information System.* The system will provide evidence for future policy-making priorities and will assist with public communication. The findings may result in a requirement for more stringent approaches to noise mitigation (WHO Europe 2004). The indicators may also provide additional guidance and information for New Zealand.

3.2.1 The Netherlands

3.2.1.1 Background

Transport planning is central to environmental policy making in the Netherlands (Banister 2002) and the integration of noise abatement measures and land use planning is a key element of this. The Netherlands first addressed the issue of noise abatement in the 1970s and the Noise Nuisance Act (NNA) was inaugurated in 1979. Central government policies and legislative instruments encompassing noise have evolved over the past 25 years.

The NNA introduced controls on noise with methods including reducing the transmission of noise and acoustic insulation. The act required authorities to establish noise zones for noise-producing land uses, including land transport, to prevent and reduce impacts on sensitive receivers. It also aimed to prevent new noise and reduce existing impacts. It embraced the polluter pays principle and encouraged the implementation of regulations by regional and local authorities. The Netherlands has a similar government structure to New Zealand in that local government has specific transport and land use planning responsibilities (Zito 2001). The implementation of the NNA aimed to achieve a co-ordinated and integrated approach to addressing noise by involving central and local government, developers and planners. Long-term measures over a period of 10-25 years were expected to achieve positive environmental outcomes (M. van den Berg pers.comm.).

At present local councils must address noise exposure in dwellings when it exceeds 55 dBA, but central government is consulted about what measures should be taken[10].

8 Integration in the EU means the integration and development of policy that is consistent, coherent, and cooperative, and based on common goals.

9 For example see: *www.harmonoise.nl* a project aimed at creating consistent, transferable methods for developing noise maps under the EC Directive on noise.

10 About 95% of infrastructure investments are made by the national government.

Approximately €25 million[11] is spent insulating severely affected dwellings each year[12]. This provides 8000 - 10000 dwellings with wall insulation (National Institute of Public Health and the Environment 2001).

Despite robust legislation, noise is an increasing problem in the Netherlands, because of high population levels, high vehicle numbers in urban areas and the increasing transportation of goods using heavy vehicles (Passchier-Vermeer & Passchier 2000, Sociaal-Economische Raad 2001). Unless a new policy direction is implemented, the population exposed to noise levels above 65 dBA is expected to rise to 5-6% (Nijland et al. 2003a).

The Netherlands is a densely populated country covering 41,526km^2 (Dutch Down)[13]; this equates to a population density of 380 people per square kilometre compared to 14 per square kilometre in New Zealand. The lack of space in the Netherlands has resulted in land use planning that promotes urban communities coupled with a desire to contain urban development (Stead & Hoppenbrouwer 2004). Over 1% of the population is estimated to be exposed to noise levels exceeding 70 dBA and over 4% are exposed to noise levels above 65 dBA, which amounts to nearly 800,000 people living in an environment where their health is compromised because of noise. In 2000 it was estimated that 2% of the Dutch population were affected by railway noise compared with 25% affected by road traffic noise (Briginshaw 2000).

Current planning policy focuses on decentralising responsibility and setting noise levels that are appropriate to the 'function and characteristic' of areas (National Institute of Public Health and the Environment 2001, Borst 2001).

3.2.1.2 Planning and policy

Dutch noise strategies have undergone a series of policy changes since 1979. New noise legislation, 'modernisering instrumentarium geluidsbeleid' (MIG[14]) which literally translates to 'modernisation of noise' is to be implemented in 2006 (M. van den Berg pers.comm.).

There are numerous policy documents linking transport and planning. They are linked by common goals and policy direction, including those relating to noise. Current policies recognise the difficulty of abating noise to the levels outlined in the NNA and targets and methods have been updated to reflect this. The key documents include:

- *The Fifth National Policy Document on Spatial Planning* (2000),
- *The Fourth National Environmental Policy Plan* (NEPP4) (2001),
- The National Spatial Strategy (NSS) (2004),

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[11] Approximately $NZ45 million.

[12] Severely affected building are those exposed to noise levels exceeding 70 dBA.

[13] In comparison New Zealand is 268,680km^2 (including Antipodes Islands, Auckland Islands, Bounty Islands, Campbell Island, Chatham Islands, and Kermadec Islands).

[14] A draft bill was submitted in 2001 but later withdrawn while implementation of the EU Directive on noise occurred - this was completed in 2004. Another Bill was drafted in 2004 and is now being considered by Parliament (M. van den Berg, pers.comm.).

- The Dutch National Traffic and Transport Plan NVVP 2001-2020 (NVVP) (2001).

National noise levels are set centrally but decisions on urban planning are made by regional and local authorities (with assistance from central government) (Nijland et al. 2003a). The NEPP4 national target for noise states that 70 dBA must not be exceeded in homes by 2010. Infrastructure modifications will be implemented to remedy at least 50% of homes which are exposed to levels of ≥ 60 dBA by 2010 (VROM 2001a, National Institute of Public Health and the Environment 2001).

The NEPP4 framework introduces area-based targets which will be implemented by local authorities. The aim is to set levels which retain the "acoustic quality of an area" (VROM 2001a). This signals a change in direction from having absolute noise targets. The preceding policy (NEPP3) target of "no more victims of serious nuisance in 2010" was considered "too ambitious" (VROM 2001a: 69). The noise levels will now be set to match the 'function' of an area (National Institute of Public Health and the Environment 2001, Borst 2001). Ambient noise levels will provide the baseline and are not to be elevated by unwanted noise. Local authorities will be required to implement local noise policy plans or integrate noise policy into existing environmental plans (Borst 2001).

The *Fifth National Policy Document on Spatial Planning: Making Space, Sharing Space* provides guidance on spatial development up to 2030 (VROM 2001b). The motto of the fifth spatial document is "centralised where necessary, decentralised where possible" (VROM 2001b: 4). It updates previous spatial planning policy which attempted to address transport impacts by restricting car use. The fifth spatial document introduces the guidance value of 50 dBA and the limit value of 70dBA described above.

Various attempts have been made to address transport noise through land used planning. Under previous planning policy, the 'ABC Location Policy' was implemented to encourage businesses to select sites with good public transport (VROM 2001a). The policy aimed to match businesses with location and create compact cities. The policy reflects the decreasing accessibility of public transport networks with 'A' being the most and 'C' the least accessible.

The policy proved unsuccessful in some areas because A-locations were less accessible and desirable than hoped (VROM 2001b). Between 1991 and 1996, C-locations witnessed the highest growth in employment (VROM 1991, quoted in Owens & Cowell 2002). Some areas were successful in implementing the policy, for example Utrecht, where a concentration of commercial development exists around the new Central Station. Utrecht has implemented a number of measures consistent with the ABC policy including a ring road controlling the entry of highway traffic into the city centre, the closure of the inner city to private cars, and a tram-only rule in pedestrian precincts (Ebels 1998).

The emphasis on design and land use planning continues in current policy. Quality of life and the environment are key features of the *Fifth National Policy Document on Spatial Planning*. The focus on compact cities and the encouragement of growth in existing urban has also been retained (Banister 2002; Stead & Hoppenbrouwer 2004).

Mixed use developments are another feature of Dutch urban planning. Mixed use development is considered beneficial to urban design and aims to increase the vitality of cities by:

- promoting more efficient and intensive use of space,
- protecting the countryside from urban sprawl,
- reducing the mono-functional character of urban areas,
- improving the quality of the environment in urban centres,
- contributing to the possibilities of finding a job close to the home,
- contributing to a reduction in car use,
- enabling residents to make use of local providers for goods and services (Stead & Hoppenbrouwer 2004: 4).

Dutch urban planning programmes go beyond regenerating the city centre[15]. They aim to re-design cities to increase their vitality and quality hoping to encouraging urban dwelling and working. As a result they reduce the need for private transport by increasing accessibility to public modes.

The urban focus is not without problems. Rural living remains a popular choice because of the unattractive elements of urban dwelling such as noise and low air quality. Local authority focus on spatial planning, urban renewal and housing planning is attempting to drive a policy that removes these barriers (Stead & Hoppenbrouwer 2004).

The *National Spatial Policy* (NSPP) furthers Dutch planning and transport policy by providing guidance on implementing policy. It is consistent with proposed MIG legislation which continues the decentralisation theme and expands local authority's environmental planning role. The MIG also introduces L_{den} measurements consistent with the European Directive (Borst 2001, VROM 2003). The NSPP also introduces a new element to transport planning by placing an emphasis on the economic impacts of traffic congestion. Infrastructure will be implemented to reduce bottlenecks and congestion.

The *Dutch National Traffic and Transport Plan NVVP 2001-2020* defines strategic traffic goals for the next 20 years and includes greater emphasis on spatial planning. It replaces the former *Structuurschema's Verkeer en Vervoer*[16] (SVV- I and II). A specific land use planning measure is to include a 50-75 m strip on either side of transport infrastructure to address the environmental impacts of transport such as noise (VROM 2001b). A requirement also exists to designate zones with a clear view, which means that the zones must be kept free of construction and noise barriers to prevent 'ribbon' development along transport corridors (VROM 2001b).

As with spatial planning policy, central government direction will remain where necessary, but greater emphasis is given to local solutions to noise and other transport issue. Along

[15] As is occurring under the Urban Task Force in London, and the City Centre Strategy in Christchurch.

[16] Traffic and transport structure plans.

with the NSPP, the NVVP seeks to address congestion by constructing new infrastructure to relieve bottlenecks, making better use of the existing infrastructure and pricing mobility by varying and separating costs (Sociaal-Economische Raad 2001). Its aim is to shift costs to users and opens the way for public–private partnership.

An increasing focus is on quiet urban areas using low speed controls[17] and restrictions on vehicle movements on some roads. (M. van den Berg pers.comm.). The Dutch are also working towards reducing the fragmentation of ecological corridors that can arise from the implementation of road networks (VROM 2001b).

In addition to spatial planning documents, the Netherlands is refining its technical measures for addressing noise. Earlier noise abatement resulted in relatively stable noise levels in some areas and increases in others. Barriers, acoustic insulation and setbacks are effective but overall not getting the desired results (M. van den Berg pers.comm., Zito 2001, Nijland et al. 2003a, Hofman & van der Kooij 2003). A research and development programme is underway to investigate this problem and develop more robust solutions over the next 30 years (Nijland et al. 2003b).

VROM[18] initiated a research and development program 'IPG'[19] in 2003. The IPG forms part of the *Dutch National Traffic and Transport Plan* NVVP 2001-2020. The basic principle of the IPG is improving noise abatement using more cost-effective measures. The goals of the IPG are similar to the 4th Environmental Policy Plan and include reducing noise exposure to >70 dBA by 100%, dwellings exposed to >65 dBA by 90% and those exposed to >60 dBA by 50% by 2030. The key elements of control include application of quieter road surfaces, quieter tyres and implementation of quieter trains or 'whispering trains' (UNECE, 2003, Nijland et al. 2003b). At present 60% of roads (about 4000 km) have 'silent' porous asphalt, and 7% (500 km) have noise barriers (Hofman & van der Kooij 2003).

3.2.1.3 Comment

The Dutch experience provides a number of lessons, the most fundamental being that the centralisation of noise strategies has proved effective for setting and applying common goals.

The Netherlands has demonstrated that land use planning and urban design can provide effective solutions to transport impacts. Compared with other European countries, only a small number of houses are exposed to significant noise levels of over 70dBA (National Institute of Public Health and the Environment 2001). The integration of transport and planning policies is necessary to provide consistency and address issues effectively.
The Dutch have recognised the importance of quality of life and attractiveness of urban cities in order to encourage people into urban spaces. Mixed development and concentration of commercial areas around transport nodes have been central to these

[17] Speed limits are 30 km/hour or less, in some areas.

[18] The Dutch Ministry of Environmental Affairs, the Ministry of Transport, Public Works and Water Management

[19] Innovatieprogramma Geluid / Dutch Noise Innovation Program road traffic (IPG).

policies. Policy aims have been achieved in some cities through urban planning, controlling vehicle use and providing suitable alternatives. However, the approach is not without problems. Cities are inherently noisy making them less attractive to residents and wealthier citizens continue to move to rural areas (Stead & Hoppenbrouwer 2004).

The Dutch have also shown that it can be more effective to control the impacts of vehicles rather than vehicle use. Recent policy changes imply that it is acceptable to have accessibility to urban centres using a combination of transport modes. The MIG system signals a change in attitude towards car use. Inner cities in particular are becoming more flexible in order to preserve the economic growth (Saçli 2004, VROM undated). It is indicative of the complexity of balancing economic, environmental and social aspects of planning policy. The change also illustrates the need to keep evolving and reviewing policies and plans.

Controlling vehicle ownership and numbers has proven unsuccessful in some areas. Transport policy now focuses on the use of the vehicle and has revamped user and polluter pays principles to alleviate impacts and cover costs. Economic instruments are needed to fund ongoing initiatives. Having spent millions of dollars on noise abatement, the Dutch are placing emphasis on optimising current approaches to make abatement more cost-effective.

The Dutch case also demonstrates that the implementation of effective measures can take many years if early planning and design is not followed. In a worst case scenario, abatement measures can be superseded by land transport growth which could have been prevented if active land use planning measures had been undertaken.

The Dutch experience confirms that planning approaches need to be consistent with national policy for long-term results (Owens & Cowell 2002) and evolve as issues and patterns are better understood. Their systems have demonstrated that integrating technology, planning and design with clear direction on desired outcomes from central government can result in a forward-thinking and successful approach to land use and transport planning.

Table 3.2 IPG research areas for reducing noise.

Measure	Approach
Knowledge and management	• Establish a system to disseminate results • Broaden basic knowledge of noise generation and shielding • Build and maintain research facilities for vehicle/tyre testing and real traffic conditions
Silent roads	• Application of 2-layer porous asphalt on highways • Improvement of acoustical and structural properties of porous and non-porous surfaces • Design and development of a new generation of silent roads
Silent tyres and vehicles	• Stimulate use of silent tyres and vehicles by national legislation • Influence consumers' behaviour by financial stimulation/taxation • Improve quality of international regulations/legislation by sharpening limit values and more representative measuring methods • Development of low-noise vehicle and tyre concepts
Enhanced noise barrier efficiency	• Improve barrier-top efficiency and barrier position • Improve barrier efficiency using active noise control
Assessment methods	• Develop and standardise acoustic & non acoustic measurement methods • Develop a decision making framework (LCA, risk analysis, traffic safety, etc.) for the implementation of measures

Source: Adapted from Nijland et al. 2003b

3.3 Australia

Noise levels in Australia have risen with population, vehicle numbers and road freight. Guidelines on acceptable noise from roads range between 63 and 68 dBA $L_{10\ 18\ hr}$. using the measurement '$L_{10\ 18hr}$'. This equates to the noise level that should not be exceeded more than 10% of the time over an 18-hour period. The 18 hour measurement does not address sleep disturbance and there are moves to replace this descriptor with L_{eq} (Malcolm Hunt Associates 2004, AUSTROADS 2004a). Day ($L_{eq\ 15\ hr}$) and night ($L_{eq\ 9\ hr}$) descriptors are used in some states including New South Wales and South Australia (AUSTROADS 2004b). In NSW noise levels are set at 65 dBA L_{eq} and 55 dBA at night. (EPA 1999[20]) In urban areas of Melbourne 12% of homes are exposed to noise levels exceeding 65 dBA (Malcolm Hunt Associates 2004). 10% of city dwellings are exposed to noise levels of road traffic noise over 68 dBA $L_{10\ 18\text{-}hr}$ (Newton et al. 2001). Overall, 14% of homes are exposed to noise levels exceeding WHO and OECD guidelines (DOTARS 2002).

Spatial distribution of cities and towns across such a large country has played a role in transport demand (Taylor & Ampt 2003). This is not uncommon in countries like Australia and the US where dispersal of urban centres and large land masses result in increases in the level of road transportation (Owens & Cowell 2002).

[20] For further information see: AUSTROADS. 2004. Issues relating to the management of road traffic noise. *Austroads internal report. PUB. ES.C.009.* Sydney: Austroads Incorporated.

Australia has a decentralised approach to transport management and land transport noise. Central government transport policy focuses on air emissions and 'greener' purchasing while roading responsibility is designated to state authorities. Major arterial roads and highways are controlled by state roading authorities while local roads come under the jurisdiction of state environmental agencies. There are eight state roading authorities in Australia. In addition, there are 673 local government councils with planning and environmental responsibilities.

Noise abatement is receiving increased attention. Vehicle noise emissions are the most developed area of noise management. The National Road Transport Commission[21] (NRTC) was established in 1991 to develop consistent provisions for vehicle regulation, operation and vehicle registration charges. A number of regulations on vehicle emissions were produced via Australian Design Rules. As a result, Australia's transport noise strategy can be divided into two categories: road design and management, and vehicle design, specification and emissions testing (Malcolm Hunt Associates 2004).

Australia recognises that a more integrated approach is necessary to curb the noise problem. The latest *State of the environment report* (Newton et al. 2001) notes that controls on noise at source, transmission and receipt are all required. Austroads[22], which undertakes research and provides advice on road transport issues, reviewed noise management options in 2004. Two subsequent documents provide guidelines for implementing abatement at each stage of development and road design. While no conclusions were drawn, a number of recommendations were made and the differences between state laws acknowledged. Noise, particularly from heavy vehicles was also identified as a key emerging issue in Austroads strategic plan (AUSTROADS 2004a).

Australia has developed standards for sound insulation under the *Building Code of Australia* (BCA). The BCA is a regulatory document and must be applied to all new developments (M. McCubbery pers.comm.). Australian/New Zealand Standard 2107:2000 also outlines recommended internal noise levels that are consistent with the building code. The acceptable noise levels are summarised in Table 3.3.

Table 3.3 AS/NZS 2107 recommended design levels for a suburban home.

Area	**Building Code Australia*** AS/NZS Standard 2107:2000	
	Satisfactory(dB)	**Maximum(dB)****
Recreation/living areas	35	40
Bedrooms	30	35
Work areas	35	40

* *http://www.greenhouse.gov.au/yourhome/technical/fs53_2.htm*

** Austroads (2004c) outlines higher values for AS/NZS 2107 at 45, 40 and 45 respectively.

21 The NRTC was replaced with the National Transport Commission (NTC) in January 2004.

22 AUSTROADS is the association of Australian and New Zealand road transport and traffic authorities. Members include the six Australian state and two territory road transport and traffic authorities, the Commonwealth Department of Transport and Regional Services (CDOTARS), Australian Local Government Association (ALGA), and Transit New Zealand.

Where noise levels in developments are expected to exceed the guidelines, the developer is responsible for mitigation to acceptable levels (M. McCubbery pers.comm.). The levels are also used as guidance where mitigation is the state road authority's responsibility (AUSTROADS 2004b). This might occur because of an upgrade or issues with an existing road.[23]

Given the variations on addressing noise it is useful to look at specific state approaches. New South Wales and Queensland have been selected. NSW is the only state where road transport noise policy is administered by the Environmental Protection Authority (EPA/DEC[24]) and implemented by the roading authority (Malcolm Hunt Associates 2004).

3.3.1 New South Wales

3.3.1.1 Background

The New South Wales Road Transport Authority (RTA) is responsible for maintenance and development of the NSW section of the national highway and the state road network and provides funding assistance to local councils for regional roads. The RTA also promotes driver safety and issues vehicle and driver licences.

In 1989 the 'State Road Traffic Noise Task Force' was established in response to a study that indicated the extent of noise pollution in Australia (EPA 1999, NSW RTA 2001). The task force produced a report recommending that the Environment Protection Agency develop guidelines and criteria for road traffic noise. This culminated in two key documents: *Environmental criteria for road traffic noise* (EPA 1999) and the *RTA environmental noise management manual* (NSW RTA 2001).

3.3.1.2 Key policy documents

The *Environmental criteria for road traffic noise* (the 'Criteria') outline the framework for traffic noise associated with new building developments near existing or new roads, and for new or upgraded roads adjacent to new or planned building developments (EPA 1999). Although they are not mandatory, the criteria are commonly applied (M. McCubbery & T. King pers.comm.).

Before the criteria were established, sleep disturbance caused by roads (other than freeways) was not considered as part of development proposals. There was no distinction between day and night noise levels or any consideration of non-residential land uses (EPA 1999, NSW RTA 2001).

The *RTA environmental noise management manual* ('the Manual') was produced to assist with interpretation of the Criteria (D. Gainsford pers.comm.) The manual provides guidelines for roading authority staff, acoustic consultants and other contractors. It includes information on noise and vibration management for new, upgraded and existing roads, road construction and maintenance (NSW RTA 2001).

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[23] For further information on design guides see the *Home technical manual: Design for lifestyle and future chapters on noise and transport. Available online at: www.greenhouse.gov.au/yourhome/technical/pdf/fs62.pdf* and *www.greenhouse.gov.au/yourhome/technical/pdf/fs62.pdf*

[24] Now incorporated into the NSW Department of Environment and Conservation (DEC).

Multiple strategies are a core theme of the criteria. The document argues that "any real gain will generally only depend on a combination of strategies" (EPA 1999: 18). The emphasis is on dealing with noise at each stage including at source, transmission and receipt. Addressing effects at the planning stage of residential development is also encouraged. Noise at source has been addressed in part, with the adoption of Australian Design Rule 83/00 on external motor vehicle noise.

The criteria list the most effective strategies for limiting maximum noise levels as:

- *reducing noise at source through stricter noise emission requirements on new vehicles,*
- *enforcing in-service noise emission limits,*
- *improved land use planning,*
- *improved noise design requirements for buildings near heavily trafficked roads,*
- *management of traffic through heavy vehicle routes, with limited access to residential areas* (EPA 1999: 17).

The criteria promote an integrated approach to noise abatement through early land use planning and design, emphasising that a range of strategies are needed in addition to road design and development controls. Where short-term outcomes are not achievable longer-term approaches (such as vehicle emission controls) are advocated. Land use planning tools such as zoning for quiet areas and restricted access at night are encouraged. Although the criteria are not mandatory, they provide direction when issuing development consents and undertaking noise impact assessments for new roads and new developments near existing roads (EPA 1999). The EPA is considering developing a guide for local government to assist in identifying road traffic noise issues at the land use planning stage. Despite land use planning being advocated in the criteria this approach element has not been widely applied (T. King pers.comm.).

Acceptable noise levels outlined in the criteria vary with the type of development (road or land use) with separate values for day (7am–10pm) and night (10pm–7am). Day time noise levels from roads are within the general range of 55-60 dBA except for new roads in rural areas which are set at 50 dBA and measured 1 m from the most exposed area of the receiver at a height of 1.5 m. Existing road criteria are slightly higher depending on the type of road and time of day. The criteria include internal noise levels for sensitive land uses including schools, places of worship, hospital wards and recreation areas. The criteria range from 35–40 dBA with the exception of recreation areas which can be as high as 60 dBA.

3.3.1.3 Land use planning controls at a local level

Land use planning also occurs at local council level. Local councils produce Development Control Plans, which are comparable to New Zealand's district plans. Councils can identify areas subject to high noise levels in Local Environment Plans and apply area zoning controls.

A number of Development Control Plans include a noise element and outline acceptable noise levels for dwellings. The levels are commonly based on the *Building Code of*

Australia and the roading authority Criteria (J. Rawlin pers.comm.). Local Councils may request an acoustic report as part of a residential development proposal. Such reports may be necessary for developments adjacent to road and rail corridors or where the development will create an increase in traffic. These are then passed to the roading authority for comment.

Hornsby Shire Council Development Controls Plan outlines requirements for developments fronting proposed or existing roads. The Council's Code of Practice for Sound Insulation which is included in the Development Control Plan (DCP) includes the consideration of land transport. Renovations or new developments must conform to the code (M. McCubbery pers.comm.). The Southern Sydney Regional Organisation of Councils[25] has also developed a model DCP on external noise insulation requirements for residential housing.

Guidance has been produced for local councils by the Department of Environment and Conservation on noise and includes an overview of land use planning instruments. The guidance focuses on design criteria and very little specific guidance is available on road and rail noise.

In effect, developers may be required to provide information to the roading authority if their proposal is adjacent to an established road. Land use developments near existing roads are subject to more stringent criteria. When noise criteria specified by the EPA cannot be met, land use is not normally considered appropriate. Mitigation measures might be considered, including redesign or re-orientation, acoustic treatment or road resurfacing. If treatment of the façade is considered to address internal noise levels ventilation requirements must be included. It is 'desirable' that abatement criteria achieve internal noise levels 10 dBA below the external criteria (EPA 1999). Planners and developers are also encouraged to consider existing and future use to ensure the most effective noise abatement options are adopted.

3.3.1.4 The environmental criteria for road traffic noise in practice

The 'Criteria' provide step-by-step guidance on conducting noise assessments for proposed roads, road bridges, realignments and development proposals near roads. Existing and predicted noise levels need to be established as part of the assessment. Information on road use, including volumes and topographical aspects of the road must be included in the report. The proportion of heavy vehicles, particularly between 10pm and 7am must also be included. Larger land developments such as subdivisions can record noise levels at different points in the development in their assessment. This encourages early design and mitigation to be incorporated.

A summary of the EPA noise criteria is contained in Table 3.4. For all proposed roads and residential land use, noise levels should meet the noise criteria where 'feasible and reasonable'. Long-term strategies such as improved planning and vehicle emission controls, may be the only option if noise criteria cannot be met. In those circumstances

[25] The Southern Sydney Regional Organisation of Councils is an association of eleven local councils that provides a forum for exchange of ideas and advice.

an assessment of 'cost-versus-equity' is required to provide information on community preference and potential long-term solutions to noise.

A review of the 'Criteria' is planned based on feedback from stakeholders (T. King pers.comm.). The Department of Environment & Conservation indicates that the criteria are 'working well' and the review is limited to minor amendments which will address issues raised by users of the policy and document any recent research (T. King pers.comm.). It may include the development of a guide for local government to assist in identifying road traffic noise issues at the land use planning stage. The guide would include developing strategic approaches to preventing noise impacts through the planning process and describe noise control measures that can be built into the initial planning, subdivision and building design stages (T. King pers.comm.). The Department of Environment & Conservation is also discussing the advantages that the planning system can provide in tackling environmental noise pollution with planners (T.King pers.comm.).

Additional land use planning direction is provided by the Department of Infrastructure, Planning and Natural Resources (DIPNR). As yet, the DIPNR has no specific policies or guidelines in relation to land use controls on noise (D. Gainsford pers.comm.). Despite the wide application of 'the Criteria', there appear to be gaps between land transport development and land use planning in NSW that will be addressed during the DEC review.

In addition, the RTA and Department of Environment and Conservation operate a noise abatement programme aimed at addressing noise impacts on properties near existing roads[26]. Priority is given to roads that are not subject to future upgrading and where daytime noise exceeds 65 dBA or night-time noise exceeds 60 dBA. At least one complaint must have been received about noise and the receiver must be classified as a sensitive receiver. Sensitive receivers include schools, places of worship, residences and health care centres. In multi-storey buildings the first two floors are given priority as these are considered the most affected floors. The programme operates through a registration system and adversely affected residents can apply for noise abatement. Where noise abatement barriers are implemented to address noise identified through the programme, they must achieve noise reduction of at least 5 dBA. Treatment must be "cost effective, equitable and practical" (NSW RTA undated).

3.3.2 Queensland

3.3.2.1 Background

Noise is also increasingly an issue in Queensland. This is in part caused by the scale of residential development and proximity to main roads (A. Hall pers.comm.). Noise is addressed in a number of statutory documents administered by the Queensland Environmental Protection Agency, Queensland Transport (QT) and in documents published by the state roading authority, Main Roads (QMR). The overarching legislation on environmental issues is Queensland's Environmental Protection Act (EP-Act). The EP-Act defines noise but is more concerned with nuisance than land transport noise. Below the EP-Act are a number of legislative documents that specifically address land transport

[26] See: *http://www.rta.nsw.gov.au/environment/noise/noiseabateprog.html?elid=3*

noise. More recently, integrated approaches have been identified as critical to future transport use and development to supplement this legislation.

Table 3.4 NSW EPA recommended road noise levels.

Type of development	Criteria	
	Day (7am-10pm)	**Night (10pm-7am)**
Proposed road or residential land use		
New freeway or arterial road corridor	$L_{eq(15hr)}55$	$L_{eq(9hr)}50$
New residential land use developments affected by freeway/arterial traffic noise	$L_{eq(15hr)}55$	$L_{eq(9hr)}50$
Redevelopment of existing freeway/arterial road	$L_{eq(15hr)}60$	$L_{eq(9hr)}55$
New collector* road corridor	$L_{eq(1hr)}60$	$L_{eq(1hr)}50$
New residential developments affected by collector traffic noise	$L_{eq(1hr)}60$	$L_{eq(1hr)}55$
Redevelopment of existing collector road	$L_{eq(1hr)}60$	$L_{eq(1hr)}55$
Land use developments with potential to create additional traffic on existing freeways/arterials	$L_{eq(15hr)}60$	$L_{eq(9hr)}55$
Land use developments with potential to create additional traffic on collector road	$L_{Aeq(1hr)}60$	$L_{Aeq(1hr)}55$
New local road corridor in a metropolitan area	$L_{eq(1hr)}55$	$L_{eq(1hr)}50$
New local road corridor in a rural area	$L_{eq(1hr)}50$	$L_{eq(1hr)}45$
New residential developments affected by traffic noise from local roads	$L_{eq(1hr)}55$	$L_{eq(1hr)}50$
Redevelopment of existing local roads	$L_{eq(1hr)}55$	$L_{eq(1hr)}50$
Land use developments with potential to create additional traffic on local roads	$L_{eq(1hr)}55$	$L_{eq(1hr)}50$
For sensitive land uses		
Proposed school classrooms	$L_{eq(1hr)}40$	-
Hospital wards (internal criteria)	$L_{eq(1hr)}35$	$L_{eq(1hr)}35$
Places of worship (internal criteria)	$L_{eq(1hr)}40$	$L_{eq(1hr)}40$
Active recreation e.g. golf courses Collector and local roads: Freeway/arterial roads:	 $L_{eq(1hr)}60$ $L_{eq(15hr)}60$	
Passive recreation and school playgrounds Collector and local roads Freeway/arterial roads	 $L_{eq(1hr)}55$ $L_{eq(15hr)}55$	

* Collector road – road that connects sub-arterial roads to the local road system in developed areas

Adapted from NSW EPA 1999

3.3.2.2 Key policies

The Environmental Protection (Noise) Policy 1997 addresses all noise sources and includes a long-term 'acoustic quality objective' of external, ambient noise levels of ≤ 55 dBA L_{eq} "for most of Queensland's population" in residential areas. It outlines procedures for decision making in relation to noise producing activities. The aim is to achieve the ambient noise level progressively but no timeframe is provided (Queensland Government 2003b).

Section 5 of the policy has special provision for 'beneficial assets' which include infrastructure such as public roads and railways. The policy defines beneficial assets as necessary for community environmental, social and economic wellbeing but recognises that they can have significant adverse effects on environmental values. Schedule 1 provides guidance to decision-makers and planners on reasonable noise levels for activities related to beneficial assets including land transport, as summarised in Table 3.5. Noise assessment tools are summarized in Schedule 3 of the policy with additional noise measurement guidance published by the Queensland EPA (2000b). Planning schemes must take into account relevant policy.

The Transport Planning and Coordination Act, 1994 includes an objective to improve the quality of life "via overall transport effectiveness and efficiency through strategic planning and management of transport resources" (Queensland Government 1994). The Act provides the framework for developing co-ordinated transport plans that must take in to account, among other things, government land use planning and environmental policies.

Table 3.5 Environmental Protection (Noise) Policy 1997, Schedule 1: Planning levels.

Planning levels measure 1 metre from affected area			
Road	State roads	$L_{10\ (18\ h)}$	68dBA
	Other public roads	$L_{10\ (18\ hr)}$	63dBA
	All public roads	$L_{eq\ (1hr)}$	60dBA
	10.00pm -6.00am	$L_{max\ /\ single\ event}$	80dBA
Rail	Daytime	$L_{eq\ (24\ hr)}$	68dBA
	10.00pm -6.00am	$L_{max/\ single\ event}$	87dBA

Queensland's Integrated Planning Act, 1997 is also relevant. It aims for ecological sustainability through co-ordinated and integrated planning at each government level and contains a planning and development assessment framework. Under the Act, state and regional authorities are required to co-ordinate and integrate local government planning schemes (Queensland EPA 2000a). The State Interest Planning for Noise Management Policy produced by the QLD-EPA outlines how this might be achieved. It outlines sustainability, integration and partnerships as the "foundations of successful integrated transport planning." Noise is recognised as one of the adverse effects of land transport that needs to be addressed through an integrated approach.

The Integrated Transport Planning Framework, 2003 provides additional guidance on integrating transport planning (Queensland Government 2003a). The Planning Framework is a joint initiative of Queensland Transport, Queensland Main Roads, the Department of Local Government and Planning and the Local Government Association of Queensland (Queensland Government 2003a).

The framework is a high level document on integrated and co-ordinated planning for land transport. It includes an overview on managing land use and influencing better transport outcomes such as reduced health and environmental impacts. It signals a move towards more integrated approaches using land use planning tools for achieving desired outcomes. The framework includes desired outcomes, directions and principles on how positive outcomes can be achieved, and planning steps. It is a voluntary framework and implementation is likely to be gradual (M. Carter pers.comm.).

3.3.2.3 Land use planning approaches

Queensland Transport is the government department responsible for the strategic transport policy agenda, transport planning and stewardship, and is comparable, in some respects, to Land Transport New Zealand. Queensland Transport's strategic plan identifies noise as an environmental issue that will need to be addressed in environmental policies (Queensland Government 2004a).

Integration of transport and land use planning is identified as a major issue because lack of integration in previous planning has resulted in a lack of consistency across government (Queensland Government 2004a). The strategic plan outlines how the integration of transport planning and land use planning will be achieved during the next five years by:

- including planning for transport in all initial planning for major government infrastructure,
- using conditions on land development to provide sustainable transport options for purchasers of land,
- giving preference to development in growth corridors and around transit nodes,
- identifying and protecting future transport corridors from encroachment by inappropriate land use (Queensland Government 2004a: 16).

Despite the reference to land use planning, noise strategy at the local level, for example by councils, is inconsistent and often piecemeal (M. Carter & A. Hall pers.comm.). It is intended that the Integrated Transport Planning Framework and additional information on effective planning practices will be implemented to address the gap between land use and transport planning (M. Carter pers.comm.).

As with New South Wales, Australian building standards and the Building Code of Australia provide a baseline for noise levels in new developments. QMR has an accord with local government which requires developers to submit plans for dwellings near state roads and it can request an acoustic report and set conditions based on the findings. QMR use a statutory covenant process to deter developers from relying on noise barriers for mitigation (A. Hall pers.comm.). Covenants are of two types: 'no house covenant' and 'single storey covenants'. To build on these sites developers must meet the acoustic requirements outlined in the AS/NZS 2107. The system is not without problems. Hall (pers.comm.) notes that external noise levels on courtyards and balconies have been problematic and there are numerous disputes about conditions and long-term maintenance of noise barriers where they are used as mitigation.

The Queensland State Government has also produced a draft regional plan for South East Queensland. One of the key principles is the integration of transport and land use. Compact urban areas and efficient transport are core themes of the transport element in the regional plan. Noise is recognised as an impact of transport but the strategy takes a strategic approach rather than dealing with specific impacts.

3.3.2.4 The role of the roading authority

At the operational level, QMR is responsible for state-controlled road systems which constitute 20% of roads and carry 80% of traffic (Main Roads undated). QMR have a similar role to Transit with roads divided between the state controlled road network of highways and major arterial routes, and local roads. Local government is responsible for local roads. The QMR code of practice (COP) has been developed to assist 'progressive compliance' with the EPA noise policy and the COP including what QMR considers best environmental management practice to achieve this outcome. It summarises the procedures required when planning for new roads or addressing noise impacts from existing roads and sets out noise criteria and attenuation options in a similar, although less detailed, manner to the NSW criteria.

Acceptable noise levels outlined in the code of practice vary with the type of road development being proposed. The levels are calculated based on traffic noise predictions for the next ten years. Mitigation decisions are based on whether an increase in noise occurs and whether the increase is between 3 and 6 dBA. All predictions are based on $L_{10\ (18\ hr)}$ levels, or 6am to midnight (Main Roads 2000a).

For new roads or existing undeveloped corridors (similar to designations in New Zealand) where traffic noise will be ≥ 63 dBA and > 3 dBA above pre-construction levels, noise abatement measures will be implemented to contain levels at ≤ 63 dBA. Existing roads and upgrades with no sensitive receivers must meet noise criteria of ≤ 63 dBA.

Where sensitive receivers exist (educational and health buildings), new road noise abatement must achieve indoor noise levels of ≤ 48 dBA and noise abatement on existing roads must achieve internal levels of ≤ 55 dBA. Further levels are provided for parks, outdoor recreational areas and outdoor education areas. The COP outlines relatively complicated noise levels for residential buildings but the overall aim is to achieve 60–63 dBA at 1 m from the most exposed facade. This is set to achieve internal levels of 57 and 60 dBA respectively; classrooms are afforded slightly more protection at 48 dBA $L_{10\ (1\ hr)}$.

QMR will only fund abatement measures within the road reserve. Noise abatement for new developments not identified in development plans is the responsibility of the developer. Any new roads require a full environmental impact assessment, including noise.

In addition, QMR has produced road impact assessment guidelines for developers (Main Roads 2000b). The guidelines are intended for development proposals that may have an impact on the state controlled road network. Impacts on pavement, structures and increases in traffic volumes must be included to assess the significance of effects. Where QMR are considered an interested party, proposals are forwarded for comment. Developers whose proposals are submitted to QMR are required to complete a road impact assessment.

3.3.2.5 Comment

In many ways the Australian experience with land use and transport is comparable to that in New Zealand and we are at a similar stage in addressing transport and land use integration.

Australia’s approach to transport and delegation of responsibility has led to considerable variation between states. In recent years, efforts have focused on centralising vehicle emission controls to achieve greater consistency.

How effective the measures have been at addressing noise or how extensively land use planning tools are used is difficult to ascertain. Integration of land use and transport is a recent addition to regional policy and is not well developed. Although the benefits of land use planning have been recognised they have not been formalised.

Some lessons may be taken from the emphasis on building codes and design. The emphasis is on early design and avoidance of noise and the onus is on home owners or developers to implement effective levels of acoustic protection in their homes. The Building Code of Australia has supported this by establishing a baseline for noise levels. Orientation and layout of homes are considered important to avoid noise and renovation is considered an opportunity to introduce acoustic insulation.

An obvious change in policy direction is occurring, from controlling noise through mitigation at each stage, to encouraging an integrated approach to transport and land use planning. This is consistent with the direction being taken in Europe. Austroads has also indicated a need for ‘harmonisation’ of environmental criteria between states and jurisdictions (AUSTROADS 2004a).

3.4 United States

The US approach to noise is complex. Responsibility lies at federal, state and local level. The main parties responsible for addressing road noise are the Environmental Protection Agency (EPA), the Department of Transportation Federal Highway Administration and state transport agencies. Local governments are responsible for planning (Atash 1996). The US has a long history of noise abatement policy stemming from the enactment of

NEPA in 1969, resulting in a wealth of research on this area. In 1972 the Noise Abatement Act came into force and established the EPA Office for Noise Abatement and Control. However, the Office was abolished in 1982 because of funding issues. The Office was responsible for promoting emission standards, product labelling and co-ordinating federal noise protection; in 1997 and again in 2003, the *Quiet Communities Bill* was introduced to reinstate the Office. The passage of the bill is uncertain; some argue that the present government is decreasing environmental protections (Noise Pollution Clearing House pers.comm.)

Before 1982 guidance on acceptable noise levels and noise impact assessment was produced. *Guidelines for Considering Noise in Land Use Planning and Control* is widely cited and provides techniques and standards for addressing noise through land use planning and outlines the various responsibilities of authorities (FICUN 1980). The EPA indicated that maximum acceptable levels of 55 dBA for external noise and 45 dBA for internal noise were adequate (US EPA 1981). In practice, state and local government have implemented their own noise criteria and noise levels have continued to escalate (Walker 2003).

The Federal Highway Administration (FHWA), an agency of the Department of Transportation, has broad responsibility for the national highway system and provides funding to state governments for state highway and local road projects. It cannot regulate the land use planning development process but advocates for other agencies and state and local governments to practise land use planning and controls near roads. The Federal-Aid Highway Act, 1970 also includes provisions for addressing noise with a requirement for FHWA to develop noise standards for mitigating highway noise.

Project proposals are subject to environmental impact assessment and significant effects require mitigation. The FHWA distinguishes between project types: Type I projects cover noise abatement on new or expanded highways; Type II projects consist of retrofit noise abatement on existing roads. Consideration of noise effects is mandatory on Type I projects if federally funded. Mitigation of noise from Type II projects is voluntary on the part of the individual states; projects compete for funds alongside other construction projects. Noise levels at which abatement requirements are triggered are also higher than WHO recommendations.

US noise abatement is three-pronged: land use planning occurs at a local level, vehicle noise emissions are controlled at numerous levels, and highways noise criteria are set at federal level (FHWA 2000). Mitigation of noise is an expectation and noise barriers are commonly implemented on state highways. The FHWA also encourages developers, government officials, planners, and private citizens to reduce highway noise by "advanced planning and shared responsibility" (Texas Southern University 2002: 2). Evidence of local and state government working together on transport and noise issues is difficult to find and Banister (2002) argues that the connection between land and transport planning has not been made.

Initial attempts to integrate transport and land use planning came with the introduction of the Intermodal Surface Transportation Efficiency Act (ISTEA), 1991. The Act focuses on air pollution and congestion and represents a major shift in federal transportation philosophy (Atash 1996). ISTEA aimed to tackle transport impacts and financial issues by considering the effects of land use policy decisions and transportation simultaneously through 20-year transportation plans (Atash 1996, Banister 2002). The focus of ISTEA is air pollution and congestion; however a requirement exists to assess the effects of measures introduced by the Act, on other parameters including noise. Metropolitan Planning Organisations (MPOs)[27] are responsible for implementing the programme using urban travel demand forecasting models.

Because of the variation in approaches to noise abatement between states it is considered beyond the scope of this document to critique the land use planning controls in all areas of the US. It is useful to consider the controls on noise of individual states: California provides one example of a state that has introduced extensive noise abatement programmes. California has implemented more noise barrier mitigation measures than any other state. By 1998, California had implemented 2,849,000 m^2 of noise barriers, at a cost of $399 million dollars. In contrast a number of states had yet to implement any noise barriers (FHWA 2000).

3.4.1 California

California is the most populated state in the US and boasts the fifth largest economy in the world. Continued growth has resulted in unco-ordinated decision making, single-use zoning and low-density growth planning resulting in increased traffic congestion and widespread transportation impacts including noise (Caltrans 2004). There has also been competition between local jurisdictions for retail developments that generate sales-tax revenue resulting in more traffic movement and poor planning of traffic corridors (Caltrans 2004). Addressing planning and transportation in California is a huge task and numerous divisions are delegated with the responsibility for each aspect, yet noise levels continue to increase alongside traffic volumes and driving speeds (J. Andrews pers.comm.).

3.4.1.1 Caltrans input

California's Department of Transportation (Caltrans) is responsible for the design, construction, maintenance, and operation of the Californian state highway system. Caltrans's Division of Design's (DOD) manual on transport project development procedures (Caltrans 1999) includes a chapter on highway traffic noise abatement. Noise abatement is also covered by the Division of Environmental Analysis (DEA) which administers Caltrans' responsibilities under federal and state environmental law. The DEA develops and maintains Caltrans' environmental standards, policies, procedures, and practices that are then implemented by Caltrans' district environmental branches. The

[27] Metropolitan Planning Organisations are designated agencies for metropolitan areas with population over 50,000. Formed in cooperation with the state, MPOs develop transportation plans and programs for the metropolitan area. MPOs prepare long-range transportation plans and short-range transportation improvement programmes, including funding sources, for the urbanised area and adjacent areas that will become urbanised.

DEA is also responsible for assisting with environmental impact assessments for Caltrans projects.

Under the Transportation Funding Act, 1997, regional transportation planning agencies (RTPAs) are responsible for planning, programming and funding regional transportation improvements. There are 43 RTPAs in California. In addition, 58 Californian state counties deal with land use planning and are required to address noise in county plans. County planning responsibilities are similar to local authorities in New Zealand and are set down in the California Government Code. County planning agencies implement and review general plans which include zoning and subdivision rules; they also review development applications. Section 63502(f) of the Code requires counties to include a 'noise element' providing information on current and predicted growth and traffic levels which provides a baseline for land use and development (see Appendix 7).

The roading authority and local counties operate independently and little policy integration occurs (J. Andrews pers.comm.). Systems have been adopted so that noise forms part of environmental impact assessments and local counties become involved at that stage. Despite planning requirements at County level there appears to be an emphasis on technical mitigation rather than forward planning. New roads and road expansions must undergo environmental review under the California Environmental Quality Act. The environmental impact report includes existing and predicted noise levels. If the project noise level is above the adopted standards (usually over 60 dB at the nearest receptor) mitigation must be included to reduce the noise to that level (W. Zumwalt pers.comm.). Rail development undergoes similar scrutiny but is controlled by Federal agencies and must comply with the National Environmental Protection Act, 1969.

As in other countries, a growing recognition exists of the need for more strategic transport planning to tackle impacts such as noise. The Caltrans transportation planning division provides guidance and advice on transportation planning, cost benefit analysis and demographic studies for demand predictions. They have also developed a Regional Transport Plan (RTP) and a draft California Transport Plan (CTP).

State law and the California Transportation Commission require regional planning agencies to adopt a 20-year long RTP every three years, and for rural agencies to adopt a RTP every four years. The CTP is a state wide plan providing broad, strategic direction. It includes goals to meet its vision for transport in 2025:

> *California has a safe, sustainable transportation system that is environmentally sound, socially equitable, economically viable, and developed through collaboration; it provides for the mobility and accessibility of people, goods, services, and information through an integrated, multimodal network* (Caltrans 2004).

Goal 5 of the CTP is to enhance environmental quality; noise is listed as a performance indicator but given little coverage in the document. Noise is included under goal 4 - policy 6: 'support the economy' and 'enhance goods movement mobility, reliability, and system efficiency'. In the latest report on transportation system performance measures, noise is excluded and environmental quality focused on air quality (Caltrans 2000).

The CTP was developed in response to the outcomes generated by past decision-making and noise remains a key issue (J. Andrews pers.comm.). It notes that planning approaches over the past few decades have had a profound impact on current transportation systems and impacts. Three predominant approaches to land use have negatively influenced urban design:

- a lack of co-ordinated decision-making,
- single-use zoning ordinances isolating employment, shopping and services, and housing locations,
- low-density growth planning resulting in considerable land consumption and sprawl-type urban development that requires higher infrastructure investments because of the distances served (Caltrans 2004).

The CTP is a new document and it is premature to critique its effectiveness. It is interesting to note however, that a long history of noise abatement and environmental policy has been surpassed by the sheer scale of development and expansion in this state.

Caltrans protocol on noise provides guidance to developers by outlining noise assessment of transport proposals, including acceptable noise levels. Noise levels in classrooms are given additional attention in the protocol. Caltrans provides noise abatement for school classrooms where road proposals are likely to cause internal noise levels greater than 52 dBA L_{eq}. Noise levels will be abated to pre-construction levels. Type I proposals are required to undertake a screening exercise to establish whether noise impacts will increase in receiving areas.

Part of the screening exercise for road proposals involves identifying future land use that might be affected by highway noise. The developer is required to identify existing activities, developed lands, and undeveloped lands for which land use is planned, designed or programmed and could be affected by highway noise (Caltrans 1998b). Potential development is considered "planned, designed and programmed", if a noise-sensitive land use has received final development approval.

If noise increases are likely, a traffic noise impact analysis is required and a preliminary assessment of noise abatement design must be submitted. Traffic noise impacts are considered to occur where noise levels increase by 12 dBA L_{eq} or where they exceed the Californian noise abatement criteria (Caltrans 1998a). Noise abatement must be 'feasible' and 'reasonable'. Abatement technology feasibility is based on technical considerations and must be capable of achieving noise reduction of at least 5 dBA. Reasonableness is based on a set of criteria including cost, change in noise level, life-cycle of the abatement technology and opinions of impacted residents. Public consultation on noise abatement is an important part of the process and abatement options will only be permitted if more than 50% of residents want them. In some situations residents near roads seek abatement using barriers but residents away further from the road on hillsides may be against the work because noise will be reflected to them (J. Andrews pers.comm.).

Like Transit NZ guidelines, the Caltrans Protocol places an emphasis on new roads and 90% of abatement in California is implemented on new road developments (J. Andrews pers.comm.). The Protocol places an emphasis on where the responsibility lies, particularly in areas zoned for noise-sensitive developments. The 'date of public knowledge' is used for determining whether noise abatement should be considered as part of the transport project and who (local government agencies or private developers) is responsible. The date of public knowledge is regarded as the approval of the final environmental decision document (Caltrans 1998a). This emphasis on responsibility is applicable in the US where law suits can be taken for personal injury arising from projects including noise impacts (Walker 2003, J. Andrews pers.comm.).

Noise abatement using barriers on existing roads is also undertaken; the approach varies with the funding source and it must fit certain criteria. For retrofitting of state-funded roads the area affected must be residential and noise levels must exceed 67 dBA $L_{eq\ (h)}$ (Caltrans 1999). For Federal-aid funded projects retrofitting is only available for areas where projects were approved before 28 November 1995 or where land development or substantial development predated the highway. Where the criteria are met, noise abatement is prioritised based on the level of noise reduction that can be achieved, whether 67 dBA is measured, the cost of barriers, and the number of residential units. In addition, the number of original occupants is factored in to assess whether they resided there before the noise impacts occurred.

3.4.1.2 Noise mitigation methods in California

Noise barrier technology is the dominant method for mitigating noise. Research shows that noise barriers are effective but they are also expensive and can create new impacts. In contrast, county general plans tend to encourage design and site planning to avoid to noise impacts. The Caltrans preference is exemplified by the extent of noise barrier implementation in California compared with other states. This is in part caused by funding agencies which favour barriers (J. Andrews pers.comm.). The Protocol does encourage other forms of mitigation as follows, though most are reactive rather than preventive:

- avoiding the project impact,
- constructing noise barriers,
- acquiring property to serve as a buffer zone or pre-empt development,
- using traffic management measures,
- insulating and/or air-conditioning public-use or non-profit institutional structures.

Caltrans is investigating pavement technology to reduce noise at source. Quiet roads are not endorsed by federal government which provides funding but research is being undertaking to demonstrate the cost-effectiveness of this form of mitigation (J. Andrews pers.comm.). Caltrans has indicated its aim to include pavement noise in transport proposal decisions (Caltrans 2003),and is also researching the impacts of noise on ecology, in particular on fish and birds.

3.4.1.3 Comment

Although new roads and noise abatement appear to be widely regulated and controlled in California, the outcomes are not particularly good. The Californian experience has demonstrated a need for integrated and pre-emptive land use and transport planning. Once transport and noise levels become a problem mitigation is difficult and expensive.

Land use and transport planning integration is endorsed by the FDWA but does not appear to be occurring in practice. The abolition of the Noise Control Office in 1982 marked a greater decentralisation of noise control in the US and has resulted in minimal direction from central government. Progress in noise abatement at a national level slowed down and individual states developed their own approaches.

The ISTEA established a state-wide transportation planning process and changed the way the MPOs undertook urban transportation planning by assigning them the lead role of defining regional long-term transportation plans. The system has been criticised for its lack of impact on transportation patterns. Despite some gains in air pollution quality other impacts remain unchanged. There are calls for more direction and assistance from federal government to fulfil the requirements of the Act (Walker 2003). Renewed interest in promoting land use compatible planning also exists; federal legislation now prohibits federal participation (or funding) for most noise barriers for new development that occurs next to existing highways (Texas Southern University 2002).

Caltrans and its detailed organisational structure with planning, environmental and design teams allows a certain level of internal integration providing consistency and transparency, but as yet departmental integration tends to be based on providing infrastructure and mitigating any impacts that arise, rather than preventive approaches.

Methods for assessing and mitigating noise are well established in California but land use and planning approaches are less consistent. The Californian counties' approach to attaching specific noise criteria to categories of land use is similar to other international approaches; however their parameters are lenient in comparison to European and WHO policies.

Noise controls themselves in the US are also relatively lenient compared with those in other countries. This is in part because the US approach to dealing with congestion is building more infrastructure rather than implementing alternative modes as in European countries (Atash 1996, Banister 2002).

3.5 Key lessons learnt from international examples

The lessons drawn from the examples discussed can be summarised as follows:

- Noise is not decreasing.
- Incremental noise abatement has not achieved desired results as it cannot compete with the volumes of traffic in cities with large populations and the rate of vehicle and population growth. These factors have outstripped noise abatement capabilities in many countries.
- Prevention is an effective approach to noise abatement and can be achieved through strategic planning that incorporates land use and transport planning. Segregation of planning and transport planning is no longer considered a viable

option. Each of the countries studied now considers more integrated, strategic policy necessary to avoid further impacts from transport as well as in relation to policies associated with other sustainability issues.

- Projecting long-term development and transport demand is critical so that effective land use planning and design controls can be implemented. Ten year projections are unlikely to be long enough.
- Noise abatement is most effective when applied early in the design and planning process and at each stage of propagation. For example, redesigning building layout and planning the location of development is more effective than implementing technical mitigation measures.
- Choice is limited in populated urban areas with existing problems. Where noise levels exceed acceptable criteria retrofit programmes may be necessary utilising technical solutions such as barriers and acoustic insulation.
- Consistency in addressing noise is simpler to achieve when noise criteria are established at central government level.
- Technical solutions are more commonly used for addressing rail noise. However, scope exists to apply land use planning to new rail networks.
- Sensitive receivers require the highest level of protection, and many are currently unprotected.
- Preserving existing quiet areas is an important element of noise abatement.
- Noise policies and strategies need to evolve over time to keep ahead of increasing noise levels and respond to growth.

Table 3.5 Examples of noise criteria for counties in California.

County	Land Use	Noise Level (dBA)		Notes
Butte	All	60		- No descriptor given; noise not considered a significant problem - Noise insulation of new multi-family dwellings constructed within the 60 dB noise exposure contours is required
El Dorado (proposed)	Residential, transient lodging, hospitals, nursing homes Office buildings, libraries and museums Theatres, auditoriums and music halls Playground, parks Churches, meeting halls and schools	60 (exterior) 45 (interior) 45 (interior) 35 (interior) 70 60 (exterior) 40(interior)		- LAeq is the descriptor; the policy does not apply to existing dwellings - Acoustic analysis required for sensitive developments in areas exceeding criteria; and developments emitting noise exceeding criteria - Design and site planning preferred mitigation (and setbacks areas adjacent to Highway 50); noise barriers are only considered after all other practical design-related noise mitigation measures have been integrated into the project and the noise barriers are not incompatible with the surroundings - New development of noise-sensitive land not be permitted in areas exposed to existing or projected levels of noise from transportation noise exceeding the criteria unless the project design includes effective mitigation measures - Noise created by new land transportation noise sources, shall be mitigated so as not to exceed the levels specified at existing noise-sensitive land uses
Los Angeles	No noise levels outlined in either the existing or draft updated plan			- Priority is given to avoiding noise rather than mitigation - Policy to avoid development in areas where outdoor ambient noise >55dB Leq unless exterior noise levels can be mitigated to ≤ 45db Leq - The implementation of aesthetically designed noise barriers is encouraged
Nevada	 Rural 7am-7pm 10pm-7am 7am-10pm	**Leq** 55 50 40	**Lmax** 75 65 55	- Transportation is the most prevalent noise source in Nevada - The criteria are for external levels - Standards apply where there are sensitive land uses only - Sensitive land uses include residential, schools, hospitals, nursing homes, churches and libraries - Where the zone is mixed the more restrictive, plus 5dB applies - Where the ambient noise level exceed the criteria standard shall be 5dB above the ambient level (**Table continued next page**)

County	Land Use	Noise Level (dBA)		Notes
	Residential and public			-
	7am-7pm	55	75	
	10pm-7am	50	65	
	7am-10pm	45	60	
	Commercial and recreation			
	7am-7pm	70	90	
	10pm-7am	65	75	
	Business park			
	7am-7pm	70	85	
	10pm-7am	65	70	
	Industrial	80	90	
Sacramento		Internal	External	- Policy applies to new land transport adjacent to residential areas and new residential developments adjacent to land transport noise sources Mitigation measures must achieve external levels of 60dB to 65dB Ldn* and 45 dB Ldn
	Residential, transient lodging, hospitals, nursing homes	60	45	- Includes noise levels which are 'acceptable, conditionally acceptable and not acceptable' based on land use
	Concert halls and auditoriums	60	30-35	- With some exceptions, land use is prohibited where levels exceed 75 dB Ldn
	Playgrounds	70	-	
	Office buildings and commercial	65	-	

* Ldn = day-night level

4. New Zealand planning and policy

The current approach to transport noise management in New Zealand is often project-based, dealing with developments on a case-by-case basis through an assessment of environmental effects. Most territorial authorities have district plan provisions on noise but few include transport noise as a specific issue.

In addition to regulatory documents, a number of voluntary guidelines and standards have varying applicability to noise management. They include technical standards, Transit New Zealand policy and government transport strategies.

4.1 The Resource Management Act

The principle legislation for dealing with environmental impacts in New Zealand, including impacts on people and communities, is the Resource Management Act, 1991 (RMA).

Section 16 of the RMA outlines a general duty to avoid unreasonable noise; under the Act noise includes vibration. It states that the best practicable option shall be adopted to ensure that the emission of noise from activities does not exceed a "reasonable level". Local authorities may prescribe noise limits through planning provisions. This complements the overall duty to avoid, remedy and mitigate environmental effects prescribed in section 17. Noise is commonly addressed through resource consent and designation procedures for new or modified transport developments.

At a district level, the RMA assigns territorial local authorities the responsibility for the control of any actual or potential effects of the use, development, or protection of land, which includes the control of noise. In addition sections 43-44 of the RMA allow for the development of regulations at a national level via National Environmental Standards (NES). NES prescribe technical standards, methods, or requirements for environmental issues, including standards for noise. They provide a consistent minimum standard on particular environmental issues, potentially at the cost of being able to respond to local conditions.

4.2 Land Transport Management Act

The Land Transport Management Act 2003 (LTMA) expands the responsibilities of Land Transport New Zealand[28] and Transit which must now take account of social and environmental issues in funding and assessing transport proposals. In this respect, the LTMA is fundamentally different from previous land transport legislation.

The LTMA amended the Land Transport Act (1998) and the Transit New Zealand Act 1989. Its purpose is to ensure funding and construction is consistent with the aim of achieving "an integrated, safe, responsive, and sustainable land transport system" outlined in the New Zealand Transport Strategy (Chapman Tripp 2003a). In achieving this purpose the

[28] Formerly Transfund New Zealand, and the Land Transport Safety Authority.

Act provides for a number of things including an integrated approach to land transport funding and improved long-term planning and investment in land transport.
The LTMA requires relevant authorities to improve long-term planning and investment in land transport. This includes developing regional land transport strategies and passenger transport plans.

4.3 Existing district planning rules

In fulfilling their functions under the RMA territorial authorities (TAs) are required to establish and implement objectives, policies, and methods to achieve integrated management of the effects of the use, development, or protection of land and resources of the district. This translates to the development of district planning documents. Of the 74 TAs in New Zealand, 48 have operative plans and only a small number have specific provisions dealing with transportation noise.

At present there are a number of shortcomings in policies dealing with transportation noise by territorial authorities. A survey of district plan provisions for the control of road and rail noise was completed in June 2003 (Incite 2003a, 2003b). The survey reflected preliminary findings that there are significant gaps in the understanding of land use planning options to control land transport noise in district plans developed under the RMA.

The report found that only eleven[29] of the councils surveyed had district plan provisions to control the impacts of noise on sensitive activities. Three of the eleven[30] respondents had rules limiting noise emissions from road vehicles on roads. No specific controls relating to rail noise were identified. Additional information from a smaller group of respondents was sought to establish how effective the rules were and what monitoring was proposed. The majority of respondents noted problems with implementation and lack of monitoring or results. The councils used a variety of mechanisms to establish the rules. In December 2004 the five key respondents were contacted again. Few changes were reported. The key rules for each council are included in Appendix 3.

Those District Plans with rules focus on new developments, and address existing noise issues only where new residential building is proposed near a transport corridor. Most councils have rules that specify acceptable noise levels at the receiver, rather than at source, representing an end of pipe approach to noise control. The most common control on receivers is the requirement for new dwellings to meet specified noise limits, in some cases using acoustic insulation. Hamilton City Council extends the requirement for noise limits to existing residential buildings and Rodney District Council has provisions for schools, hospitals and educational facilities. Controls on the source of noise are less commonplace. However, North Shore City Council reports that quieter road surface ‘hot seal’ can be applied to local residential roads if residents are prepared to pay (T. Reidy pers.comm.). This is an interesting response in that the affected party is fully responsible for mitigation costs.

[29] 18% of respondents.
[30] 5% of respondents.

Although the group was small, inconsistencies in approaches are evident and a more robust, consistent approach to establishing policies and rules on noise pollution is needed if the anticipated outcomes of the New Zealand Transport Strategy (NZTS) are to be achieved.

Inclusion of road and rail noise controls in district plans and regulations is uncommon. At worst, this is a gap that could lead to unsustainable transport and land use planning that fails to address the long-term implications of urban development and growth.

A common complaint of councils is the lack of consistent guidance on noise standards and acceptable values. While not perfect, the use of New Zealand Standards on air and port noise demonstrates that consistent guidance has a good uptake and can assist local councils implementing policies on noise. More consistent guidance and direction on acceptable noise standards is considered pertinent to avoiding increases in noise impacts on sensitive receivers. Integrating policies is also very important for achieving consistency in plans, particularly given the structure of council boundaries.

4.4 Transit New Zealand Planning Policy Manual

The purpose of the Transit Planning Policy Manual (1999) (PPM) is to set out Transit's policies for ensuring that adverse effects arising from the construction and operation of state highways are avoided, remedied or mitigated. In addition, it aims to ensure surrounding land uses do not adversely affect the highway system. Achieving the purpose is dependent on available funding and is a set of ideals rather than standards. The PPM aims to assist Transit to manage the state highway, including new highway development, and anyone involved or affected by state highway issues. The PPM does not contain an overall vision for future planning outcomes and takes a project-based approach rather than the more strategic approach to environmental assessment embodied in the more recent Transit New Zealand Environmental Plan (2004).

In 1999, Transit's aims mirrored their statutory responsibility at the time for delivering a "safe and efficient" state highway network, with the legislative requirement to let network management and maintenance contracts through 'competitive' pricing procedures. This was similar to Transfund's allocation objective of achieving a safe and efficient transport system. More recently Transit's objective has been expanded to "operate the State highway system in a way that contributes to an integrated, safe, responsive, and sustainable land transport system" (section 77, Land Transport Management Act 2003). While the PPM discusses environmental management it is aimed at encouraging contractors to adopt EMS practices and the development of codes of practice to cover key environmental aspects of maintenance and construction work. The PPM clearly needs updating to reflect changes and the focus of the current Government and legislation.

Transit's 1999-based environmental objectives reflect the RMA section 17 duty to "avoid, remedy and mitigate effects". However, project-based environmental assessment is prevalent and long-term goals of sustainable management through land use planning for noise are lacking. Transit's approach was to deal with environmental issues associated with transportation on a case-by-case basis subject to economic efficiency (which then determined funding). Little discussion occurs on existing road impacts other than addressing impacts of maintenance activities although Transit do make a commitment to consultation and addressing adverse effects in the PPM.

Social and economic effects are identified as community severance, effects on amenity, and barriers between communities. Noise is also identified as a potential and growing issue in the PPM. While the PPM discusses noise effects from construction and new roads, it does not address existing roads.

The policies on noise read:

i. *To address the effects of noise in relation to new rural and urban highways in the Assessment of Environmental Effects required by the RMA.*

ii. *To provide some degree of protection from the adverse effects on noise arising from the adverse effects of noise arising from construction activities.*

iii. *To provide some degree of protection from the adverse effects of traffic noise for residential and other noise sensitive areas adjoining high noise State highways within existing 'noise affected areas'.*

iv. *To facilitate, where practicable, any other measures that reduce noise generated by roads.* (Transit 1999)

The policies rely to some extent on the development of a New Zealand standard for road traffic noise, reducing heavy vehicle noise through re-routing and adoption of noise mitigation by territorial authorities. As few of these have reached fruition, Transit's aims have not been achieved in full.

4.4.1 Transit New Zealand's noise guidelines: Appendix 6 of the PPM

Appendix 6 of Transit's Planning Policy Manual (1999) contains guidelines for dealing with road traffic noise for new roads or improvements that require a new designation[31]. The guidelines apply to some noise-sensitive facilities adjacent to new state highway stretches aimed at achieving cost-effective noise avoidance and mitigation.

The Noise Guidelines are a 'design' guideline, to assist Transit to design new roads and major road improvements in a manner that ensures traffic noise does not exceed a reasonable level. The noise levels that a new road is to be designed to are highly dependent on the ambient noise levels in the locality in that noisier roads are permitted in noisier areas, under the following categorisation of ambient noise levels:

- low-noise areas: 50dBA $L_{eq\ (24\ hr)}$,
- medium-noise areas: 50-59dBA $L_{eq\ (24\ hr)}$,
- high-noise areas: >59dBA $L_{eq\ (24\ hr)}$.

[31] A designation is a mechanism under the RMA which is like a 'spot zoning' over a site or route in a district plan. This 'spot zoning' authorises the requiring authority's works or project on the site or route without the need for a subsequent land use consent from the relevant territorial authorities. Once the designation is put in place, the requiring authority may do anything in accordance with the designation, and the usual provisions of the district plan do not apply to the designated site (MfE 2004).

Noise levels are assessed one metre in front of the most exposed facade of permanently occupied buildings, measured as $L_{eq\ (24\ hr)}$.

Residential areas and teaching environments are considered the most sensitive receptors of noise in the Guidelines. Although sleep disturbance is identified as a key impact, sleeping as a secondary activity, for example sleeping accommodation in retail areas, is excluded. Only living areas, including kitchens, are considered areas requiring internal noise mitigation. Noise buffer strips are endorsed for designations and state highway improvements and encouraged through rules in district plans for existing state highways. Noise buffer strips of 20 and 50 metres, for residential and rural areas respectively, are recommended in the Guidelines, but do not appear to have been universally achieved by either Transit or local authorities.

The Transit Noise Guidelines are essentially the only New Zealand guidelines on land transport noise emissions. Although less then perfect, the guidelines are widely referred to by Transit, other roading authorities and local authorities. The guidelines are adhered to closely and only in exceptional cases are they deviated from, up or down. Lack of other guidelines means they are at times used for purposes outside the narrow application they were written for: new roads or substantial improvements requiring a new designation by Transit. There are several significant limitations of the guidelines, which limit either their use by Transit, or their wider application for land use planning. These include:

- Limited application to the design of new roads or substantial improvements requiring a new designation by Transit. On this basis, the guidelines do not apply to new roads or substantial improvements which may have been designated decades ago.
- A lack of application and consideration of how to deal with existing transportation noise impacts and the cumulative effects of noise. Including only provisions for new roads and improvements fails to address the impacts of changes to traffic volumes, flows, and cumulative noise arising from new roads and improvements.
- The measurement location for noise, being one metre in front of the most exposed façade of permanently occupied buildings, does not account for undeveloped land for which urban development is likely. This includes areas with a residential zoning or areas on the urban fringe. Given the often long-term nature of planning for new roads, by the time the road is built it can then be surrounded by sensitive receivers. The measurement location has also attracted some Environment Court criticism, particularly with respect to schools[32].
- The Guidelines "look forward" 10 years in some cases, which may be too short.
- The $L_{eq\ (24hr)}$ measure has limitations, including the applicability of the measure to buildings or facilities that are occupied for less than 24 hours, such as schools. In addition, it recognised that $L_{eq\ (24hr)}$ is not ideal for 'describing' the noise level actually perceived by receivers. The guidelines do not cater for undeveloped, residentially zoned areas, or future planning.

[32] See Nelson Intermediate School v Transit NZ C35/2004 paragraphs 96-98 and 103-104.

- The design noise levels set out in the Guidelines have attracted criticism over several years. They are largely inconsistent with levels in local authority district plans, and have no upper limit. Essentially, when a new road is to be built in a high noise area, it can match the ambient noise level. This is a somewhat crude guideline, as the existing noise may be created by inappropriate road noise, or some other relatively temporary source.
- The onus is on territorial authorities to develop suitable land use controls in existing noise problem areas, and few territorial authorities have embraced this.

Overall, it is timely to consider the Transit Guidelines in the context of land use planning for noise, as land use planning needs to encompass controls on emitters and receivers, and the Transit Guidelines, from an emission point of view provide a valuable baseline and provide the main source of experience.

4.5 New Zealand Transport Strategy

The NZTS provides a reference point for transport strategies (Ministry of Transport 2002). It is part of the Government's overall aim to return to the top half of OECD nations. This includes meeting OECD guidance and recommendations on transportation including impacts arising from transportation such as noise. The Government's overall vision for transport is:

> *By 2010 New Zealand will have an affordable, integrated, safe, responsive, and sustainable transport system.*

The strategy contains a number of objectives aimed at meeting this vision, including protection and promotion of public health. Noise is considered one of the negative aspects of transport. The Strategy aims include greater emphasis on social and environmental planning in transport planning and funding. Noise is considered a key public health issue in the NZTS (Ministry of Transport 2002).

A key policy approach for dealing with issues such as noise and emissions is to promote alternatives to motorised methods of transportation and reducing the need to travel (e.g. by using telecommunications networks). Rail is also considered a preferable method of transportation. While rail is considered to have less environmental impact than roads, noise remains a concern and, if rail is more widely used, appropriate strategies for dealing with rail noise will also require consideration.

The major difference between this and earlier transport strategies is a shift in emphasis from road building to a more sustainable, broader view of transportation, which is consistent with international approaches. The emphasis is on alternatives to transport and promotion of walking, cycling and public transport. Non-vehicular movement is encouraged for journeys of less than 2 kilometres.

4.6 Transit New Zealand's Environmental Plan

Transit's Environmental Plan (the 'Plan') represents a significant change in direction regarding sustainability issues. The key change is the focus on managing the interface between the state highway system and the environment and the recognition that environmental management is a key element of sustainability. This is in stark contrast to the 1999 Planning Policy manual which outlined "efficient movement of traffic" as the centre of sustainable transport systems. The Plan lists key environmental issues as:

> *Noise levels, air quality, water resources, resource efficiency, culture and heritage, visual quality, ecological resources and vibration levels.*

The Plan takes a strategic approach to dealing with these issues by outlining a key message, objectives for a given issue, an implementation plan with responsibilities outlined, and annual performance measures. A key difference between the Plan and earlier documentation is a commitment to continuous improvement and review through annual performance measures and integration of responsibilities.

Noise is considered a significant environmental risk in the Plan; the critical change is the consideration of existing state highway noise levels and impacts. Transit aims to address the impacts of noise by setting an acceptable noise level of ≤ 65 dBA $L_{eq(24\ hr)}$ on new roads. Noise levels exceeding 65 dBA $L_{eq(24\ hr)}$ will be minimised. In addition land use planning tools will be used to deal with noise-sensitive areas. Road surfacing is the preferred option for reducing existing noise. This can be considered mitigation at source and is considered a more effective approach than dealing with noise where it is received. Construction and maintenance noise is also considered in the Plan.

It is clear from the Plan that information on noise levels and sensitive sites is lacking. An approach to environmental assessment is included to address these gaps and Transit intends to develop a better understanding and share knowledge on particular areas, including noise. A GIS of the state highway network is included under the *environmental assessment* objective and would integrate well with developing noise maps. The data collected from these assessments will enable prioritisation of retrofitting in noise-sensitive areas or where issues are arising. The success of such approaches will be subject to monitoring and a key outcome of 'no-complaints'.

Noise impacts are considered independently, as well as being part of the other approaches, such as land use planning and environmental assessment. Land use planning will be the basis of many of the long-term objectives for road transport. Transit considers effective district and regional planning has a critical role in addressing some of the wider community issues such as reverse sensitivity, long-term community planning and a responsive transport system. Transit recognises the value of this type of collaboration and relevant methods of implementation are included.

A crucial element of fulfilling the Plan objectives, particularly noise, is data collection. Without that, information improvements and priorities will be difficult to assess. In addition, buy-in from territorial authorities will be critical to achieving many of the land use approaches. This has not been fulfilled with earlier approaches and it is likely that an integrated commitment with central government and developers will be necessary to ensure noise standards are agreed and implemented at road development and land use planning stages.

4.7 New Zealand Standards

Standards provide a further non-mandatory option for addressing noise levels. Both port and airport noise are covered by New Zealand Standards. Standards provide specifications and criteria for classification of materials, manufacturing testing and terminology (International Standards Organisation 2004). They are voluntary and do not have any legal status. Standards are often market-driven; for example the development of the ISO 14001 standard on environmental management is a response to growing concern and action on environmental issues. In addition standards can assist regulatory compliance by specifying guidance on achieving outcomes (Standards New Zealand 2004).

New Zealand Standards for airport noise (NZS 6805:1992) and port noise (NZS 6809:1999) were published in 1992 and 1999 respectively. The aim of the Standards is to provide methods and guidance on establishing noise assessment and land use planning provisions through local authority plans. The Standards outline methods for establishing controls using zoning, imposing controls or restrictions on land use within specified zones and establishing noise limits. Measurement techniques for noise are covered by NZS 6801:1999.

A number of councils have adopted the guidelines and levels in their District Plans. However, acoustics specialists have expressed concerns with the values and the lack of consideration of existing noise by the standards (S. Camp pers.comm.). Air and sea ports are regarded as essential infrastructure or activities that are impractical to relocate. The guidance in Standards is therefore considered a compromise with responsibility allocated to the port or airport operators and surrounding land owners (Allan 2004)

4.7.1 NZS 6809 Port noise

NZS 6809:1999 outlines potential land use planning measures for use by local authorities to control and mitigate the impacts of noise from ports through provisions in district plans under the RMA. The Standard is applicable to new, altered and existing ports. It outlines a number of methods based on identifying current and future areas affected by port noise. Noise-sensitive activities are subject to restrictions depending on the zone. Zoning is based on the concept of inner and outer control boundaries identified on maps using noise contours. The Standard encourages local authorities to address future noise-sensitive land uses by restricting development within the zones. Existing noise-sensitive areas are addressed through measures such as acoustic treatment.

Acceptable maximum noise levels are specified for the two zones. Only new development that is compatible with noise levels within each zone is encouraged. The inner boundary is defined by the area of land used for port purposes or where land and water is within a contour of noise of ≥ 65 dBA $L_{dn.}$ The standard encourages local authorities to include provisions in plans that prohibit noise-sensitive activities such as residential development, hospitals and schools, from occurring in the inner boundary. Outer boundaries are defined by the predicted 55 dBA L_{dn} contour. It is recommended that new development and alternations be subject to conditions such as acoustic treatment. Between the two boundaries noise abatement conditions are recommended for sensitive activities. Where insulation of noise-sensitive development is required, 45 dBA L_{dn} is the maximum sound level stipulated for any room used for a noise-sensitive activity measured with windows and doors closed. This may limit room use during warmer weather unless air-conditioning is provided.

NZS 6809 outlines criteria for noise mitigation for new and existing ports and suggests a rule status for each. For example, new noise-sensitive activities in the inner zone of existing ports should be prohibited and alterations and additions to existing buildings should be discretionary with conditions requiring adequate insulation. New ports are subject to slightly different rules. In the outer zone any type of development, new or existing is discretionary. Discretion relates to whether adequate insulation is provided. New ports are also encouraged to establish buffer areas. Future projection of 55 dBA L_{dn} and 65 dBA L_{dn} contours also features in the standard to encourage long-term planning responses. Local authorities are encouraged to establish relevant policies, objectives and rules to define the status of activities within the boundaries.

In setting noise limits the Standard provides guidance on long- and short-term noise limits. The former is used for compliance monitoring within the port, the latter for controls on noise away from the port. These have been adopted to allow for the different industrial requirements of ports outlined in the standard. Day and night-time limit levels are replaced with day-night averages calculated over a consecutive 5-day period. This allows for slightly higher limits for existing ports and aims to strike a balance between operational needs and the external environment. The Standard also outlines requirements for noise management plans to be completed by the port in consultation with the local authority.

A number of territorial authorities have included the restriction elements of the Standard as provisions in their Plans. The former Banks Peninsula District Council (BPDC) included a policy that levels of noise shall be consistent with guidelines set out in the relevant New Zealand Standards. Lyttelton Noise Control Maps are included in the BPDC Plan to address noise arising from Lyttelton Port with inner and outer noise controls levels set at 60 dBA L_{dn} and 55 dBA L_{dn} respectively; additional levels are set for night and L_{max}. Tauranga City Council (TCC) has also adopted specific provisions for port noise with boundary noise levels set at 65 dBA L_{dn} and 55 dBA $L_{dn.}$ TCC includes provisions for new and existing sound levels for residential buildings, educational buildings and hospitals.

The approach taken by both Councils is very similar to the NZ Standard guidance. The TCC Plan also includes provisions to deal with ventilation where windows and doors are to be kept closed to achieve the noise standard; the rule is specific to in habitable rooms and additions beyond 25% of existing floor area. Insulation that results in measurements of 35 dBA L_{10} or less with windows open is also acceptable.

Dunedin City Council has also incorporated the mapping of noise contour into their Plan. Problems arising in Port Chalmers are mainly the result of existing noise impacts there. The Port offers residents living within the 65dBA L_{dn} noise contour the choice of insulation to achieved an internal noise level of 40dBA L_{dn} (with windows and doors closed) or purchase of their house so they may move (J. Sule pers.comm.).

Overall, NZS 6809 appears reasonably well adopted by local authorities. However, for each port, minor variations from the standard have developed to respond to community concerns, port company needs or local authority views. As each port in the country has to deal with only one set of rules, this is not a particular concern.

4.7.2 NZS 6805 Airport noise

NZS 6805 contains less detail than NZS 6809: it still focuses on land use through air-noise boundaries and zones but contains additional detail on technical elements of noise measurement and recording. The Standard includes set limits for average daily amount of aircraft noise exposure permitted in the vicinity of the airport. Noise data is based on average 24-hour exposure over the busiest 3 months of the year with a night weighting. Like port noise, airport noise is generally concentrated in a specific area and can be addressed in slightly different ways from traffic noise, e.g. controls on night movements are possible.

The 'air noise boundary' is defined by the area subject to average weighted noise levels exceeding 65 dBA. Like port noise the outer boundary is the zone where noise levels are less than or equal to 55 dBA. Noise control measures are required when levels exceed 65 dBA L_{dn} or 55 dBA L_{dn}. In the outer zone, sensitive land use is discouraged. NZS 6805 encourages local authorities to establish compatible land use planning and establish maximum acceptable levels of exposure in plans. The most common response from Councils has been to implement exclusion zones around airports and to keep an active eye on proposals in the relevant area. Future noise predictions are required for areas likely to be subject to noise levels of 55, 60, 65, 70, and 75 dBA using sound exposure contours over a ten year period. The Standard recommends projecting noise levels for a minimum of ten years which is considered consistent with local and district plan durations. Projections are based on aircraft type, flight frequency and timings.

Both standards recommend minimum levels required to protect people from the effects of noise although local authorities may set stricter standards in their plans. This became the subject of debate in an Environment Court hearing that took a 'a 'tortuous route' on its journey to resolution (Robinsons Bay Trust, National Investment Trust, Christchurch International Airport Ltd, Clearwater Land Holdings & Others, Suburban Estates Limited v Christchurch City Council in "the Christchurch Airport Case"). The hearing involved one of the largest gatherings of international acoustic experts in NZ (S. Camp pers.comm.). The Christchurch Airport Case focused on Rule 6.3.7 of the Proposed City Plan regarding peripheral urban growth involving noise-sensitive activities. Submitters questioned whether the noise control contour line should be set at 50 dBA L_{dn} or 55 dBA L_{dn}. Christchurch City was the first authority to propose an outer contour of 50 dBA, 5 dBA lower than the New Zealand Standard recommendation. The district and regional authorities argued that the lower value would better satisfy the requirements of the RMA. The Court agreed, concluding that the 50 dBA limit was consistent with the Act and the proposed city plan and would not impact on future land use.

4.7.3 Comment

The New Zealand Standards for port and airport noise offer specific solutions to meet the requirements of those industries. Emphasis is on the sustainability of ports and airports given their immovability.

The key difference between controlling this type of noise and road noise is that the Standards offer reactive solutions. Controls at source are not included in the methods except for some consideration of future port development plans. Airport and port noise can be effectively controlled through limiting operating times. Flight times and patterns can be projected annually and appropriate controls implemented.

Further issues with New Zealand Standards are the inability to state any 'policy' within the standards, and the difficulties of varying interpretations being applied across what is essentially a linear network.

While the Standards are not mandatory, the relatively consistent uptake of the Standards indicates that a role exists for robust guidance on implementing solutions to noise.

4.7.4 A New Zealand Standard for road noise?

In 2000 a technical committee was set up to produce a New Zealand Standard for road noise (NZS 6806). It appears to have commenced with a strong basis of the Transit Noise Guidelines, with additional guidance information for local authorities.

The technical committee was unable to agree on some significant issues, including an overall maximum noise level for road noise. The technical committee was promoting the L_{dn} noise measure, and a set of district plan rules to discourage sensitive receivers from moving closer to high noise roads.

Acrimony between members of the technical committee was evident The Standards project was wound up in about April 2001, when it was obvious that agreement would be unable to be reached between the technical committee members.

4.8 National Environmental Standards

National Environmental Standards (NES) are a mechanism under the RMA to provide regulatory and national direction on issues affecting New Zealand. NES set mandatory minimum standards that apply nationally and their aim is to create consistency and certainty across the board.

The first NES relate to air quality. Of the fourteen, seven relate to the banning of activities that discharge dioxins and other toxics into the air; five standards address air quality; one addresses wood burners, and one is on collection of landfill emissions.

In many ways NES are comparable to New Zealand Standards in that they provide a consistent approach and direction for planners, developers and individuals. The key difference is their legal status and mandatory nature. NES automatically apply to local and regional authorities which must include them in resource consent decisions and planning policies. This is considered the key benefit of the NES approach.

An NES on land transport noise is a strong mechanism to address the major deficiency in achieving sustainable outcomes which is the voluntary and likely haphazard uptake of guidance. An NES might include minimum acceptable noise level criteria for avoiding health impacts, so that councils could set rules for both the establishment of sensitive receivers, and noise emissions from transport routes.

4.9 Future directions using current policy and approaches

The opportunity to develop land use planning options for controlling transport noise has been missed by many district councils which have developed district plans that lack controls on road and rail noise and provide little direction on land and transport development issues. Little integration of noise abatement policy or guidance in New Zealand has occurred.

The stark contrast with the inclusion of controls on port and airport noise in plans is caused by the availability of guidance as much as the nature of port and airport developments, which are relatively static and predictable. While the voluntary standards have evolved little since their development, and most stakeholders agree they could be improved, the recurring comment from district council staff is that a lack of guidance and resources has hindered development of appropriate standards on land transport noise.

Addressing transportation noise requires long-term projection of wider issues including land use and transport predictions. Current policies on noise are fragmented. Transport noise is considered in more recent policy but generally forms part of wider transportation strategies. The most comprehensive guide on noise and road development is contained in the Transit Guidelines yet these are outdated and have a narrow scope. The 1999 Guidelines mirror the ‘predict and provide’ philosophy which focuses on meeting transport demand with the provision of new infrastructure (Owens 1995), a philosophy that was prevalent in many countries until the 1990s and can fail to integrate long-term requirements. Many of those countries, including the UK, Australia and the US, are now looking at more integrated approaches in a bid to achieve sustainable outcomes dealing with transport as a whole and noise as a specific issue.

New Zealand is in the process of updating approaches to transport with the publication of the NZTS and the LTMA. The statutory framework for implementing noise strategies using land use planning tools has been in place since the enactment of the RMA. These additional documents signal a significant change in the direction of transport planning and should give direction and impetus to more effective regional planning.

New Zealand is presented with an ideal opportunity to address noise using current statutory planning tools and various mitigation described in the preceding sections. It is clear that from the range of abatement options, preventive strategies such as effective land use planning provide the best results. Existing noise problems will require more technical solutions. For these to be implemented, developers and planners need clear direction on acceptable noise levels, for example via a national environmental standard. No single method will achieve effective noise abatement.

5. Land use planning

5.1 What is land use planning?

Land use planning is a widely used term. In its simplest form land use planning is the process of assigning land to different uses. Alternatively, land use planning has the task of determining where and in what form development can occur (DETR 2001). In New Zealand, land use planning is synonymous with the regional and district planning requirements of the Resource Management Act.

Land use planning definitions are often determined by the advocate. For example, the former UK Confederation of Business and Industry (CBI) describes land use planning as a tool which aims to protect environmental assets and establish the location of essential infrastructure (CBI 2001). Chapin & Kaiser (1979) widen the scope and define land use planning as "the process of identifying and analyzing problems and exploring and assessing options open to a community in pursuit of general goals and specific land development objectives”. Land use planning involves balancing social, market and ecological values while monitoring and responding to change (Kaiser et al. 1995).

Since the publication of the Brundtland Report in 1987, the role of planning has been revitalised (Owens & Cowell 2002). Land use planning has evolved from the traditional ‘town planning’ concept providing for infrastructure and service facilities, to a tool for achieving sustainable outcomes. A suitable definition of current land use planning is:

> ***Land use planning:*** *The systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses* (European Environment Agency website).

Land use planning may occur at an international, national, district or local level. Good land use planning allows for participation by land users, planners and decision-makers. This practice is inherent in New Zealand's RMA which endorses a participatory approach.

5.2 Transportation and land use planning

Transport planning may be considered part of land use planning. Historically, transport planning has been undertaken separately from land use planning but it is now accepted that development (including road development) and land use influence both the quantity and mode of travel (Owens 1995). In turn, the quantity and mode determine the noise levels emitted. Noise therefore can be considered an element of both land use and transport planning.

Increasing interest in planning for transport and land use in tandem exists to ensure that the adverse effects of one do not impinge on the other. This interaction has also been given greater attention since the 1990s (Owens 1995, Owens & Cowell 2002). It is now considered pertinent to align land use and transport planning (Owens & Cowell 2002, Banister 2002, Still et al. 1999). In addition, land transport should not be exempt from land use controls.

The number of cars per capita is often used as an indicator of the impact of transport (Bertolini & le Clercq 2003). Car volumes and speeds correlate well with level of negative environmental impact. For example, as vehicle numbers increase so does noise. Thus, sustainable urban transport and land use planning often focus on decreasing car use and providing alternative modes of transport (Owens 1995). Malcolm Hunt Associates (2004) note that a significant reduction in traffic volumes is required to reduce noise levels.

This thinking is reflected in a number of international and national policies that focus on reducing car use through promoting walking, cycling and public transport[33]. In Perth, Australia, this approach was initiated under the 'three E's' for urban transport 'equity, efficiency and environment' which translates to:

- equity through accessibility for all,
- efficiency of the transport system,
- environment for the liveability of cities (Taylor & Ampt 2003: 167).

The concept of integrating land use and transport planning recognises that transport is linked to housing, land use, transport networks, commercial development and recreational assets (Rabinovitch 1996). While this may seem obvious, roads and other types of development often occur separately. In the past, transport policy has focused on projecting and meeting demand through infrastructure, where funding is available (Owens 1995).

Transport and land use planning can be combined to ensure adverse effects are avoided where practicable. This requires long-term projections to be made about transport and development demand, and then co-ordinating those projections to ensure sustainable outcomes. The role of land use planning is to assist this process by assigning areas of appropriate land use and designing cities and suburbs in a manner that avoids or reduces the effects of associated transport demand, including noise.

There are alternative views. Kassoff (2004) argues that 'sustainable highways' and the implementation of systems to cope with growing car ownership and mobility are more effective than reducing demand. In some situations this may be true, but overseas attempts to curb car use have illustrated that changing the dependence on cars is complex (Dobilas et al. 2000, Taylor & Ampt 2003, Owens & Cowell 2002, J. Andrews pers.comm.).

5.3 Creating the land use and transport connection

As indicated, car numbers and vehicle speeds have continued to increase, which has had the effect of increasing noise, despite policies to encourage the opposite effect. Land use

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[33] See for example regional transport planning strategies in New Zealand.

development on urban fringes has also increased the need to travel. As Owens (1995: 46) notes, "increasing mobility and dispersal of land uses have reinforced each other over at least half a century, so that in many areas car use has become more of a necessity than a choice". International experience does indicate that controlling the effects of transport may be more effective than trying to control use (Owens 1995, Stead & Hoppenbrouwer 2004, Stopher 2004).

Land use and transport planning at its most ideal provides for alternative modes of transport that connect people with their destination (particularly work) in an efficient manner. In turn the demand for private travel is reduced and noise from land use transport may be avoided. This approach is most successful when part of early land use planning (Rabinovitch 1996). There are limitations to controlling vehicle use, and planning processes must accept that individuals select their place of residence for a number of reasons, not just their proximity to work (Bertolini & le Clercq 2003, Maat et al. 2005, Owens 1995, Taylor & Ampt 2003). This can restrict the success of policies aimed at reducing private travel.

Land use planning has a key role in curbing land transport noise. It is increasingly seen as a positive solution in Asia and America, though not always formalised (Steger 1997, D. Gainsford & J. Andrews pers.comm.). Land use planning options for curbing noise include long-term forward planning (like zoning and city layout) as well as specific land use controls such as setbacks along roads or residential areas.

Generally, good land use planning aims to implement a combination of approaches adapted to fit the situation. For example early land use planning for a new development may implement preventive approaches such as re-zoning, setbacks and building code measures. Where land transport corridors or designated roads already exist, noise can also be controlled by land use planning. The surrounding area may be zoned as unsuitable for sensitive receivers while setbacks can provide a buffer for noise.

Land use planning for noise can also have positive repercussions on other aspects of a development. Building controls requiring acoustic insulation will also increase the energy efficiency of a building because of the double glazing and insulated wall cavities. Setbacks implemented for noise abatement can reduce the visual impacts associated with buildings or avoid high fences lining transport corridors. This focus on amenity values features in Australian approaches to noise abatement, discussed in Chapter 3. Australian guidelines for mitigating noise include landscape and design considerations in a bid to avoid more invasive methods such as noise barriers (A. Hall pers.comm.).

Urban design is also considered an important element of land use planning. Planning through design can reduce motor vehicle dependent land use by shaping urban areas to fit mobility needs (Rabinovitch 1996, Newman & Kenworthy 1996). For example, urban areas may be planned around a central transport node such as a railway station. The Netherlands experience, detailed in the previous chapter, provides examples of this and illustrates that appropriate urban design is crucial.

The Netherlands illustrates that it may be possible to combine approaches by developing land use planning solutions that are suitable for different situations, in the face of vehicle number increases. For example, congestion may be best addressed through providing infrastructure that is designed to have low or no impacts or by restricting vehicle access to specific areas.

Land use planning for areas that have current noise issues often requires different approaches. Some are consistent with transport planning approaches which attempt to prevent the transmission of noise using barriers or setbacks between the road and the development. Others are concerned with addressing existing impacts and noise occurring outside urban centres, for example within residential development in suburban areas[34]. An example for addressing existing noise in suburban areas is the restriction of vehicle access at night or reducing speed through the use of speed (judder) bars.

A further consideration in developing land use and transport planning objectives is setting strategic goals. Owens (1995: 48) notes that it is necessary to consider the "kind of environment that we want to hand on to future generations and to some extent to tailor transport policy [and land use policy] to it". One method of achieving this is to set emission limits and acceptable noise levels for land transport and various land uses. This provides direction and consistency for planning. This approach has proved successful in the Netherlands.

Another approach is to set a limit on noise, then provide methods and options for achieving that limit through plans. This is the basis of the case study on SH74 in Section 5.7.2. The Christchurch City Council has implemented performance standards for noise for residential developments along SH74. In certain living zones setback provisions become less stringent as additional noise abatement is implemented. Transit New Zealand guidelines were used as the baseline for the performance standard, and mitigation is measured through reductions from that level (R. Malthus pers.comm.).

In addition there must be agreement as to the areas that will be exempt from development and therefore noise, e.g. setting aside parks or reserves. An increasing focus is developing on protecting valuable habitats from noise in this way, particularly in areas short of space such as city centres (J. Andrews & M. van den Berg pers.comm.).

5.4 The New Zealand approach

Limited integration of transport and land use planning has existed traditionally in New Zealand (PCE 1998). Managing transport noise using land use planning tools in New Zealand is not unknown, but has been poorly addressed in New Zealand planning documents.

A number of local councils in New Zealand blame this on a lack of direction from central government (T. Reidy pers.comm.). This problem is not confined to New Zealand. This section provides an overview of the various land use planning techniques available for

34 See the Christchurch City Council SH74 example, Section 5.7.2.

addressing noise. It is based on the international research and experience in New Zealand.

5.5 Tools and options

5.5.1 Location policy

Location-based land use planning usually occurs on a regional scale. Location policy attempts to plan for transport and land use by providing for land use and transport needs around workplaces, jobs, shopping, leisure facilities and services (DETR 2002). The main aim is to promote development in areas that have existing or potentially well-serviced public or alternative forms of transport, thereby reducing car dependence and related effects. Location policy takes into consideration residential development, other infrastructure, and the form and type of development that might occur (Maat et al. 2005).

Location policy is exemplified by the 'ABC-location' Policy implemented in the Netherlands and described in Chapter 3. The policy is aimed at encouraging development in areas with good public transport and discouraging it in areas without.

In England and the Netherlands, location policy has proven most successful in areas with existing congestion and environmental problems. It has proven more difficult in rural areas where public transport has declined (Owens & Cowell 2002). Individual autonomy can influence the success of this policy however, with many people favouring to live some distance from their workplace (Maat et al. 2005). However, New Zealand is in an advantageous position to tackle noise problems before they reach international levels.

Examples of location policies include:

- *Additional housing in existing urban areas:* This aim is to locate housing in existing areas that are well served by public transport. It relies on individuals using public transport, cycling and using walking routes.
- *Locating facilities in close proximity to housing development:* This also aims to reduce the need to travel and relies on people using alternative forms of transport. Providing services and workplaces near people's homes facilitates a reduction in travel. This approach is particularly relevant where an existing or proposed passenger rail network exists. Maat et al. (2005) argue that this approach does not consider the full range of individual travel choices and may have limited results.

5.5.2 Control-based approaches

Numerous control-based approaches are applied to land use planning. These include controlling where, and in what form, development can occur. Control-based approaches are exemplified by rules and zoning in district plans or policies around the world. Controls may include restrictions on urban development along planned major roads. Alternatively, developments along corridors may be subject to specific building standards aimed at reducing noise.

Where urban development occurs on city peripheries, strictly urban solutions, such as mixed use development, may be less effective at controlling noise. In these situations a combination of strategic planning (for example restrictions on future development in a specific area) and planning controls may be more appropriate. Examples of control-based planning tools are outlined below.

5.5.2.1 Zoning

Zoning is one of the most common approaches to land use planning. Zoning involves dividing communities into a number of areas or zones defined by the predominant activity in an area (Steger 1997). For example zones may be residential, rural, business or industrial. Each zone has rules and controls designed to suit the activity in the area.

Zoning is often considered the first step in early land use planning as it establishes acceptable use in an area. Other land use planning controls are applied within zones. These are described below.

- *Site layout*

  Site layout can be specified for particular zones through setback provisions. Setbacks provide for noise dissipation reducing the effect of noise on receivers. Setback requirements can be applied to transport corridors as well as buildings.

  By making long-term transport and development projections, planning authorities can plan for growth and related noise by including setback provisions along transport corridors or along land proposed for urban development.

  Setbacks can be inefficient in terms of land loss and cost of purchase. Agreement must be reached on whether the land owner or transport authority is responsible for these costs. An added benefit of setbacks is that they can subsequently be utilised to provide walking or cycling tracks, or reserves which can add amenity value.

(Source: US Federal Highway Agency[35])

Figure 5.1 Artist's impression of land use planning for highway noise.

[35] Retrieved 16 March 2005 at: *http://www.fhwa.dot.gov/environment/noise/quietzon/qz6.htm*

- *Use*

  Zoning may also be used to restrict noise-sensitive activities in a particular zone. Sensitive users include residential areas, schools, learning centres and hospitals. Areas may be zoned in proximity to a land transport corridor and restrictions placed on them unless they can achieve an acceptable external or internal noise level.

  Alternatively, new road development may be subject to restrictions such as the speed limit or vehicle capacity.

- *Structural restrictions*

  In certain zones structural controls such as building height or orientation can be used to address noise. This is particularly relevant where development occurs near a road that has barriers or bunding. As noted in previous sections, barriers need to block the 'line of sight' to be effective; a barrier next to a multi-storey housing complex will not provide any benefit to residents on the upper levels.

- *Define zones of acceptable noise levels based on the character and function on an ar*ea

  Identifying acceptable noise levels allows consistency and transparency for decision-makers, planners, developers and stakeholders. Defining zones of acceptable noise levels based on character and function provides a certain amount of flexibility compared with setting a single noise level.

  The aim of this approach is to establish ambient noise levels in specific areas, which then become the acceptable noise levels. This is a new approach being undertaken overseas[36]. It differs from setting acceptable noise levels for sensitive activities by applying the acceptable levels to a zone or area. More guidance would be needed to agree on noise levels arising in particular areas and how to monitor outcomes.

5.5.2.2 Rezoning

An additional form of zoning is 'rezoning'. This involves changing the zone of an area to reflect changes in land use patterns.

Rezoning may be necessary where noise levels are increasing to an unsustainable level but cannot be controlled through other means. It provides guidance as to the future use of the area. Its limitation is that it can take time to implement and may be unpalatable to existing land owners. Noise affecting existing land owners may also need to be addressed through additional measures such as acoustic insulation.

5.5.3 Building controls and standards

Building controls and design standards have an important role in addressing new and existing noise. Building controls are common in other countries including Australia and the Netherlands. In New Zealand there has been growing consideration of noise in relation to the compact, urban apartments that are becoming more common in cities like Auckland. The use of building standards could be extended to all types of housing. Examples of building control options include:

[36] See the Netherlands case study in Chapter 3.

- *Development standards e.g. building codes relating to acoustic insulation*

  Building codes could include standards on acoustic insulation to control noise at the receiving end. Ideally insulation would be required for all new buildings and renovations[37]. Building codes could include acceptable noise levels for external living areas, bedrooms and living areas, which could be based on WHO guidelines.

- *Building layout and orientation*

  The layout of rooms and orientation of a building can assist noise mitigation. Road noise is highly directional and disproportionably affects one side of a building. Siting bedrooms and living areas away from the noise source or minimising the number of windows on that side can make a significant difference to the noise experienced within those more noise-sensitive areas. Buildings can also be oriented away from the noise source and/or garages placed between the main building and noise source.

5.5.4 Urban design

Urban design can be defined as the organisation of towns and cities (Steger 1997). It includes the layout of buildings and open spaces within a specified area. Urban design operates at a local level to define the layout of urban areas. In relation to transport its aim is to reduce the need to travel by car, encourage alternatives and thereby reduce noise (De Roo & Miller 2000, Maat et al. 2005). It also considers compatible use (Steger 1997).

Urban design can introduce or preserve 'quiet areas' or place restrictions on vehicles in specific areas. Urban design can be used to reduce vehicle use and plan urban layouts to best protect sensitive receivers from noise. Examples of urban design to reduce noise include:

- *Mixed use development*

  Mixed used development encourages a mixture of development such as commercial, industrial and residential. It is a central theme of many European sustainable development policies. Mixed used development aims to combine living and working areas to reduce the need for travel and associated impacts.

  Mixed use is synonymous with *compact urban design* which encourages higher density housing around transport nodes to reduce car numbers and noise (Vreeker et al. 2004). It is not suitable for all locations and is usually more acceptable in urban centres where commercial, retail and residential developments are already increasingly integrated.

  Mixed used development requires a certain amount of flexibility and alterations to the existing system. For example, single use zoning (commercial, residential or industrial) may inhibit mixed use because of restrictions imposed on those zones. In addition, any conflicts between different land uses in mixed uses need to be considered (PCE 1998).

[37] The former Building Industry Authority proposed changes to the Building Code Clause G6 in 2004. The proposal outlines methods for controlling environmental noise (including road noise) through use of appropriate construction materials.

This consideration might include noise emissions, particularly from the associated land transport corridor.

- *Compact cities*

Compact cities aim to reduce the spread of urban development into semi-rural or rural areas and make cities self-contained (de Roo & Miller 2000). This in turn reduces the need for travel and the associated impacts of transport.

The success of this approach has been dubious and urban development continues to grow on city peripheries in international examples (de Roo & Miller 2000, Maat et al. 2005). High density development does not always result in reduced pollution and noise and there are also limits on how dense a city can be before amenity values and quality of life are affected[38]. However, New Zealand with lower population densities, may have more scope for introducing these solutions.

- *Public transport oriented planning*

Public transport oriented planning involves designing urban areas around a transport node such as a combined bus and railway station (Newman & Kenworthy 1996). It has links to mixed use and high density planning encouraging the development of service and infrastructure near the transport node.

The benefits and limitations of public transport-orientation planning are consistent with mixed-use planning and compact cities approaches. In addition, the areas around transport nodes will require remediation from noise associated with these nodes. This might include acoustic insulation or restricting sensitive activities in the vicinity.

- *Quiet areas and setbacks*

Effective urban design considers setback areas along developments (including roads) and reserves quiet areas such as parks. This avoids situations where dwellings hug the road corridor which may leave little space between the boundary dwelling and the road.

5.6 Further considerations in land use planning

5.6.1 Data and monitoring

Data collection and monitoring are not strictly land use planning controls but are an important consideration when implementing land use planning (Kaiser et al. 1995) Data collection provides baseline information on noise levels in an area. Monitoring can be measured against that baseline to determine whether increases or decreases arise from land use planning.

WHO (1999a) outlines three key steps to assist land use planning for noise control:

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38 See for example: Heslop et al. 2004.

- *Calculation methods for predicting noise impacts*

  Effective land use planning involves projecting future trends in development and land use so that measures can be implemented early to avoid negative environmental effects.
  A number of calculation methods are available for predicting noise[39]. These can be combined with growth predictions to estimate what the noise levels will be so that appropriate controls can be implemented.

- *Establishing noise level limits for various zones and building types*

  This was discussed briefly under *Zoning* (Section 5.5.2.1). Guidelines on noise set out acceptable noise levels for different activities[40]. Establishing noise level limits for zones and building types provides consistency and certainty.

- *Noise maps or noise inventories to show the existing noise situation*

  Noise maps range from basic maps showing noise contours to more sophisticated approaches that incorporate datasets on population density, building fabrication and location of noise barriers.

  Effective noise mapping can assist land use planning. Noise maps can also be used for monitoring the efficacy of mitigation measures. They can indicate how different types of building layouts affect the spread of noise and any quiet zones that need to be preserved (Defra 2004a). See Appendix 3 for a more detailed description.

5.6.2 Heavy vehicle routing

Heavy vehicle routing needs to be considered when developing land use policies. Heavy vehicle noise is an increasing problem, as exemplified by the case study in Section 5.7.1. Many of the land use and transport planning options for sustainable development focus on private car use and journeys to work (Dobilas et al. 2000). Yet heavy vehicles emit significantly more noise particularly along major roads and in hilly areas (European Federation for Transport and the Environment 2004).

One option for addressing heavy vehicle noise through land use planning is to designate heavy vehicle routes. Re-routing heavy vehicles through less sensitive areas is a common approach in rural townships.

A more futuristic approach suggested by Dobilas et al. (2000) involves severing the connection between heavy freight routes and sensitive receivers by restricting access and creating a buffer. The buffer zone would involve siting less sensitive receivers in between the heavy vehicle route and residential areas. Goods can then be transferred from off loading facilities to residential areas by smaller, quieter vehicles. This could be achieved through long-term rezoning, for example along routes to ports.

Other options include placing restrictions on movement around sensitive users and restricting night-time movement.

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[39] See: AUSTROADS 2004b.

[40] See: WHO (1999a) guideline values for noise in specific environments.

5.6.3 Compensation

In some situations significant increases in land transport noise may not be able to be addressed through land use planning or other options. Compensation may be the last available option in this situation. This approach was taken in Dunedin for Port Chalmers residents affected by port noise. The Environment Court decision on Careys Bay Association Inc. v Dunedin City Council[41] required the port company to offer to purchase, or provide acoustic treatment for properties where noise levels exceeded 65 dBA L_{dn} anywhere within the property boundary. Requirements to purchase would only be suitable in extreme situations where retrofitting through insulation, bunding or other means was impossible or ineffective.

5.7 Case studies

5.7.1 Opawa Road, SH 73 Christchurch

Opawa Road represents a case of cumulative noise impacts that have arisen with increased road use and changes to the road layout. The road is the main route through Christchurch City to and from the Port of Lyttelton and has been subject to a significant increase in heavy vehicle movements.

In 1997 a report was produced outlining the concerns of local residents who reported that noise was their ‘largest environmental concern’ (TH Jenkins & Associates 1997: 107). Residents reported that a number of elements contributed to noise including:

- vehicle noise – exhaust systems, engine braking, and gear changes,
- road surface and vehicle interactions – empty trucks created banging noises,
- road surfaces – coarse road seal (chipseal), potholes and areas in poor condition.

Based on the existing road surfacing, noise levels along the Opawa Road and Port Hills Road section of the state highway were calculated as 70.9 dBA and 71 dBA respectively.

Land along the east side of Opawa Road has been progressively purchased by Transit and the Christchurch City Council over the past 30 years and zoning in the area has also changed. Under the City Plan the area is now zoned Business 4 (suburban-industrial), whereas in the past the area was mostly residential with some remnants of housing existing today. These changes indicate that some of the problems with the road have been identified in successive land use and planning decisions.

Public consultation occurred in the mid 1990s and early 2000s to assess solutions to noise and other impacts. It was agreed that the road would be realigned using purchased land.

The Christchurch City Plan specifies that major arterial roads in urban areas, carrying more than 12,000 cars per day, must be constructed or reconstructed with a minimum of four lanes. Transit policy is for roads carrying 20,000 vehicles per day to be constructed or reconstructed with at least 4 lanes. The current average daily volume along Opawa

41 C150/2003

Road is 9,000 vehicles and two lanes are expected to provide sufficient carrying capacity until 2024 (Beca 2004).

The plan is therefore for the existing road to be used as a buffer zone and service lanes for the residential area with the main road being realigned to follow purchased land on the east side. There are no plans to increase the main road to four lanes, although there are concerns that the service lane will be absorbed into the main road when vehicle numbers reach 20,000.

Noise abatement also consists of provision for a setback and quieter road surface. It is also presumed that a 500 mm-high mounding between the main road and service road will soften tyre noise. The desired outcomes from the upgrade are a reduction in noise and vibration and improved accessibility. Changes will accommodate heavy vehicle demand from the city to the Port of Lyttelton. No monitoring is proposed in the project plan.

The road realignment is a drastic and expensive approach to reducing noise. However, it appears that the Council had predicted these traffic increases and purchased land over many years to cater for future change. Significant changes had already been made to this road in the early 1980s when a road bridge was placed over the Heathcote River. The case study provides an example of the long-term planning projections that are required for transport and land use planning.

5.7.2 Christchurch City Council, Suburban Estates and SH 74

Rule 3.4.4 of the Christchurch City District Plan includes special setback provisions for residential and other activities. The plan includes provisions for dealing with noise on certain high speed roads and limited access roads which are subject to significant urban development.

The rule signals a move away from a setback rule to a performance standard with a focus on progressive steps to reduce the transmission of noise. A minimum setback is required unless mounding capable of reducing ‘traffic noise intrusion’ by 10 dBA is implemented. Where double glazing or acoustic treatment of the building to achieve an external to internal sound reduction of 25 dBA or more is achieved the setback drops again. The rule does not state whether the acoustic standard applies to a room with closed or open windows and doors. The inclusion of a performance standard aimed to allow flexibility in design and provides a monitoring target (Christchurch City Council 1999).

The rule does not set a target for ambient noise levels in dwellings - it only describes the noise reduction sought from acoustic treatment. In effect, the abatement is testable but the environmental outcomes are not as the desired noise level is not stipulated. A noise performance standard was considered too onerous to monitor and the Council considered it more effective to check noise abatement using an acoustic specialist (Christchurch City Council 1999). Despite this, consultants working for two other subdivisions covered by the rule proposed siting and building houses to achieve internal noise levels of 30 dBA in bedrooms (R. Malthus & S. Camp pers.comm.). In their opinion, this gave greater flexibility to layout and design of housing while setting acceptable noise standards consistent with WHO guidelines (S. Camp pers.comm.).

Development of Fairway Park in Christchurch commenced in the area around the time the rule was being developed. The subdivisions are alongside SH 74 and are subject to a number of noise abatement conditions in line with the plan that appear to be relatively successful (K. Sanders pers.comm.). A combination of planted earth mounds and wooden fencing has been implemented to reduce transmission of noise to dwellings.

The Fairway Park subdivisions, which were started in 1998, use barriers consisting of earth mounds and an acoustic fence of 3 m giving a combined height of 5 m and are said to achieve at least a 10 dBA reduction. No monitoring has been undertaken since the implementation of the barriers (K. Sanders pers.comm.). Two-storey houses which look over the barriers have also been built alonside sections of the road.

During the district plan hearing relating to Rule 3.4.4 it was argued that a set noise level would be too difficult to monitor and it would be more effective to set a performance standard to be addressed by the developer. However, in Rule 2.4.7 of the plan a maximum noise level of 57 dBA $L_{10\ (18\ hr)}$ is included for other specific major arterial roads. The rules provide direction for land use planning but irregularity of the rules within the same plan will make it difficult to anticipate or monitor environmental outcomes in a consistent manner.

5.8 Integrated planning

A key lesson from international case studies is the need for the integration of policies and within different government departments to achieve sustainable outcomes. It is widely cited that integrated decision-making across land use, environment and transport policy is fundamental to sustainable and strategic goals (Banister 2002, EC 1996, Geerlings & Stead 2003, Potter & Skinner 2000).

Commitment to sustainability is outlined in a number of New Zealand Government policies. The Parliamentary Commissioner for the Environment also recommends greater integration of land use, environmental and transport planning to curb impacts, such as noise, in urban areas (PCE 1998). An integrated approach means policies and standards are consistent in their approach to achieving sustainable outcomes including those related to transport (Camagni et al. 1999).

Integrated planning goals have featured in European policies for some time (Geerlings & Stead 2003). A key driver is the recognition of the impact of transport on air quality, noise and the degeneration of city centres caused by transport networks and vehicle numbers (Owens & Cowell 2002). This is consistent with New Zealand policy on sustainable transport where noise is just one issue.

When developing policy to address noise it may be seen as part of an overall plan to reduce the impacts of transport on human health and the environment. Any policy must be carefully integrated with existing or proposed policies to ensure consistency and transparency (Geerlings & Stead 2003). Examples of the different types of policy integration are:

- **vertical** –integration between different levels of government,
- **horizontal/inter-sectoral** – integration between sectors or professionals within organisations,
- **inter-territorial** – integration between neighbouring authorities with some shared interest in infrastructure or resources,
- **intra-sectoral** – integration between different sections or professionals within a department (e.g. between environmental sectors such as air quality, noise, or biodiversity), or integration between different transport sectors (Geerlings & Stead 2003: 188).

An example is the UK where planners and local authorities are provided with direction through a series of planning practice guidance notes (PPGs). *PPG13: Policy guidance on transport* emphasises the need to link development plan allocations with local transport priorities and investment. PPG13 is modelled on the Dutch 'ABC-location Policy' (Owens & Cowell 2002). These approaches are described as 'the new urbanism' (Newman & Kenworthy 1996) and rely on integrating different aspects of planning to achieve common goals. New urbanism considers design and planning as essential elements for high-quality development (Vreeker et al. 2004)

By focusing on policy integration, traffic impact assessments for individual road developments have been replaced by 'traffic assessments' widening the scope for developers to include transport alternatives in their plans (Syms 2002).

Examples of other policies that could integrate well with options for addressing noise are outlined below. They include the Urban Design Protocol and the Auckland Growth Strategy. The Building Industry Code, referred to under land use planning, is a further example.

5.9 Case studies

5.9.1 Urban design protocol

The *New Zealand Urban Design Protocol* is part of the Sustainable Cities Programme of Action. The programme aims to achieve quality urban design represented by safe, attractive and healthy places to live and work (MfE 2004). An obvious area to include in such a programme is transportation issues, including noise impacts. Good design and planning is considered synonymous with environmentally sustainable cities in a bid to achieve less noise and less traffic congestion (Stead & Hoppenbrouwer 2004).

The protocol includes a vision for transportation based on the integration of different modes of transport. This is similar to the compact cities approach discussed above. Reducing travel distances and environmental impacts are also considered in the protocol.

The protocol relies on integration at all levels and encourages a number of the land use planning options described above. This is reflected in the section on local authorities and forward planning which suggests the following mechanisms:

(a) detailed policies and objectives for specific local urban design areas
(b) integrated planning of all urban design functions
(c) integrated urban planning with key external stakeholders (including land owners)
(d) forward planning of major urban infrastructure to support future land uses
(e) proactive guidance to encourage appropriate future urban development
(f) guidance on appropriate management of town and city centres (MfE 2004: 33).

Transport and noise are important considerations in urban centres, although noise is not discussed directly in the protocol. Amenity values and health, both of which are related to acceptable noise levels, are discussed.

Noise and pollution associated with cities often encourage people to move away. Traffic noise is the most common cause of complaints about noise in cities (Stead & Hoppenbrouwer 2004). Urban development can also impact on the location of transport networks and increase demand (Still et al. 1999). The protocol aims to counteract these trends.

The consideration of noise is an important element in achieving positive outcomes in urban areas particularly as the protocol focuses on good design that encourages city use and enjoyment. Noise is likely to be covered by transport planning and urban design elements. Current noise issues could be identified as the protocol develops. The protocol could also be used to identify quiet spaces for preservation.

5.9.2 Auckland Regional Growth Strategy

The *Auckland Regional Growth Strategy* was launched in 1999 (ARC 1999) and is currently under review. The strategy aims to deal with the impacts and implications of population growth in Auckland. It uses inter-territorial integration by involving the regional and district authorities. The strategy relies on integration with other policies, including the *Regional Land Transport Strategy (ARC 2003)* to implement specific mechanisms. The ARC has also been a key player in development of the Urban Design Protocol.

Auckland is experiencing particular problems with population increases and urban growth. It is predicted that up to 2 million people could be living in Auckland by 2050 and city living is increasing significantly. The strategy identifies transportation growth and noise as obvious concerns (ARC 1999). With this growth comes an increased need and demand for transport within and around the city. In addition, quality of life and enjoyment of open spaces need to be maintained. Addressing the impacts of increased growth including transport is a key focus. The key desired outcomes imply a reduction in noise and include:

- safe, healthy communities,
- diversity of employment and business opportunities,
- housing choice,

- high amenity of urban environments,
- the protection and the maintenance of the character of the region's natural environment,
- sustainable use and protection of the region's natural and physical resources (including infrastructure),
- efficient access to activities and appropriate social infrastructure for all (ARC 1999).

The Strategy seeks to accommodate future growth of metropolitan Auckland through more compact urban development (Lyne & Moore 2004). Auckland is predicted to see a significant increase in intensive housing and development such as terraced housing, town houses and apartment buildings. By the year 2050 up to 30% of Auckland's population may live in high-medium density housing, an increase of 18% (Lyne & Moore 2004). This may also bring increased noise.

Particular areas of concern about existing noise include controlling night noise, controlling car noise (especially modified cars), implementation of roading materials, and location of dwellings in association with major infrastructure and acoustic treatment of sensitive receivers (B. Waghorn pers.comm.).

Integrating land use planning, building standards and urban design are considered key mechanisms for the successful implementation of the Strategy. This should also be a consideration of other urban strategies as they develop. For example, Canterbury Regional, Christchurch City, Waimakariri District and Selwyn District Councils and Transit New Zealand have begun the development of an Urban Development Strategy for the greater Christchurch area. Transport and its impacts are key issues outlined in the proposal[42].

[42] See *www.greaterchristchurch.org.nz*

Table 5.1 Summary of land use planning options.

Method	Implementation method	Advantages	Disadvantages
Building setbacks	• Rules in District Plans • Building Standards	• Provide amenity value • Can be used for recreation or cycle ways and footpaths	• Land requirements • Initial cost $/m^2 • Need to be considered early
Zoning	• Rules in District Plans	• Match development type to ambient noise levels	• Restricts other forms of land use planning, e.g. mixed use, this may increase the need to travel
Re-zoning	• Rules in District Plans	• Addresses developing noise issues	• Occupants performing old zone activities will remain affected
New Zealand Standard	• New Zealand Standards Organisation	• Provides consistency and direction	• Implementation time • Industry-driven, may not be regarded as a key issue • Voluntary
National Environmental Standard	• Policies and rules in District Plans • Building Standards	• Strategic direction and certainty • Consistency • Can be monitored against	• Cost of implementation • Enforcement difficulties • District Plan Changes required
Mixed use development **Location policies** **Compact cities**	• Policies and rules in District Plans • Urban Design Strategies • Regional Transport Management Plans	• Strategic view • Reduces the need to travel and therefore noise • Good long-term options • Have additional benefits e.g. reduced air emissions	• Only viable where good public transport exists • Relies on use of public transport • Lengthy implementation in existing areas • Does not address heavy vehicles • May increase noise from other sources, e.g. neighbour noise • Less effective in semi-rural / rural areas

Table 5.1 Summary of land use planning options (continued).

Method	Implementation method	Advantages	Disadvantages
Noise barriers **Mounding / bunding**	• Rules in District Plans • Transit Guidance • District Council asset management plans	• Aesthetic benefits can be designed or landscaped in • Good level of noise reduction • Bunds can be cost-effective where infill exists • Relatively low maintenance once landscaping is established • Solid barriers, e.g. concrete have low maintenance requirements	• Effects on amenity values • Cost and maintenance • Wooden fencing 2 m high $20,000/km • Landscaped bunds $190,000 - $400,000/km excluding maintenance • Responsibility for ongoing maintenance • Need to link with other rules to avoid designs that counter their effect, e.g. multi-storey housing
Site layout	• Building Standards • Rules in District Plans • Urban Design Strategies	• Provides flexibility • Can be used in combination with other approaches	• Limited noise overall reduction • Limited by zoning densities • May compromise other site elements e.g. energy efficiency aspects

6. Summary of key findings and options

6.1 Key findings

This research has confirmed that a number of land use planning approaches are available for addressing land transport noise.

A selection of options for addressing land transport noise in New Zealand are included and based on existing approaches, current gaps, the legislative framework and international research. Using this approach the key findings are:

1. **Land transport policy has been most effective where national direction is provided.**
   The international case studies clearly indicate that a centralised approach to managing noise is effective. A centralised approach provides consistency and focus for planners, developers and individuals. National direction provides a baseline for the protection of health and the environment from noise.

2. **A variety of approaches are available for addressing land transport noise including technical, and land use planning options.**
   A combination of technical, land use planning and legal instruments provide an effective approach to managing land transport noise. This research set out to establish where and how land use planning is effective. A wide variety of approaches, including land use planning, are available. In summary:

   - *Technical options* are increasingly applied for controlling the generation and transmission of noise on New Zealand roads and are particularly useful for addressing rail noise. They can be an expensive solution, particularly when used for retrofitting. Technical options are subject to innovation and experimentation, particularly internationally, and some local testing may be necessary to determine their viability and applicability.
   - *Land use planning options* are valuable for addressing transport noise in a strategic manner. When implemented early in the planning process, they provide consistency and certainty. Land use planning tools can be applied nationally, regionally or locally. Many land use options may integrate well with other sustainability measures such as transport strategies and urban design. To date, land use planning options for noise have not been effectively implemented.

3. **Land transport noise management is particularly effective when policies and approaches and are integrated.**
   Integrated decision-making across land use, environment and transport policies is fundamental to sustainable and strategic goals. An integrated approach ensures policies and standards are consistent and transparent. Integration also benefits from national direction.

As noted, land transport noise may be seen as part of an overall plan to reduce the impacts of transport on human health and the environment. Any policy must be carefully integrated with existing or proposed policies. This is essential for long-term, sustainable transport planning.

4. **Addressing land transport noise can be an expensive and lengthy exercise but is most expensive during retrofitting.**
   The short-term cost of addressing future and existing transport noise will be relatively expensive. Implementation costs are inevitable with any type of environmental improvement programme. Cost is greatest during the implementation phase as individuals, businesses and organisations become accustomed to planning and design requirements. Initially, this may require alterations or changes to planning documents and developments. In the long term, noise management will become a standard consideration requiring forethought rather than change, and costs will decrease[43].

5. **Specific activities (sensitive receivers) are affected by noise and their protection should be the key objective when developing solutions.**
   The anticipated environmental results of noise management should be the protection of sensitive receivers from the impact of noise. International guidance on acceptable noise levels for specific activities are widely accepted and considered appropriate to New Zealand.

6.2 The options defined

6.2.1 National Environmental Standard (NES)

A National Environmental Standard would provide the consistency and direction inherent in other national policies. An NES on noise would provide a minimum level of protection from the impacts of noise.

An NES on noise might:

- establish performance standards for noise,
- prohibit an activity from certain areas or spaces,
- allow development subject to compliance with rules on noise,
- restrict the making of rules and granting of resource consents for certain developments,
- require certification as to compliance with the NES,
- specify the effect of the NES on any existing rules (adapted from MfE website 2005).

One uncertainty of an NES, noted by Chapman Tripp (2003b) is how existing use rights and district land use consents are affected. It is unclear what the prohibition of an activity actually means and whether existing use rights or activities provided for in a resource

[43] Cost should not be a reason for discarding options but will need to be weighed up. The aim will be to implement solutions which offset long-term health effects. Some of the costs can be reduced by providing a suitable lead-in time and interim measures for existing noise problem areas.

consent could become a prohibited activity. This will require investigation as part of any NES development process.

An implementation programme, including a call for public submissions, would be required for this approach. The details of such a programme are beyond the scope of this document. Needless to say, those affected by the legislation should be provided with sufficient lead-in time and assistance in making the necessary changes. Many lessons can be taken from implementation and development of the NES for Air Quality.

6.2.2 New Zealand Standards

A New Zealand Standard on land transport noise and land use planning would provide a national, but voluntary, option for addressing noise. A New Zealand Standard is unlikely to provide any additional benefit if an NES is implemented and is considered an alternative to an NES.

The main limitations of a New Zealand Standard are the voluntary nature and a lack of policy guidance. While the take-up of other noise standards has been high, the issues with air and sea port noise are dissimilar to land transport noise. The air and sea port standards offer reactive solutions such as restricting land use and flight times. Some variation between district council approaches to implementing the standards' guidance has also arisen. Variation may be less appropriate for implementing solutions for land transport noise, given the lineal, cross-boundary nature of land transport networks.

6.2.3 New Zealand Building Code

Building standards implemented through the Building Code would be useful tools for implementing acoustic design rules for new buildings and renovations. An amendment would be necessary to include noise management.

The Department of Building and Housing is slowly progressing changes to the Building Code Clause G6. The proposal outlines methods for controlling environmental noise (including road noise) through construction materials used in household multi-unit dwellings (BIA 2004).

The Building Code proposal has limitations as it generally only applies to new building work and multi-unit dwellings. Proposed noise levels are based on external sound levels set by the relevant territorial authority. In part, the inclusion of sound in Clause G6 strengthens the relationship between the Building and Resource Management Acts. However, implementation of the proposed responsibility rests with territorial authorities, not all of which have appropriate noise limits or monitoring in place.

6.2.4 Road and rail controlling authorities

Road and rail controlling authorities can exert some direct influence over adjoining land uses. This may be through use of designation powers to limit development on noise-affected sites, trade-offs when developers seek affected party approval, or through promoting noise management through district plans. Many of the rule options suggested for the district plan rules[44] would be appropriate to incorporate into designations, affected party approval processes, or plan changes.

[44] See Appendix 1.

The constraints on this option are primarily the cost on road and rail controlling authorities, in terms of staff costs and time and the (political) willingness of councils to support the actions. Promoting and justifying controls through the actions of road- and rail-controlling authorities on a site-by-site basis is considered to be inefficient from the perspective of almost all parties, and is likely to lead to impractical levels of variability. A more co-ordinated and integrated solution is possible through other alternatives.

6.2.5 District Plans

Territorial authorities will play a key role in land transport noise management and the most obvious method for managing noise is through district plans. The development of polices and rules could be closely linked to an NES and performance standards set at that strategic level.

Further scope exists to address land transport noise through planning documents. Rules need to be strengthened and made more consistent to provide transport authorities, land owners and developers with certainty. In many cases this would require plan changes or variations.

At a district level, the choice of options is also dependent on the existing environment – be it a central city area, suburban area, future residential subdivisions or semi-rural living. Most urban councils will have a good understanding of current noise issues including key transport routes, future development areas and sources of land transport noise. As not all districts are affected by land transport noise at present, rules should be developed with this in mind.

A number of district plan rule frameworks are suggested in Appendix 1. Existing noise will need to be addressed through a combination of land use planning, vehicle control and retrofitting programmes if a significant effect on receivers is to be achieved.

6.2.6 Urban design

Urban design is receiving increasing attention in New Zealand. It provides a strategic approach to land use planning and can be applied to protect against noise in urban areas. Urban design incorporates many of the options discussed under land use planning, focusing on the massing and organisation of buildings and on the spaces between them, rather than on the design of individual structures.

Urban design is about setting policies on the design of urban spaces and may provide for many issues, including noise. In the context of land transport noise, urban design should ensure noise is considered as part of other design considerations. This is particularly relevant to concepts such as compact and mixed used development, e.g. the proposed changes to the Building Code Clause G6 were largely the result of noise impacts in compact multi-unit dwellings.

Urban design may be implemented through a combination of statutory planning documents such as district and regional plans, urban growth strategies and regional land transport plans. Implementation using these documents requires a more integrated approach with central and local government and other agencies working together to develop an overall strategy. Urban design is important for the integration requirements discussed in the Chapter 5, as no one agency is responsible.

Noise is implicit in many of the existing documents but needs to be made more explicit if it is to be incorporated into urban design considerations. Urban design is already a consideration in most cities. It may also need to be considered in development of noise management solutions; e.g. urban design of noise barriers is a key policy in many countries and some novel approaches have been applied in some areas[45].

As urban centres evolve noise must be factored in to urban design elements. Urban design will be limited where existing noise prevails. In these situations acoustic insulation of building may be required.

Once again, there are overlaps with other options including National Environmental Standard and additional guidance would be required to bring various elements together to address noise.

6.3 Further considerations

Some of the limitations have been discussed in the preceding paragraphs. In addition, district planning rules will only apply to new developments and existing use rights will usually apply. However, redevelopments and extensions to buildings containing noise-sensitive activities should be seen as an opportunity to improve noise control performance.

Where existing noise is having a significant effect on sensitive receivers, the most significant reduction is likely to come from on-road mitigation by road controlling authorities and improvements in the performance of the vehicle fleet.

The implementation of district plan rules for controlling land transport noise have until now been inconsistent and, in many cases, unenforceable. As discussed, consideration must be given to how the rules might be implemented through guidance at a national level potentially through development of a National Environmental Standard. Objectives and policies to support the rules[46] will be required. The wording of objectives and policies will be reliant on a decision on proceeding with an NES in tandem with a National Policy Statement (NPS) and, if not, on the format and structure of the relevant district plan.

Noise mapping will allow far more targeted and accurate application of potential restrictions, given that many impose significant costs on land owners. Monitoring and data collection on existing noise levels will greatly assist the development of options and provide baseline information for monitoring and reviewing the results.

The implementation of all of these options should be undertaken in such a way that innovation and new technology for addressing noise is not undermined. Performance standards will assist this.

The costs of each option will also require more detailed analysis.

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45 For example, Maurice Nio's 'Cyclops' development in Hilversum, Netherlands (Szita 2005).

46 See, for example, suggestions in Appendix 1.

7. Conclusions

Increased land transport noise is inevitable with transport growth and urban development. New Zealand's transport is following international trends as reliance on private vehicles and road freight continues to rise. Road transport is the main concern in New Zealand.

Land use planning presents a useful tool for addressing road and rail noise. Lessons from international examples show that a number of land use methods can be applied to New Zealand to ensure sustainable transport and development outcomes are achieved in the long term. Land use planning is most effective as a preventive tool while technical options may be more effective for existing noise problems.

A key lesson from international case studies is the need for the integration of policies within different government departments, to achieve sustainable outcomes. An integrated approach that combines traditional land use planning measures with transport planning has proved effective in countries such as the Netherlands and is now being embraced by Australian and US state planning authorities.

Land use planning tools do not come in 'one size fits all'. Instead, a selection of tools suited to the particular situation is most effective. For example mixed use planning, which focuses on a combination of development types, around a central public transport node, is most suited to urban centres such as cities. In urban peripheries setbacks or zoning are considered more effective.

Ultimately, transport and land use planning aim to address noise by reducing the number of vehicles on the road and by encouraging public transport. As with other options, this has proven to have limited application in some areas. For example, higher density development can result in increased noise caused by the concentration of people. These particular land use planning options may be pursued in the interest of other issues and noise may still require additional mitigation.

The key consideration in applying land use tools is predicting current and future noise levels, potential transport growth and development trends. New Zealand's legal framework provides an opportune format for implementing noise management including national environmental standards, local authority plans and building standards. The research indicates that the key to achieving effective outcomes is co-operation and consistency under a framework of national-level guidance.

8. Recommendations

The key recommendations from this report are as follow:

- **Integrate land transport noise controls at a national level**
  The policies and actions of different government departments and agencies need to be applied under a consistent framework to achieve sustainable outcomes. An integrated approach that combines land use planning measures, transport planning, vehicle-based controls, building controls, road design and the retrofitting of on-road noise mitigation is recommended for most effective noise outcomes.

- **Implement a National Environmental Standard**
  A centralised approach is recommended as a starting point for addressing land transport noise. A centralised approach provides consistency and focus for planners, developers and individuals. National direction provides a baseline for protection of health and the environment from noise and should set performance standards for emissions and receivers. The mandatory nature of an NES is considered a more effective approach, compared with a New Zealand Standard.

- **Use the WHO maximum noise standards as a start-point for New Zealand policy**
  While the development of actual levels is beyond the scope of this research, WHO guideline values are summarised for specific environments and effects. The values indicate that annoyance occurs at around 55 dBA for the general population during the day. The values take into consideration known health effects and are based on the lowest levels of noise that affect health. However, the WHO levels are guidelines and in many instances will not be able to be met, practically or economically, particularly on existing land transport networks.

- **Establish the preferred noise criteria**
  The criteria for noise measurement need to be agreed. Internationally and currently in New Zealand the measurement $L_{eq\ (24hr)}$ is recommended for general road traffic noise measurement. However, this measure has been criticised as not being a close representation of the noise that people actually experience. Current Australian research recommends using both $L_{eq\ (15hr)}$ and $L_{eq\ (9hr)}$ to provide separate measures for day and night, and can be manipulated to very closely approximate L_{dn}.

- **Develop effective land use planning objectives, policies and rules in plans**
  The development of an NES will provide direction and consistency in district planning policies. Appropriate lead in time and guidance is recommended to assist district councils.

- **Undertake noise measuring and monitoring**
  More widespread noise measurement and monitoring is required, particularly in urban areas. Noise levels should be assessed at the onset of district planning policy or NES development to provide a baseline for information gathering. The areas and methods for noise monitoring should be established and consistent approaches be encouraged allowing comparative analysis. Using baseline information,

improvements and future monitoring can be progressed. District councils should also commit to regular reviews of monitoring programmes. This includes updating noise mapping data as predictions based on calculations are superseded by actual measurements.

More information on monitoring and noise mapping can be found in Appendix 3.

Appendix 1 Potential frameworks for developing district planning rules

Section 5.2 discusses the role of district planning in implementing land use management. Table A1.1 provides examples of how rules on land transport noise might be developed. At present few councils include rules for transport noise; none include rules for rail. Those that include road development rules tend to default to the Transit NZ guidelines, which apply only to new designations.

New road and rail developments can utilise land use planning methods such as setbacks, acoustic mounding, and urban design. In existing urban areas options will be more limited and may need to rely on technical solutions or acoustic insulation.

The overall aim should be to allow flexibility in approaches to mitigating noise and minimising impacts on amenity values.

Table A1.1 Examples of possible development of rules on land transport noise.

Rules	Example	Advantages	Disadvantages
For receivers: Rules on receivers rely on some form of 'trigger' for their application. Ideally this would be through noise mapping of land transport noise, which would then provide a contour showing an affected area, and hence the rules would be applicable to those areas. In the absence of noise mapping, an estimation of noise effects, based on the distance from the transport corridor, and traffic volumes can be utilised.			
Performance-based rule for sensitive receivers in urban areas In urban areas, one option is to include a performance standard for dwellings and other sensitive receivers. This rule could be applied to most areas and sets an acceptable level for noise.	An acoustic design report from a suitably qualified acoustic engineer shall be submitted to the Council prior to construction confirming that, immediately following construction, noise attributable to road or rail traffic will not exceed 30 dBA L_{eq} at night (10pm-7am) and 45 dBA L_{eq} during the day (7am-10pm) in habitable rooms.	• Simple and universal in its application. • Provides good protection from night-time sleep disturbance. • Allows flexibility and innovation in providing solutions that meet the levels. • Easy to enforce – only requires enforcement at the time of construction.	• Adds cost to building design and construction. • High cost of site-by-site acoustic reports (may be reduced through design guides). • Requires no protection of outdoor areas. • Is a snap-shot in time (the time of construction) increasing noise levels over time are not accounted for.

<table>
<tr><th>Rules</th><th>Example</th><th>Advantages</th><th>Disadvantages</th></tr>
<tr>
<td>Performance standard based on the activity
A similar approach is to provide additional detail based on the activity but still using performance standards. This option would potentially provide more protection to outdoor areas. This rule has been developed from the proposed Rodney District Plan.</td>
<td>Acoustic performance:
An acoustic design report from a suitably qualified acoustic engineer shall be submitted to the Council prior to construction confirming that, immediately following construction, noise attributable to road or rail traffic will not exceed the following levels:
<table>
<tr><th rowspan="2">Activity</th><th colspan="2">dBA L_{eq}</th></tr>
<tr><th>Day (0700-2200)</th><th>Night (2200-0700)</th></tr>
<tr><td>New dwellings and additions to existing dwellings and elderly persons' accommodation: Internal noise level (habitable rooms only)</td><td>35</td><td>30</td></tr>
<tr><td>Outdoor areas of new dwellings and elderly persons accommodation and school playgrounds</td><td>55</td><td></td></tr>
<tr><td>New hospitals, teaching areas in educational facilities, travellers accommodation - Indoor noise level (habitable / sleeping rooms only)</td><td>35</td><td>30</td></tr>
</table>
</td>
<td>• Reasonably simple, but greater flexibility than a blanket level.
• Provides good protection from night-time sleep disturbance.
• Allows flexibility and innovation in providing solutions that meet the levels.
• Requires protection of outdoor areas for 'residential' activities.
• Easy to enforce – requires enforcement only at the time of construction.</td>
<td>• Adds cost to building design and construction.
• High cost of site-by-site acoustic reports (may be reduced through design guides).
• May be difficult to achieve the outdoor noise levels, particularly in existing urban areas.
• Is a snap-shot in time (the time of construction); increasing noise levels over time are not accounted for.</td>
</tr>
</table>

<table>
<tr><th>Rules</th><th>Example</th><th>Advantages</th><th>Disadvantages</th></tr>
<tr>
<td>Performance standard for zoned areas
Where zoning exists performance standards may be linked to the zone. This approach takes into account the expected noise levels of different zones. It is largely based on the South Waikato District Plan.</td>
<td>Acoustic performance:
Noise levels will be measured at a height of 2 m above ground level, 1 m in front of the façade of the nearest building to the road or rail corridor, which is occupied by a noise-sensitive activity.
<table>
<tr><th rowspan="2">Zone</th><th colspan="2">Maximum noise (dBA L_{eq})</th></tr>
<tr><th>Day (0700-2200)</th><th>Night (2200-0700)</th></tr>
<tr><td>Rural</td><td>50</td><td>40</td></tr>
<tr><td>Residential</td><td>50</td><td>40</td></tr>
<tr><td>Commercial core</td><td>55</td><td>45</td></tr>
<tr><td>Commercial fringe</td><td>55</td><td>45</td></tr>
<tr><td>General industrial</td><td>60</td><td>60</td></tr>
<tr><td>Heavy industrial</td><td>70</td><td>70</td></tr>
</table>
</td>
<td>• Allows recognition of different noise expectations.
• Allows flexibility and innovation in providing solutions that meet the levels.
• Will result in protection of outdoor areas.</td>
<td>• The external noise levels stated can be very difficult, if not impossible to achieve.
• Enforcement would be very difficult.
• Impractical for any existing urban development areas – only really applicable to 'green fields' sites.</td>
</tr>
<tr>
<td>Setback rule for new residential subdivisions
Setback rules are useful where land is currently undeveloped and available. They need to be used for existing roads, and proposed roads. This possible rule includes a performance standard and incorporates external measures to address noise.</td>
<td>Acoustic performance:
The minimum setback for noise-sensitive activities along existing or proposed roads with actual or 20 year forecast traffic volumes >10,000 vehicles per day shall be 80 m except where:
• Mounding or other physical barrier(s) to noise transmission, capable of reducing noise intrusion to all parts of any site by at least 10 dBA is provided within 20 m of the road boundary and extending across the entire site frontage. Such mounding or barrier shall be screened from the adjoining road by landscaping, in which case the required setback shall be 40 m.
• Where the provisions of subclause (i) above are complied with, and the building containing the noise-sensitive activity is acoustically treated to achieve a sound transmission loss of at least 25dBA with windows and doors closed, then the minimum building setback shall be 20 m.
An acoustic design report from a suitably qualified acoustic engineer, shall be submitted to the Council prior to construction confirming that these noise levels will be met.</td>
<td>• Provides comfort to councils and roading authorities that substantial noise protection is being undertaken.
• Allows developers to maximise the use of the site.
• Provides basic protection of outdoor areas, and better protection of indoor areas.
• Easy to enforce but relies on modelling of the noise transmission.</td>
<td>• The most complex and prescriptive rule, with potentially high cost of site-by-site acoustic reports and treatment.
• Based around an achievable reduction in noise levels, not an absolute level.
• Realistically can only be applied to larger 'green fields' developments.</td>
</tr>
</table>

Rules for road and rail corridors

Rules	Example	Advantages	Disadvantages
Option 1 – Performance standard for new roads or rail lines Option one requires conformance with a set performance standard.	1. New roads or rail lines are a permitted activity where they are designed so that the noise attributable to road or rail traffic does not exceed 55 dBA $_{Leq\ (24hr)}$, measured: i In existing urban areas – 1 m from the façade of the nearest building occupied by a noise-sensitive activity, at a height of 2 m above the ground, at the point closest to the road or rail line, or ii In undeveloped areas, where noise-sensitive activities may be established as a permitted activity – 10 m from the road or rail boundary. 2. An acoustic design report from a suitably qualified acoustic engineer, shall be submitted to the council, prior to construction, confirming that these noise levels will be met for predicted traffic or rail volumes forecast for the next 20 years.	• Sets a simple level for all roads and rail lines. • Recognises future development areas, where development is likely. • Will result in protection of both indoor and outdoor areas. • Resource consent is still an option for roads and rail lines that do not meet this rule.	• The noise levels stated can be very difficult, if not impossible to achieve, but are based on WHO levels. • Only applies to new roads or rail lines. • The $L_{eq\ (24hr)}$ measure is not ideal for describing the noise actually experienced by noise-sensitive receivers.

Rules	Example	Advantages	Disadvantages
Option 2 – Performance standard for new roads An alternative option is to set the performance standard in relation to the ambient noise. This is essentially similar to the existing Transit Noise Guidelines approach, but with reduced noise levels and an upper limit. It is reinforced that it is beyond the scope of this research to arrive at recommended levels. The levels in this rule are start points, and represent a position part way between the existing Transit Guidelines and the WHO levels. The levels would be best set on a national basis.	1. New roads where the predicted traffic volume is greater than 10,000 vpd* and where noise-sensitive activities may be established as a permitted activity within 80 metres of them at the time of construction, shall be a permitted activity provided that the road is designed and constructed so that the 20 year predicted traffic noise level, measured 10 m from the road boundary, or 1 m from the facade of any existing building occupied by a noise-sensitive activity, does not exceed: a. in areas with an ambient noise level of less than 47 dBA $L_{eq\ (24hr)}$ – 55 dBA $L_{eq\ (24hr)}$ b. in areas with an ambient noise level of 47-50 dBA $L_{eq\ (24hr)}$ – ambient plus 9dBA c. in areas with an ambient noise level of 50-57 dBA $L_{eq\ (24hr)}$ – 60 dBA $L_{eq\ (24hr)}$ d. in areas with an ambient noise level of 57-67 dBA $L_{eq\ (24hr)}$ the level shall not exceed the ambient noise level, plus 3 dBA. e. in areas with an ambient noise level of more than 67 dBA $L_{eq(24hr)}$ – 70 dBA $L_{eq\ (24hr)}$ An acoustic design report from a suitably qualified acoustic engineer, shall be submitted to the council, prior to construction, confirming that these noise levels will be met for predicted traffic volumes forecast for the next 20 years.	• Ignores low volume roads. • Recognises future development areas, where development is likely. • Will result in protection of both indoor and outdoor areas. • Recognises existing ambient noise levels (however, the ambient noise levels will likely be caused by existing traffic noise, which is questionable). • Resource consent is still an option for roads that do not meet this rule.	• The rule is complex. • The noise levels are less than in the Transit Guidelines, and the actual levels have little justification. • The $L_{eq\ (24hr)}$ measure is not ideal for describing the noise actually experienced by noise-sensitive receivers. • Only applies to new roads.

* vpd= vehicles per day

Appendix 2 District planning rule examples from previous research

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
Christchurch City Council *Operative*	**2.4.7 Special setback provisions - residential and other activities** (a) In that part of the Living Zone which is: (i) Adjacent to the proposed expressway between Travis and New Brighton Roads, (ii) Adjacent to SH73 (Southern Motorway) and between Annex and Curletts Road, (iii) Adjacent to SH75 (Curletts Road) between the intersection with SH73 and Lincoln Road. Building setbacks, or building location, or acoustic barriers, or other means, either singly or in combination, shall be used such that the following noise insulation standards are met: Sound levels attributable to traffic from these roads shall not exceed a level of 57 dBA $L_{10\ (18\ hr)}$ 54 dBA Leq $_{(25\ hr)}$ in any outdoor area of the site and a design level of 60 dBA $_{Leq\ (24\ hr)}$ measured 1 m from the façade of any residential unit. All measured in accordance with NZS 6801:1991 Assessment of sound. **3.4.4 Special setback provisions – residential and other activities** The setbacks in the locations specified below shall be as follows: (a) In the Living 1A zone the minimum setback from Cavendish Road shall be 10 m. (b) In the Living 1A and 1B Zones the minimum setback from a limited access road listed in Part 5, Appendix 8, shall be 80 m except that (i) Where mounding or other physical barrier to noise transmission capable of reducing noise intrusion to all parts of any site by at least 10 dBA is provided with 20 m of the road boundary across the entire site shall be 40 m provided that such mounding or barrier shall be screened from the adjoining road by landscaping.	n/a	The rules are relatively complicated and only apply to certain areas, they do not address noise along roads not listed in the Rule or Appendices. The inconsistency in approach may make monitoring more complicated. Rule 3.4.4 set a performance standard for the mitigation measures and does not set a noise standard for dwellings making the outcomes difficult to assess. (See Section 5.7.2 for further information.)

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
	Such landscaping shall be a minimum depth of 1.5 m, a minimum height of 1.8 m and be located between the mounding or fencing adjoining the road. Where such screening is by way of landscaping, the minimum height shall be the minimum at the time of planting. (ii) Where the provisions of sub clause (i) above are complied with, and all external windows and doors of the residential units including those installed in the roof are acoustically treated to achieve a sound transmission loss of at least 25 dBA with window and doors closed, then the minimum building setback shall be 20 m.		
Kapiti Coast District *Operative*	Permitted activity status provided setbacks and noise limits are met. **Rule D.1.2.1 (ii) (a-b)** Existing Excessive Noise Routes Dwellings constructed within 80 metres of State Highway 1 must meet the following requirements: • In all habitable rooms an internal $L_{10\ (18\ hr)}$ level of 45 dBA to be achieved with all opening windows closed. • An acoustic design certificate to be provided to show how this level can be met using approved noise abatement measures. b) Predicted Future Excessive Noise Routes; The only future road predicted, at this stage, to become an excessive noise route is the Sandhills Arterial, the route and extent of which is shown by the designation in the planning maps. No dwelling shall be erected within 80 m of the boundary of the Sandhills Arterial designation except where the following standards can be satisfied: • An external $L_{10\ (18\ hr)}$ level of 60 dBA required at a point 1 metre from the facade of the building. • An internal $L_{10\ (18\ hr)}$ level of 40 dBA in all internal rooms with the windows closed.	n/a	The rule sets controls for receivers but not land transport providers. The rule on setbacks is limited to specific roads which are defined as 'future excessive noise routes'. The limited scope of the rule may impact on the ability to prevent noise through land use planning. There is scope to alter the rule but this could take some time. The internal noise levels are slightly higher than WHO guidelines and do not include allowance for sleep disturbance.

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
	• An acoustic design certificate to be provided to show how this level can be met using approved noise abatement measures. Transportation noise levels shall be measured in accordance with NZS6801:1991 "Measurement of sound".		
Napier City *Operative*	Permitted activity provided conditions are met for acoustic insulation of dwellings. **Rule 5.22 (2)** The following acoustic insulation conditions shall apply to all new noise-sensitive activities within the Expressway Noise Boundary: a) Where any building used for a noise-sensitive activity is to be located within the Expressway Noise Boundary as shown on the planning maps: i) All habitable spaces within buildings used for the noise-sensitive activity must be adequately insulated from noise arising from use of the Napier/Hastings expressway. ii) Adequate sound insulation must be achieved by constructing the building to achieve a spatial average indoor design sound level of 40 dBA Leq in any room used for sleeping and 45 dBA Leq in all other habitable spaces. The indoor design level must be achieved with all windows and doors open unless adequate alternative ventilation means is provided, used and maintained in operating order. iii) An acoustic design report must be provided to the Council prior to any building consent being granted or where no building consent is required, prior to the commencement of the use. The acoustic design report must be prepared by a person qualified and experienced in acoustics. The report is to indicate the means by which the noise limits specified in this rule will be complied with and is to contain a certificate by its author that the means given therein will be adequate to ensure compliance with the noise limits specified in this rule.	Controls are included in the Expressway designation.	The rule only applies to development along the Expressway noise boundary. The rule sets an acceptable noise standard which provides a measure for monitoring. The rule could be an effective tool for land use planning were it applied to all residential development. The acceptable noise levels are slightly higher than WHO guidelines for internal noise levels for sleeping.

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
	b) Prior to any person requesting a Certificate of Compliance, an acoustic design certificate prepared by a person qualified and experienced in acoustics must be supplied, verifying compliance with the rule in 2(a) above. c) It will be a condition of subdivision of land (as defined in the Act) that a consent notice issued under Section 221 of the Act must be entered into before the issue of a Section 224 Certificate, with such a consent notice to be registered on the Certificate(s) of Title of the relevant lot(s). The consent notice is required to ensure that compliance with the acoustic insulation requirements in 2(a) above are achieved.		

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
Waimakariri District *Operative*	**Rule 30.1.1.10 Setbacks for structures**		These controls are unlikely to address noise from roads as no performance standard or acceptable noise level is included. The rule does not include any controls on roads or railways noise.

Location	**Setback is required from**	**Depth**
Rural zone	Any road boundary	20 m from any dwellinghouse
		10 m from any other structure other than a dwellinghouse
	Any internal site boundary	20 m for any dwellinghouse
		3 m from any other structure other than a dwellinghouse
	Any existing dwellinghouse on an adjoining site	10 m from any structure other (excluding a dwellinghouse)
All residential zones	Any road boundary (other than a boundary to a strategic road or arterial road	2 m
All residential zones where the site fronts onto a strategic or arterial road	The road boundary of any strategic or arterial road	6 m or 4 m for any garage where the vehicle entrance is generally at right angles to the road
Residential zone 5	Any site boundary adjoining accessway for allotments 15, 16, 17, 27, 28 and 29 shown on DP Map 140	4 m
Business 2 and 3 zones where the site fronts onto a strategic or arterial road	The road boundary of any strategic or arterial road	10 m
All business zones, where the site is adjacent to a residential zone or a rural zone	The zone boundary, or where the zone boundary is a road, the road boundary	10 m

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
North Shore City *Proposed*	**9.6.7 Subdivision of Land Adjacent to a High Noise Route** Applications for any residential subdivision adjacent to a high noise or future high noise route shall be accompanied by an assessment to show: (a) The proximity of the subdivision to any existing or future high noise route. (b) The measures taken in the design and layout of the subdivision to avoid or mitigate the potential effects of unreasonable levels of traffic noise; including but not limited to the incorporation of acoustic fences, earth bunds, parks, reserves and roads in the subdivision design to act as a buffer between the subdivision and the high noise route. Rule 10.5 All Permitted and Controlled activities are subject to the following controls: (b) Residential zones Existing High Noise Routes In circumstances where a residential unit is to be constructed on any site near to an existing and/or potential high noise route as specified in Appendix 10D and subject to a daily noise exposure level (L_{eq} (6am-10pm)) as defined in *New Zealand Standard 6801:1991* equal to or greater than (L_{eq} (6am-10pm)) 65 dBA on any part of the site, an Acoustic Design Report is to be obtained from a suitably qualified Acoustic Engineer confirming that the building will be constructed not to exceed a daily noise exposure of $L_{eq\ (6am-10pm)}$ 40 dBA in all habitable rooms with ventilating windows open.	Road construction or reconstruction outside a road reserve is a limited discretionary activity. **Rules 12.5.1.3(c) Road Construction / Reconstruction** In the case of the construction or reconstruction of any arterial or principal road which is proposed to extend beyond the boundary of any existing road reserve, the following assessment criteria shall apply: • The proposal should demonstrate appropriate measures to avoid and mitigate any adverse effects of traffic noise on any adjacent residential properties, in general accordance with *Transit New Zealand's Draft Guidelines* for the management of Road Traffic Noise, June 1994 and any subsequent updates. **Rule 12.5.4.2 Road Construction / Reconstruction** In the case of the construction or reconstruction of any arterial or principal road which is proposed to extend beyond the boundary of any existing road reserve, the following assessment criteria shall apply: a) The proposal should demonstrate appropriate measures to avoid and mitigate any adverse effects of traffic noise on any land zoned residential or used for residential purposes, in general accordance with *Transit New Zealand's Draft Guidelines for the Management of Road Traffic Noise June 1994* and any subsequent updates and any New Zealand Standard on the management of road traffic noise published at the date of the proposal.	The noise performance standards for residential areas are limited to existing or potential high noise route. This limits land use planning potential to address noise in other area. The rule does not take into consideration sleep disturbance. Road noise is directed to Transit New Zealand's Draft Guidelines for Management of Road Traffic Noise June 1994.

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
	c) Business zones New buildings and alterations to existing buildings to be used for residential purposes in any business zone must meet the following: • Noise received in all habitable rooms shall not exceed 35 dBA L_{10} between 2300 hours and 0700 hours with ventilating windows open • An Acoustic Design Report shall be obtained from a suitably qualified Acoustic Engineer confirming that the building will be constructed to meet the above requirement.		

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
Papakura City *Operative*	**Residential Zone** Rule 4.9.8.1 Permitted activity Yard setbacks: Arterial / principal roads 10 m; All other roads: 3 m	n/a	No specific controls relating to noise from land transport.
Waitakere District *Operative*	**Rule 1.2 High noise routes** Any dwelling erected on a front site adjoining a High Noise Route shall be a permitted activity where that dwelling is built to an acoustic standard, providing that the traffic noise as measured within any habitable room does not exceed a level of 45 dBA $L_{eq\ (24\ hr)}$ with windows closed.	**Rule 1.3 Future high noise routes** Roads which are to be High Noise Routes shall be a permitted activity where they are designed so that the traffic noise as measured 3.0 m inside any adjoining site or 1.0 m from the existing dwelling does not exceed 65 dBA $L_{eq\ (24\ hr)}$.	The values exceed WHO recommendations for sleeping areas. The rules are focused on short term transport predictions and provide limited land use planning.
Gisborne District *Proposed*	New habitable buildings must be designed to meet specified noise limits where adjacent to arterial roads. **Rule 11.16 -** 11.16.1 No new residential dwelling shall be erected adjacent to an arterial road, except where the following rules can be satisfied: a) An external $L_{eq\ (24\ hr)}$ level of 60 dBA measured at a point 1m from the facade of the building; or b) An internal $L_{eq\ (24\ hr)}$ level of 40 dBA in all habitable rooms with the windows closed.	n/a	No controls on land transport proposals. Nor are there any specific rules or controls relating to rail corridors. The performance standards for residential dwellings have a wide application, however, there is no consideration of sleep disturbance.

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
Hamilton City *Proposed*	**Rule 5.1.1 (i) Residential Activities adjoining major and minor arterial roads** Any habitable rooms in new residential activities or the construction of new habitable rooms or extensions to habitable rooms in existing residential activities shall meet an internal $L_{10\ (18\ hr)}$ noise level of 40 dBA, where constructed on a site adjoining: ▪ an existing major or minor arterial road (constructed before October 30 1999) specified as a High Noise Route in Appendix 5.1-I. ▪ a new major or minor arterial road (constructed after October 30 1999) which has been designated and only where habitable rooms are located above the height of 2.4 m above ground level. (ii) Where an internal noise level for a habitable room can only be met with doors and windows closed, then an alternative means of ventilation must be provided in accordance with the Building Act 1991. (iii) An acoustic design certificate will be required to show how the required noise standard will be met.	**Rule 5.1.1 h) Design and construction of new arterial roads** New major or minor arterial roads which adjoin the Residential Zone or Future Urban Zone shall be designed and constructed to meet the following noise standard at a point 3 m within boundary of any adjoining site and at any point up to 2.8 m above ground level: ▪ Any new major or minor arterial road (constructed after October 30 1999) where frontage access is limited or restricted - 60 dBA $L_{10\ (18\ hr)}$. ▪ Other new major or minor arterial roads (constructed after October 30 1999) – 65 dBA $L_{10\ (18\ hr)}$.	The rule provides a useful standard for land use planning setting noise standards for roads and residential dwellings. However, the rule does not consider sleep disturbance. Nor does the rule include any other types of noise-sensitive activities such as schools or hospitals.

Local authority & plan status	Controls on the receiver	Controls on road & rail	Comment
Rodney District *Proposed*	**Rule 16.9.2.2.1.1 New Activities** New household units, schools, hospitals and educational facilities in Residentially Zoned areas within 70 m of any existing or proposed road or highway shown on the Planning Maps or any Structure Plan in this Plan; which exceeds 10,000 vehicle movements per day, or road areas subjected to traffic noise levels of 60 dBA $L_{eq\ (24\ hr)}$ or greater; Shall comply with the following noise performance standard *New Residential Activities* Indoor Noise Level dBA (habitable rooms only), $L_{eq40\ (24\ hr)}$, L_{max55} (10:00pm –7:00am) Outdoor Noise Level dBA Private open space high intensity zone only, $L_{eq55\ (24hr)}$ *New Hospitals activities and teaching areas in Educational Facilities* Indoor Noise level dBA, (habitable rooms only), $L_{eq40\ (24\ hr)}$	**Rule 16.9.2.2.1.2 New Roads** (a) New Roads designed for an annual average daily traffic flow of 10,000 vehicles per day (vpd) or more, and which could have new residential lots created within 70 m of them, shall be so designed and constructed that the 10 year predicted traffic noise level when measured 3 m into any residential land facing the road, or 1 m from the facade of any existing building does not exceed 62 dBA $L_{eq\ (24\ hr)}$ in areas with a medium ambient noise level (50-59 dBA). In areas with a high ambient noise level (59-67 dBA), the level should not exceed the ambient noise level, plus 3 dBA $L_{eq(24\ hr)}$. (b) Any new road which was designed to meet these standards, shall be maintained to ensure that this Rule is not compromised.	Relatively consistent with WHO recommendations, although traffic predictions are based on 10 year projections and this is not considered long enough. Indoor noise levels do not consider sleep disturbance.

<table>
<tr><th>Local authority & plan status</th><th>Controls on the receiver</th><th>Controls on road & rail</th><th>Comment</th></tr>
<tr>
<td>South Waikato

Operative</td>
<td>14.4.2: Rule B

The following Performance Standards for noise shall be complied with throughout the District as detailed in this rule unless otherwise provided for in Rule C.
Noise levels to be achieved will be measured at the affected boundaries of the properties receiving the noise of the activity or the notional boundary of a rural dwelling.
The notional boundary will apply in the event that the nearest dwelling in the Rural Zone is more than 20 m away from the boundary of the property on which the noise is sourced.
The notional boundary may shift in the event that a new dwelling is erected on a lot created in the Rural Zone prior to 21 July 1994 (the date on which the Proposed District Plan was publicly notified).

<table>
<tr><th rowspan="2">Zone</th><th colspan="3">Maximum noise (dBA) L_{10} at the boundary of the receiving property</th></tr>
<tr><th>Day L_{10}</th><th>Night L_{10}</th><th>L_{max} night</th></tr>
<tr><td>Rural</td><td>50</td><td>40</td><td>75</td></tr>
<tr><td>Residential</td><td>50</td><td>40</td><td>75</td></tr>
<tr><td>Commercial core</td><td>55</td><td>45</td><td>80</td></tr>
<tr><td>Commercial fringe</td><td>55</td><td>45</td><td>80</td></tr>
<tr><td>General industrial</td><td>60</td><td>60</td><td>80</td></tr>
<tr><td>Heavy industrial</td><td>70</td><td>70</td><td>85</td></tr>
</table>
</td>
<td>14.4.2: Rule C: (i)

The following Performance Standards for noise apply to the specified activities:

Traffic Noise

Maximum Noise dBA
Day L_{10} 70
Night L_{10} 60
L_{max} Night 85
L_{10} 18 hour 63</td>
<td>The performance standard is used as 'trigger' (it is not applied as a rule) for determining whether the road is an excessive noise route that is listed in a hazards register that sits outside the district plan (B. Okell pers.comm.). Land owners with properties within 80 m of the centreline on either side of an excessive noise route (as defined in the district plan) are advised that they should expect higher noise levels than those that would normally apply to the zone in which they are located.

Rule B specifies noise limits for each zone. These noise limits apply as specified in that Rule B unless otherwise provided for in Rule C. This would cover roads that are not included in excessive noise routes.

The rules provide information for land use planning insofar as new development could be planned away from excessive noise corridors and transport networks could be bundled.</td>
</tr>
</table>

Local Authority & Plan status	Controls on the receiver	Controls on road & rail	Comment
Matamata - Piako District *Proposed*	**Rule 3.2.1(iii)** specifies that the front yard requirement in the Rural Zone for residential or habitable buildings on State Highways is 50 m (compared with a front yard of 25 m on other roads . **Rule 5.2.1(i)** specifies that where any dwelling in a Business Zone is to be constructed within 10 m of any road boundary an acoustic design report, prepared by a suitably qualified acoustic engineer, confirming that the specific design of the dwelling will provide a noise level ($L_{eq(24hr)}$) that will not exceed 45 dBA and the maximum noise levels (Lmax) that will not exceed 78 dBA in all habitable rooms with all opening windows closed shall be obtained within twelve months of the commencement of construction.	n/a	The rule only has limited application and does not cover all zones. The requirement to provide an acoustic report, within twelve months of the commencement of construction, is questionable.

Appendix 3 Data collection and monitoring noise exposure – focus on noise mapping

A3.1 Overview

Data collection and monitoring is considered a necessary part of effective noise policy (WHO 1999a). Noise can be calculated using various road traffic modelling tools. Initial data trends on noise exposure impacts may also be identified through public surveys and statistical analysis.

Little data exists on levels of noise exposure in New Zealand or where it occurs. State of the environment reporting is undertaken by many local authorities in New Zealand but information on land transport noise is scarce. The most common types of information are noise complaints made to local authorities. In contrast, noise monitoring and data collection has become increasingly sophisticated in a number of countries including the Netherlands, France, Austria, Germany and Denmark (Defra 1999).

Accurate data on exposure to noise provides valuable information for undertaking impact assessments and is an essential component of noise abatement strategies. In the right format data can assist decision-making on transport and land use planning (Defra 2004a). Monitoring also provides information on the effectiveness of mitigation measures and can assist cost-benefit analysis of future noise abatement technologies (de Kluijver & Stoter 2003).

It is prudent to develop consistent, accessible data to aid policy making and allow cross-referencing. Geographical information systems (GIS)[47] are widely used for strategic planning and assessment and particularly useful for mapping areas affected by noise and to assess current land use patterns. GIS provides a visual interpretation of noise that is readily accessible and interactive (de Kluijver & Stoter 2003).

Noise maps are commonly used in European countries to map information on noise, its source and the receiver. The maps are comprised of data derived from noise calculation models which are then integrated with GIS systems. GIS mapping is widely used by local authorities in New Zealand for resource consent and planning purposes and can provide a useful dataset for noise mapping development (S. Camp pers.comm.).

When establishing data, agreed noise descriptors assist consistency across regions. A growing consensus exists on which parameters are most effective for measuring noise. It is important to develop consistent measurements and methods of data collection if monitoring is to occur. This is the approach taken in Europe where harmonisation of data collection methods is encouraged to allow comparisons and policy review (European Parliament 2002, de Kluijver & Stoter 2003).

[47] GIS is a tool that establishes spatial relationships between geographically based objects, for example roads and buildings, by storing information on such objects as different layers of data which may then be compared (Defra 2001, Ordnance Survey website).

Noise mapping is one approach to measuring and monitoring noise. Noise maps range from basic maps showing noise contours to more sophisticated approaches that incorporate datasets on population density, building fabrication and location of noise barriers. Where maps are used for a national noise mapping strategy, regular updates of the noise maps and comparison between different moments in time are necessary (AEA Technology Rail BV 2004). The following section provides an overview on more sophisticated approaches.

A3.2 Noise mapping for land use planning

Noise exposure mapping or sound immission contour mapping (SICM) provides a visual interpretation of the location and number of people affected by noise in a given area. Maps assist in the collection of baseline information from which to measure future noise abatement. Noise mapping aims to locate affected people and assess their sensitivity based on the activities being undertaken (for example, residential dwellings, schools or quiet places). Noise maps are also effective for monitoring the efficacy of mitigation measures. Noise maps also show how different types of building layouts affect the spread of noise and identify any quiet zones that need to be preserved (Defra 2004a).

The European Commission Working Group on the assessment of exposure to noise (WG–AEN 2003) produced a detailed document on developing noise maps for member states including tool kits and information on using GIS to develop accessible and consistent mapping (WG-AEN 2003). In keeping with that guidance, de Kluijver & Stoter (2003) outline the six key steps to noise mapping as follows:

1. collecting, preparing, storing and querying raw data,
2. computing noise levels using computer models,
3. cumulating noise levels (when there are different sources),
4. determining noise contours,
5. determining noise effects,
6. presenting the impacts of noise.

A3.3 Data collection

This first stage in map development is data collection. Data collection is the most intensive element of noise mapping and accuracy is critical. Two sets of information are required including information on the source of noise and information on the receiving area. The latter includes information on population, numbers of dwellings and quiet areas. Information on road surfaces, bridges and topography is also required to predict noise. A summary of data requirements is outlined in Table A3.1.

Table A3.1: Noise mapping data requirements.

Geometrical data	Road traffic data	Population and land use#
• Numerical terrain model (grid points or altimetric lines) • Intersection of platforms with numerical terrains (i.e. embankments, viaducts, bridges) • Buildings (base height, height above ground, gutter or roof top, number of floors) • Ground characteristics (uniformly averaged, area specific, interfered from aerial photographs) • Climate data • Barriers (height, length, angle, type)	• Fleet composition and vehicle categorisation (monitored, deduced from national data, arbitrary or legal values) • Flow and speed distribution (with hourly, weekly, seasonal variations per vehicle category) • Road platforms (centreline/number of lanes) • Location of driving lines on the platform • Road surface characteristics • GSM / GPS measurement of driving speed on real traffic flows (disputable), or location dependent design speeds	• Population data: per building, per housing block, per town, per district • Categorisation of building use: industrial, commercial, offices, housing, schools, rest homes, hospitals, recreational • Data available per cadastral unit, per floor, per building, per zone • Quiet areas or areas of natural beauty

Population and land use are not essential to modelling and computation but they are required for establishing strategic noise maps and conflict maps if noise limits are related to land/building use (WG-AEN 2003)

A3.4 Calculating noise levels

Noise levels are computed rather than measured to allow for future predictions and a number of calculation methods are available. The Netherlands uses software developed using measures taken in the 1970s and 1980s (de Kluijver & Stoter 2003). The Dutch have ‘official’ calculation methods, one of which must be used when calculating noise for maps. Work on a third noise calculation model for railway noise is also underway (de Kluijver & Stoter 2003). UK calculation methods are based on a 1988 model which was reviewed in 1997[48].

Calculation methods need to be able to estimate the noise emission at source and calculate its transmission across a given area taking into account wind, weather conditions, distance, heights of buildings and land and ground absorption. Individual vehicles in combination with traffic characteristics determine noise levels and both are included in noise calculations.

48 For more information on calculating noise see: AUSTROADS. 2004a. Modelling, measuring and mitigating road traffic noise. *Austroads project no. PUB ES.C.009*. Austroads Inc: Sydney, NSW, Australia.

Malcolm Hunt Associates. 2004. *Noise impacts of land transport – stage 3: Development of policies for the management of noise from land transport*. Malcolm Hunt Associates: Wellington, New Zealand.

A3.5 Cumulative noise levels

The cumulative effect of noise levels from all sources needs to be considered when assessing noise and it is important to understand the cumulative effect of noise when considering new infrastructure (Stoter 1999). This can be useful for planning purposes as noises can be 'bundled' together, particularly transport corridors, e.g. juxtaposing rail and road corridors (de Kluijver & Stoter 2003) or avoided where maximum acceptable levels have been reached.

A3.6 Determining noise contours

The effects of noise are calculated by combining the two sets of data (noise exposure and locations of people and activities). The effect of noise is determined by the sensitive receivers in the area. This information can be useful when developing land use plans for areas.

The number of data points used to calculate and determine noise greatly influences the accuracy of results (de Kluijver & Stoter 2000, 2003, Ordnance Survey). It is prudent to determine the number of data sampling points. In areas where noise dissipates quickly over short distances more data points are needed - these are usually the point of barriers or buildings that obstruct noise transmission (de Kluijver & Stoter 2003). In contrast, fewer data points are needed in areas with little differentiation such as rural zones.

A3.6.1 Presentation of the impact of noise

Noise data are usually presented using a colour coded map. Colour bands give an indication of the level and spread of noise. Simpler versions are often based on noise contours which estimate noise levels using contours similar to bands of pressure on a weather map.

Limitations of the data must also be presented, e.g. very high readings will come from the middle of a road. It is important to show the actual location of such readings and compare with what occurs at the receiving end. Models are available which account for such errors; alternatively exact noise contours can be replaced with 'uncertainty bandwidths' (de Kluijvier & Stoter 2003).

A3.6.2 International experience with noise maps

Noise mapping is a requirement of the European Directive 2002/49/EC covering the assessment and management of noise. European Union member states must develop noise exposure maps to assist the development of 'action plans' for noise.

Noise mapping is currently used in a number of European Countries and has various uses including monitoring against standards, transport planning and data collection for environmental impact assessments. Germany, the Netherlands and Austria have computer-based mapping that provides detail on urban noise in a number of cities (Defra 1999). In the Netherlands traffic noise maps exist for all towns with populations over 50,000 and is an important tool for land use planning (Defra 1999, M. van den Berg pers.comm.).

The UK Government investigated international approaches to assist noise mapping in England (Defra 1999) and this culminated in the development of noise maps for London. An earlier pilot noise-mapping exercise was undertaken in Birmingham. The Birmingham project was the first comprehensive, city-wide map in England and was triggered by Birmingham City Council's involvement with the European noise mapping initiatives (Defra 2000).

The Birmingham project provided the former Department of Transport and the Regions (DETRA - now Defra) with a local case study on noise mapping that could be applied in other English cities. The Birmingham mapping project took 10 months to complete with the use of consultants.

The most recent example of noise exposure mapping in England is in Greater London. It provides a useful case study of how new mapping systems are implemented. The London mapping project sourced information from Europe and Birmingham and will be interesting to watch as the system matures. It took 13 months to complete and cost £500,000 (Defra 2004b).

A3.6.3 Case study: London, England

London's noise problems match those in other major urban centres. Defra (2004a: 6) claim that 13% of London residents consider noise a serious problem. The Greater London Authority (2004: 3) claim that 65% of Londoners believe noise is a problem where they live and 74% state that noise is a problem for London as a whole. In addition, 2.67 million buildings in Greater London are considered to be 'acoustically significant', or sensitive to noise (Defra 2004a: 9).

The Noise Mapping England project culminated in the development of online noise maps for London called the 'London noise map web viewer[49]'. Visitors to the website enter a road name, postcode or map reference to find noise levels from roads or major roads. There are two sets of maps, one showing noise from all roads and the second set showing only noise from major roads. Each map shows the level of noise at different times of day. Noise levels are shown using a key consisting of 12 colours ranging from 0-30 dBA L_{dn} to >80 dBA L_{dn}.

The development of noise maps for London involved three key elements including data collection and collation, engaging London Boroughs and stakeholders, and providing training. Information collection was assisted by the use of the Atmospheric Emissions Inventory which is used for calculating air pollutant levels and contains information on traffic movement on major roads. Additional information on road surface types, elevated bridges and artificial topography was obtained from additional sources (Defra 2004a).

Noise levels were calculated using the UK *Calculation of Road Traffic Noise (1988)* model (see Appendix 6). Detail on the location of noise barriers was needed to ensure accurate calculations. Photogrammetry[50] was used to obtain information on the location and height

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[49] See Defra 2004a

[50] Obtaining measurements by using photographic images.

of such features. For other details, such as building height, some assumptions were necessary.

The calculations were made on a square grid covering the whole of the calculation area at 10 m intervals, at a height of 4 m above ground level. This equates to 10,000 calculation points per square kilometre over an area of 1,600km^2, the resulting map containing approximately 16,575,000 calculation points (Defra 2004a).

A number of lessons and limitations were learnt in the process. The first was that the maps only provide a strategic insight into road traffic noise impacts and their locations. The development team argues that the maps do not provide a platform for reviewing noise control policies. Rather the maps provide an indication of the impact of noise. It is hoped that this will be possible as the system matures and the information improves in terms of precision (Defra 2004a).

The most time-consuming aspect of the map development is data collection. Resources were focused on gathering information on specific details. Examples of the specific detail required included information on the profile of road surfaces and factors affecting noise propagation such as gaps between buildings (Defra 2004a). That document also noted that the use of compatible datasets, which can be integrated in the mapping system, is important.

A3.7 Comment

Noise exposure mapping provides valuable information to predict, prevent and cure land transport noise. Sophisticated maps can provide a useful tool for land use planning. Once maps are developed software can be used to present different scenarios such as the effect of new infrastructure or different building layouts and designs.

The most challenging aspect of developing noise mapping in London was data collection. Information on parameters that affect noise propagation, such as buildings and barriers, proved complex and time-consuming to collect.

Noise mapping can be an expensive exercise. Estimates for mapping Christchurch range from $500,000 to $1 million (S. Camp pers.comm.). Prior to the development of noise maps in London, resources were spent identifying the most effective data sources and calculating the number and location of people exposed to noise (King & Bush 2001). This seems a logical approach to ensure mapping is cost-effective.

Simple noise contour mapping is an alternative option and is commonly used in New Zealand around ports and airports. Contour maps have limited application and do not usually include information on topographic features affecting the transmission or propagation of noise. Nor do they identify individually affected properties. Contour maps are considered to have limited application for land use planning.

Because of the cost and initial resource requirements of noise maps, some consideration must be given to their application and who will have ultimate responsibility for their maintenance. Ultimately the balance of responsibility between central and local government and transport authorities needs to be decided (Defra 2001). The Birmingham project team recommended developing a standardised method of producing noise mapping information, particularly at a local level to overcome technical difficulties or inconsistencies when comparing data. This seems a sensible suggestion for New Zealand where it would provide consistency for land use planning decisions that utilise the maps and may reduce implementation costs.

The London noise map as it appears on the London Noise Map website. This view shows west central London; a section of Hyde Park can be seen the bottom left hand corner and Regent's Park is at the top of the map.

(Reproduced with permission from Atkins Noise and Vibration)

Figure A3.1 London noise map

Appendix 4 Noise measurements

Consistent measurements are useful to apply for describe noise levels. The World Health Organisation (WHO) and the OECD are the main bodies that have helped to define a consistent approach to measuring. Noise levels are commonly described using the following measurements.

A4.1 Long-term exposure

- **L_{eq} / L_{Aeq}** (equivalent continuous sound pressure level)

  The equivalent continuous sound pressure level is widely cited as an acceptance scale for the measurement of long-term noise exposure (EC 1996, WHO 1999a, Malcolm Hunt Associates 2004, AUSTROADS 2005). L_{eq} has been adopted by the International Organisation for Standardisation the measurement of both environmental noise exposure and hearing damage risk (EC 1996). L_{eq} provides a level that is equivalent to the average sound energy over that period. Average levels are usually based on integration of A-weighted levels. Thus L_{eq} is the average energy equivalent level of the A-weighted sound over a period T (WHO 1999a). L_{eq} can be used to measure continuing sounds such as road traffic noise.

A4.2 Individual noise events

To describe quick fluctuating sound and sound events with less frequent sounds additional measurements which describe the time history are used. These include:

- **L_{max}**

  This is the measurement of a single sample level of sound often used in night emission limits a means of ensuring sleep protection. L_{max} controls short duration, high level sounds such as audible single passing vehicles. When there are distinct events to the noise such as with aircraft or railway noise, measures of the individual events can be taken using L_{max} in addition to L_{eq}.

- **SEL** (Sound Exposure Level)

  Another sound measurement that can be used to measure single noise events.

- **L_n**

  The statistical noise levels (indicating the level that is exceeded (100-n)% of time).

- **L_{10}**

  The level of sound exceeded for 10% of the monitoring period. This level of sound equates to an average maximum sound and is used widely in emission limits as the L_{10} correlates well with the subjective reaction to sound. L_{10} is generally measured over 10-15 minute time periods.

- **L_{90}**

  The level of sound exceeded for 90% of the monitoring period. This level of sound equates to the average background sound level and is influenced by sources such as industrial equipment and constant low-level sounds from air handling equipment. Noise emission limits are not generally specified in terms on an L_{95} level (Malcolm Hunt Associates 2004). L_{90} or L_{95} can be used as a measure of the general background noise level (WHO 1999a).

Appendix 5 OECD Environmental sustainable transport (EST) guidelines (OECD 2000:11)

1. Develop a long-term vision of a desirable transport future that is sustainable for environment and health and provides the benefits of mobility and access.

2. Assess long-term transport trends, considering all aspects of transport, their health and environmental impacts, and the economic and social implications of continuing with 'business as usual'.

3. Define health and environmental quality objectives based on health and environmental criteria, standards, and sustainability requirements.

4. Set quantified, sector-specific targets derived from the environmental and health quality objectives, and set target dates and milestones.

5. Identify strategies to achieve EST and combinations of measures to ensure technological enhancement and changes in transport activity.

6. Assess the social and economic implications of the vision, and ensure that they are consistent with social and economic sustainability.

7. Construct packages of measures and instruments for reaching the milestones and targets of EST. Highlight 'win-win' strategies incorporating, in particular, technology policy, infrastructure investment, pricing, transport demand and traffic management, improvement of public transport, and encouragement of walking and cycling; capture synergies (e.g., those contributing to improved road safety) and avoid counteracting effects among instruments.

8. Develop an implementation plan that involves the well-phased application of packages of instruments capable of achieving EST taking into account local, regional, and national circumstances. Set a clear timetable and assign responsibilities for implementation. Assess whether proposed policies, plans, and programmes contribute to or counteract EST in transport and associated sectors using tools such as Strategic Environmental Assessment (SEA).

9. Set provisions for monitoring implementation and for public reporting on the EST strategy; use consistent, well-defined sustainable transport indicators to communicate the results; ensure follow-up action to adapt the strategy according to inputs received and new scientific evidence.

10. Build broad support and co-operation for implementing EST; involve concerned parties, ensure their active support and commitment, and enable broad public participation; raise public awareness and provide education programmes. Ensure that all actions are consistent with global responsibility for sustainable development.

Appendix 6 UK calculation of road traffic noise

The following is adapted from the National Measurement Laboratory web page *http://www.npl.co.uk/acoustics/techguides/crtn/* which provides an online calculation for assessing road traffic noise adapted from the UK Calculation of Road Traffic Noise (CRTN) issued by the UK Department of Transport in 1998. Copies of CRTN are available from Calculation of Road Traffic Noise in the UK and can be ordered online from the Stationery Office *http://www.tso.co.uk/.*

The CRTN is commonly used for calculating noise in the UK. It provides a method for calculating road traffic noise levels for non-complex situations. The model has limitations, for example when a simple reflective correction is needed for reflective surfaces. Where low traffic flows occur, further correction is generally needed.

The CRTN was used to assess road traffic noise during development of the London noise maps. Using CRTN the main features that need to be represented are:

The noise source:

- *vehicle flow rate,*
- *percentage of heavy vehicles (defined as vehicles with unladen weight > 1525kg),*
- *mean vehicle speed,*
- *gradient of road,*
- *road surface characteristics*.

The propagation path:

- *perpendicular distance of receptor from source,*
- *average height of propagation above ground surface,*
- *the acoustic characteristics of the ground surface,*
- *angle of view of source from receptor,*
- *path difference over barriers that interrupt the line of sight,*
- *reflecting surfaces close to the source*.

The receptor:

- *the location, height and angle of view of the receptor,*
- *reflecting surfaces close to the receptor* (Defra 2004a: 10-11).

A visual representation is provided in the following web page, also from the NPL website noted above.

Stage 1 - Divide the road scheme into segments

Divide the road scheme into segments such that the variation of noise within the segment is small.

Stage 2 - Basic noise level

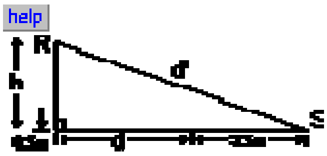
Calculate the basic noise level at a reference distance of 10m away from the nearside carriageway edge for each segment.

Time Period	☐ Hourly L_{10} ☑ 18 Hour L_{10}
Total Vehicle Flow	26000 (Veh/Hour : Veh/18 Hour)
Speed	65 (km/h) - Estimated from the road class? ☐
Heavy Vehicles	22 (%)
Gradient	3.3 (%) ☑ Upward flow help
Road Surface	Impervious help
	dB(A)

Stage 3 - Propagation

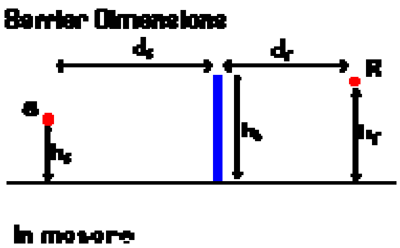
Assess for each segment the noise level at the reception point taking into account distance attenuation and screening of the source line.

Distance d (From edge of NS Carriageway)	21.0 (metres)	help
Source/Receiver Height Difference h	3.5 (metres)	



☐ The view of the road IS obscured

☑ The view of the road is NOT obscured



d_s	8.5	Absorbent Ground Cover: 40% to 59% (I=0.5)
h_s	0.5	
d_r	37.0	
h_r	4.0	Average Path Height: 2.25 (m)
h_b	3.0	
		dB(A)

Stage 4 - Site Layout

Correct the noise level at the reception point to take into account site layout features including reflections from buildings and facades, and the size of the source segment.

Include a correction for the receiver facade	☑
Angle of View	120 (degrees)
Total angle of reflective surfaces (opposite)	45 (degrees)
	dB(A)
The total for this segment can now be calculated from those values above	dB(A)

Stage 5 - Combine contributions from all segments

Combine the contributions from all segments to give the predicted noise level at the reception point for the whole road scheme.

Add up all of the segment totals: the final number should be rounded to the nearest whole number (0.5 being rounded up). Also, remember that the screening and reflection corrections applied here are the simple ones defined by CRTN. Sections 34 and 35 of CRTN should be consulted where a more complex arrangement of reflective surfaces is to be considered.

The combined running total for all segments is calculated as described

Updated each time a segment total is calculated. Segments

Predicted noise level dB(A)

©

Appendix 7 California Government Code, Section 63502f

(f) A noise element which shall identify and appraise noise problems in the community. The noise element shall recognize the guidelines established by the Office of Noise Control in the State Department of Health Services and shall analyze and quantify, to the extent practicable, as determined by the legislative body, current and projected noise levels for all of the following sources:

(1) Highways and freeways.

(2) Primary arterials and major local streets.

(3) Passenger and freight on-line railroad operations and ground rapid transit systems.

(4) Commercial, general aviation, heliport, helistop, and military airport operations, aircraft over flights, jet engine test stands, and all other ground facilities and maintenance functions related to airport operation.

(5) Local industrial plants, including, but not limited to, railroad classification yards.

(6) Other ground stationary noise sources, including, but not limited to, military installations, identified by local agencies as contributing to the community noise environment.

Noise contours shall be shown for all of these sources and stated in terms of community noise equivalent level (CNEL) or day-night average level (L_{dn}). The noise contours shall be prepared on the basis of noise monitoring or following generally accepted noise modelling techniques for the various sources identified in paragraphs (1) to (6), inclusive.

The noise contours shall be used as a guide for establishing a pattern of land uses in the land use element that minimizes the exposure of community residents to excessive noise.

The noise element shall include implementation measures and possible solutions that address existing and foreseeable noise problems, if any. The adopted noise element shall serve as a guideline for compliance with the state's noise insulation standards.

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