ROAD TRAFFIC NOISE: LOSING THE FIGHT?

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Abstract

In 1986, the OECD produced "Fighting Noise: Strengthening Noise Abatement Policies" [1] and, less than a decade later, "Fighting Noise in the 1990s " [2]. More recently, the Australian Academy of Sciences used a similar title [3] – all dealing with the management of environmental noise. These titles clearly signaled resolve to tackle the issues of environmental noise, including the focus of this paper, road traffic noise, and one would have hoped that, now a decade or two down the track, we could report good progress. But, even in Australia, where we have had environmental noise legislation for over 30 years; Environmental Protection Agencies or equivalent in each state; a highly competent skill and knowledge base with respect to road traffic noise; noise control as an integral component of new roadway design – we are losing the fight against road traffic noise. This paper demonstrates that we have a major problem in Australian cities of exposure to high levels of road traffic, and that this situation will continue into the future, if not deteriorate. The paper examines why this is so, and speculates that significant change at policy level will be required to address this problem. This will require recognising that engineering *noise control* approaches to road traffic noise have failed to reduce overall urban exposure and cannot be relied upon to do so in the future. New concepts such as *soundscapes*, where several professional areas work together to define and implement desirable acoustic environments, warrant experimentation.

Introduction

Noise, along with other forms of pollution, has figured on the action agenda of communities, governments and researchers for well over three decades. The focus has been on both non-transport and transport sources, and in the latter, each of air, road and rail modes has had attention. The United States lost much of its interest in road traffic noise when the US EPA's Office of Noise Abatement and Control was shut down by President Reagan in the early 1980's, but other developed countries have continued to recognise the problem of road traffic noise and to apply well-known solutions to its control. This is described, for example, in the OECD publications in 1986 and 1991 [1,2] and, more recently, on the Australian Academy of Sciences *Nova: Science in the News* site [3]. These publications have all pointed to the need for "fighting noise", including the noise from road traffic, and techniques for its management. How are we travelling in this *fight* against road traffic noise?

This paper suggests that, despite several decades of national noise controls for new vehicles; environmental noise legislation and Environmental Protection Agencies, or equivalent, in each State; a competent and skilled acoustical knowledge base with respect to road traffic noise; road traffic authorities that now generally adopt noise control as an integral or add-on component of new roadway design – we still are not traveling particularly well in the fight against road traffic noise.

We know that road traffic noise has significant effects on quality of urban life, potentially even on human health, and while we have been tackling the problem for decades, there is evidence that the extent of exposure to road traffic in our cities remains at unacceptably high levels. If, after all the effort and expenditure to date, there is little joy in current data as to our success in managing the overall problem of road traffic noise in our urban areas, we need to examine where current policies and approaches are failing us, and look for alternative or complementary approaches.

The Extent of Road Traffic Noise Exposure: Estimates for Australian Capital Cities

Despite considerable resources being devoted in the past to urban noise surveys, and to State of the Environment reporting in a range of jurisdictions, there is an absence of reliable estimates of trends in the extent of exposure to road traffic noise in Australia. While trends are not available, recent work by Brown and Bullen [4] provides a good snapshot estimate of the population of each city exposed to road traffic noise in excess of any nominated level above about 55 dB L_{Aeq24h}.

Based on a carefully constructed random sample of dwellings in Australian capital cities, Brown and Bullen's study measured traffic flow and propagation distance information and used these to calculate the road traffic noise exposure of dwellings. The results of that study are reproduced in the figures below. Figure 1 provides an estimate of the proportion of dwellings within the Urban Centres of Sydney, Melbourne, Brisbane, Adelaide and Perth for which the calculated traffic noise level exceeded various values of $L_{A10,\ 18h}$. Figure 2 shows the same results, but using the L_{Aeq24h} scale.

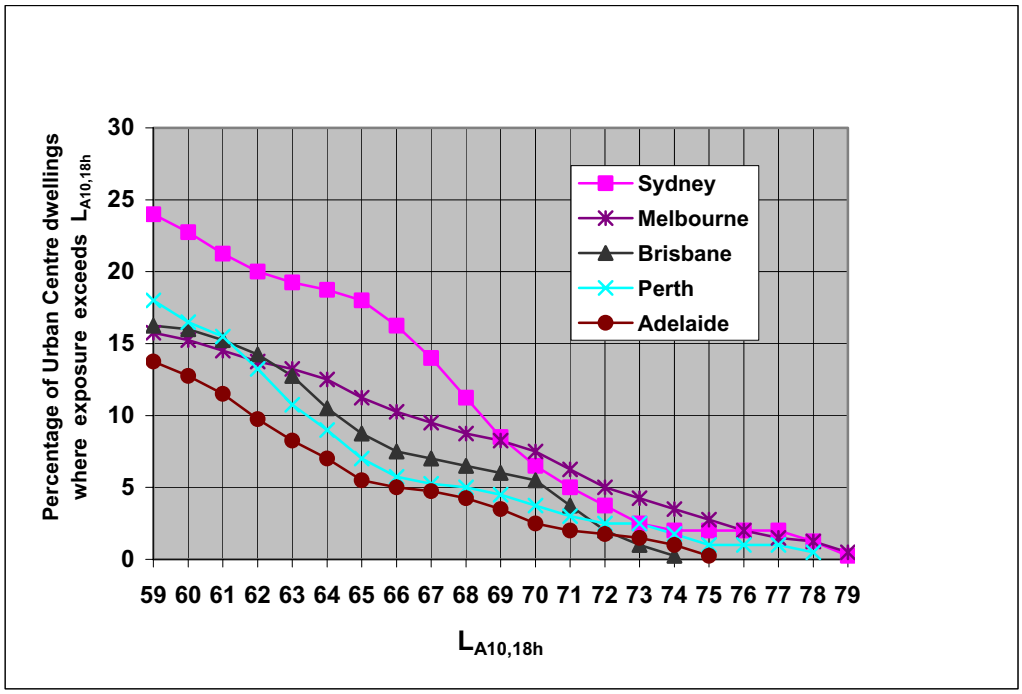

Figure 1. Cumulative noise exposure of dwellings in Australian capital cities, $L_{A10,18h}$ [4].

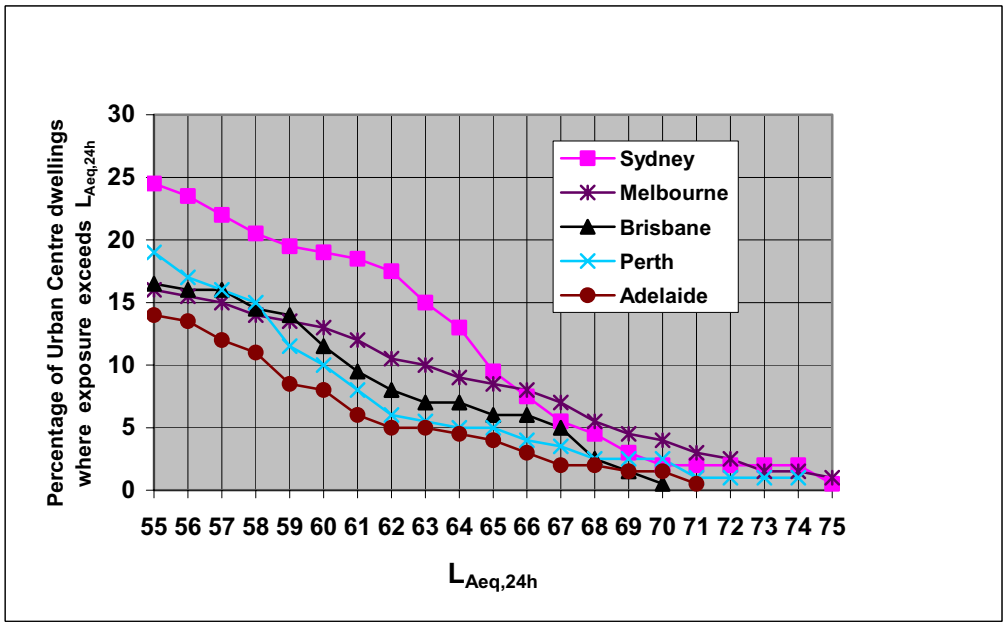

Figure 2. Cumulative noise exposure of dwellings in Australian capital cities, L_{Aeq24h} [4].

For Sydney, over 11% of the population were exposed to $L_{A10,18h}$ of 68dB or above, and 19% of the population were exposed to $L_{A10,18h}$ of 63 dB or above. Confidence limits for these estimates have been provided. For example, the percentage of dwellings in Sydney exposed to 68dB or above was 7.7% to 15.5%, and for the percentage of dwellings exposed to 63 dB or above was 14.6% to 24.3% ($p < 0.05$). For Adelaide, over 4% of the population was exposed to $L_{A10,18h}$ of 68dB or above and 8% of the population to $L_{A10,18h}$ of 63 dB or above. The confidence band for the percentage of dwellings in Adelaide exposed to 68dB or above was 2.2% to 7.2% and for the percentage of dwellings exposed to 63 dB or above 5.2% to 12.0% ($p < 0.05$). The exposures for the other cities lie generally between the exposures for these two cities.

These estimates show that the situation with respect to road traffic noise in all capital cities is poor. Some 8-20% of dwellings exposed to $L_{A,10,18h}$ levels above 63 dB, and 5-11% of dwellings above 68 dB, must be regarded as unacceptably high proportions of the population subject to such levels. Given the above levels, variously adopted as criteria in Australian states, are considerably higher than those recommended by a WHO expert task force [5] as necessary to protect against annoyance and sleep disturbance, the extent of the problem is even greater than suggested by these proportions.

The Extent of Road Traffic Noise Exposure: Detailed Modelling for the City of Gold Coast

A similar level of road traffic noise exposure in another Australian city can be confirmed through a quite different approach. Brown, Affum and Chan [6] have used Griffith University's TRAEMS modelling procedure in a demonstration project in the City of Gold Coast. TRAEMS is an acronym for **TR**ansport planning **A**dd-on **E**nvironmental **M**odelling **S**ystem and is a GIS-based tool for the estimation and evaluation of the environmental impacts of multi-modal transport proposals. Transport and environmental planners can use it as an add-on program to travel demand models to provide information on the environmental impact of any transport-planning scenario. The environmental effects considered are traffic noise, air pollution, energy consumption and greenhouse gases, but only the traffic noise results are reported here.

Road transport data sets for the Gold Coast were obtained from the Gold Coast City Council and comprised output data generated from their EMME/2 transport model. The data sets included:

- modeled road networks for the years 2000, 2011 and 2021
- existing road traffic flows for 2000 and modeled future traffic flows for 2011 and 2021. The modeled traffic flow for 2011 and 2021 assume the proposed Gold Coast Light Rail system will be operational by those dates.

These traffic flows were used, together with the measured location of all dwelling units relative to the roadways, to calculate road traffic noise exposure of dwellings in Gold Coast City.

The resulting distribution of road traffic noise exposure levels for year 2000, at Gold coast dwelling units, is shown in Figure 3. Only dwelling units exposed to noise levels of 50 dB(A) or above are shown.

In year 2000, 7701 dwelling units in the City (some 4% of the total dwelling units) were exposed to noise levels of 68 dB $L_{A10,\ 18h}$ and above, and another 8288 (4%) were exposed to levels of 63-67 dB, $L_{A10,\ 18h}$. These indicate road traffic noise exposures of the same order as those reported in the national survey of Australian Capital cities above, particularly those of the smaller cities of Adelaide and Perth (Figure 1), falling within the confidence bands of those city estimates.

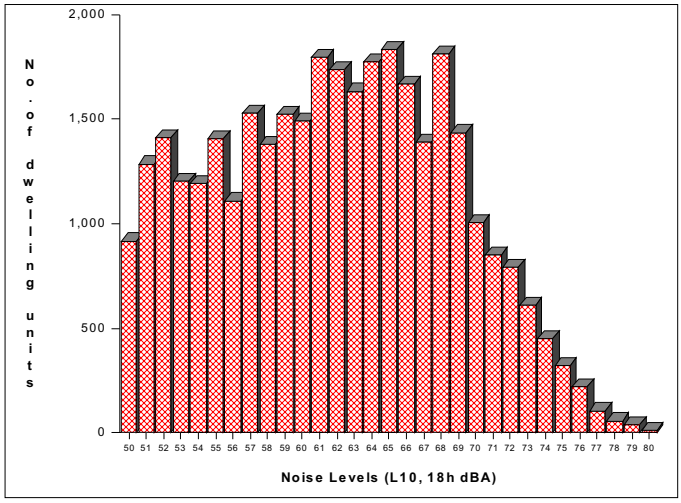

Figure 3. Distribution of noise immission levels at the facade of dwellings for the year 2000 modeled network for the City of Gold Coast [6].

The TRAEMS modelling also provides future estimates of exposure, based on predicted traffic flows. Table 1 shows estimates for years 2011 and 2021. The situation overall does not improve, with the number of dwelling units above 68 dB(A) in 2021 increasing 9% over the 2000 estimates. There are two aspects of the futures modelling that underestimate deterioration. Firstly, all estimates of future noise exposure are based on year 2000 dwelling unit stock - potential infill in the housing stock along the road network has not been included in these results. As a consequence, years 2010 and 2021 estimates likely underestimate the extent of future exposure. Secondly, the traffic flows in 2011 and 2021 assume a new light rail network will be in place with a consequent shift of significant traffic flows from the roadway to the light rail network.

Table 1: Number of dwelling units in Gold Coast City exposed to different road traffic noise levels for each of 2000, 2011 and 2021 scenarios (and percentage total dwelling units) [6].

	2000	**2011**	**2021**
Number of dwelling units exposed to levels of 68 dB(A) and above	7701 (4.1%)	7452 (4.0%)	8382 (4.5%)
Number of dwelling units exposed to 63-67 dB(A)	8288 (4.4%)	8367 (4.5%)	8297 (4.4%)

It is instructive to examine how these high noise exposures are distributed across the city. Figures 4 and 5 provide the approximate location of the dwellings in Table 1 relative to the year 2000 road network - Figure 4 shows these for the entire City of the Gold Coast while Figure 5 presents the same data, but for a part of the City at a larger scale. The problem of high noise exposures is not confined to major roadways in the road network, but can be found along a high proportion of the roads in the City's network.

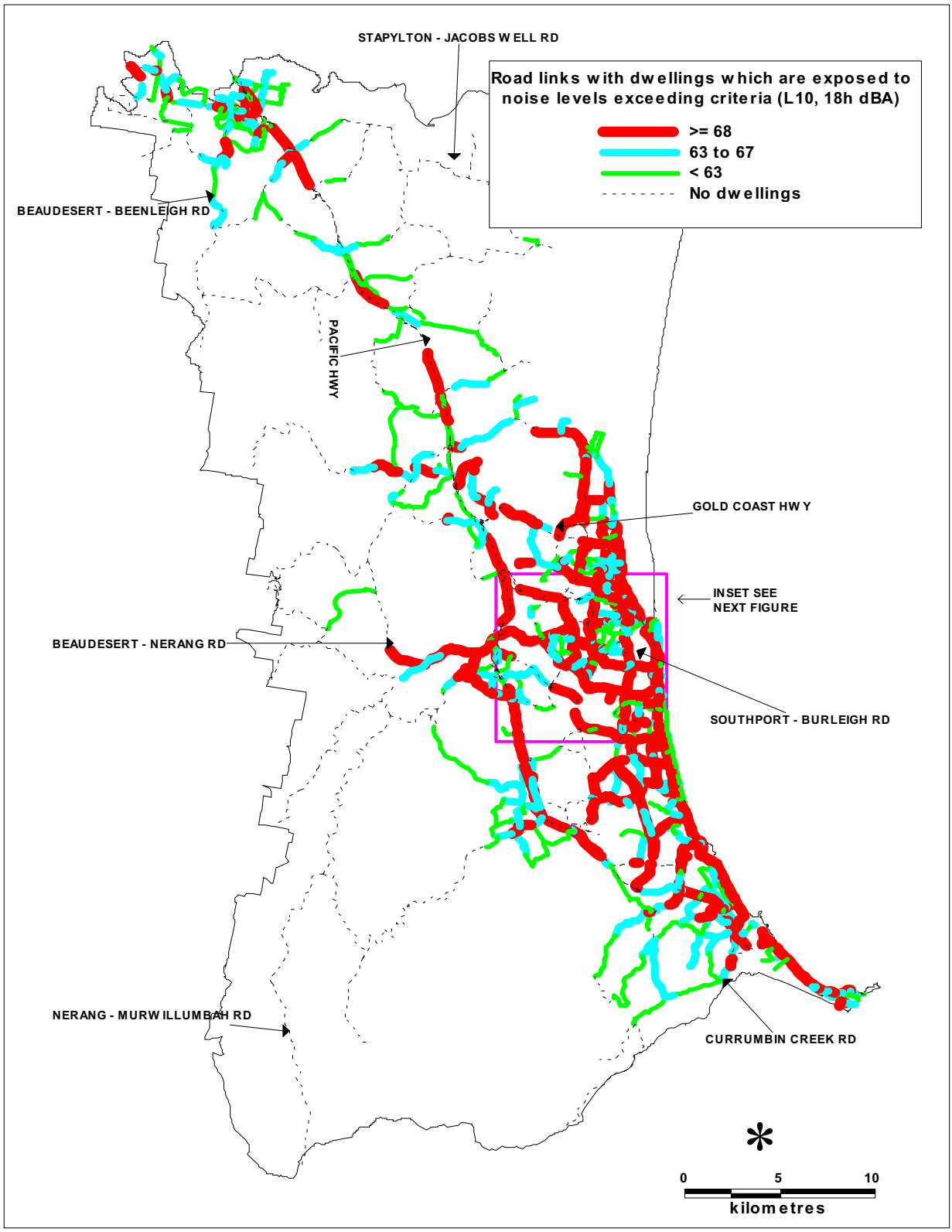

Figure 4: Noise immission levels resulting from the 2000 modelled network for the City of the Gold Coast.

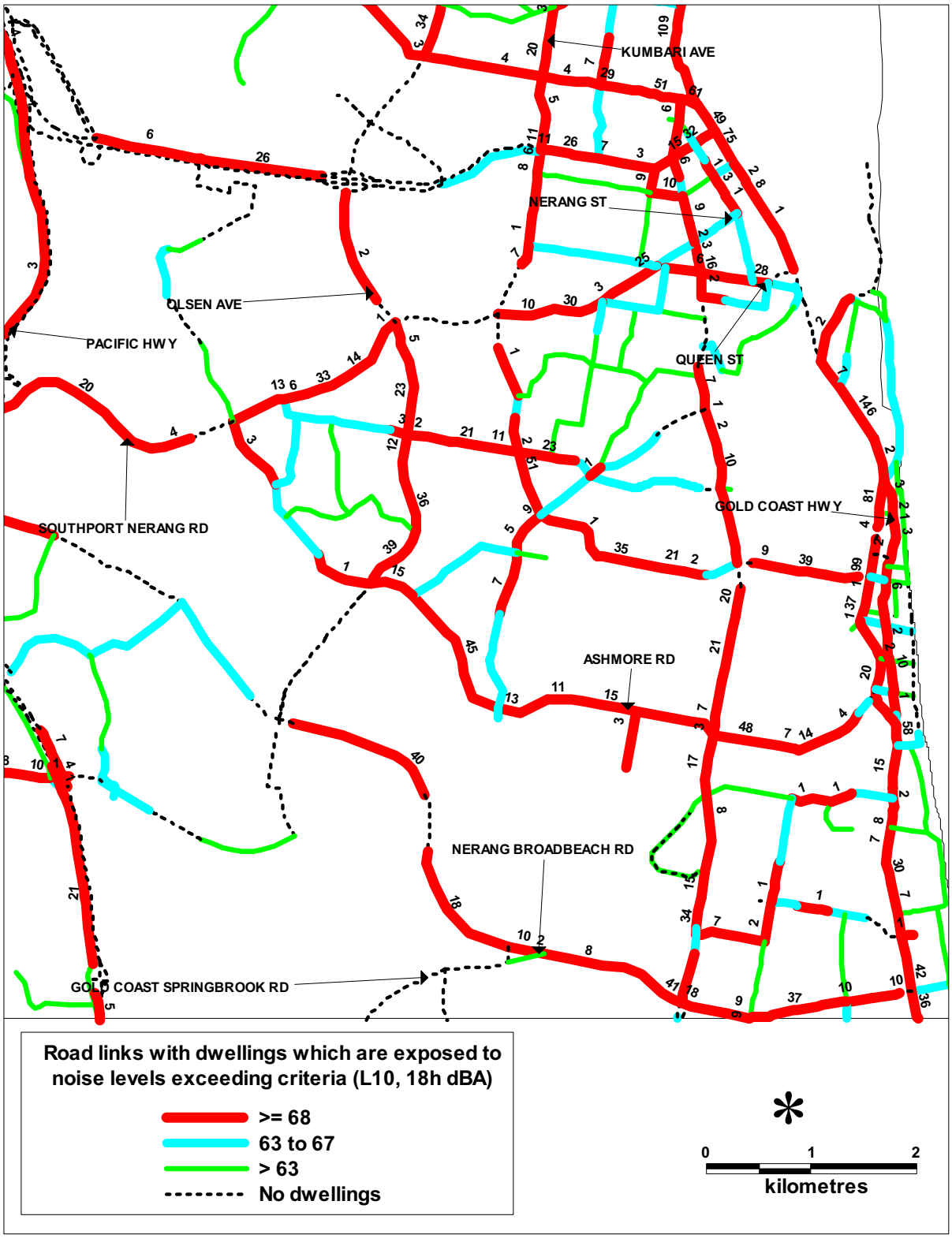

Figure 5: Noise immission levels resulting from the 2000 modelled network for the part of the City that includes the Light Rail corridor. Link labels show the number of dwellings on that link whose exposure exceed 68 dB.

Failure of Road Traffic Noise Policy

These two sets of data show that there is a significant segment of the Australian urban population that is exposed to unacceptably high levels of noise - and there is no evidence that this will decrease in future. The conclusion must be that current approaches and policies to control road traffic have significant limitations. Why and where is road traffic noise policy failing us? And are there approaches we could adopt in the future that are not just more of the same?

While an easy answer to the first question may be that most governments have never been particularly serious in their commitment to addressing road traffic noise problems, this is too simplistic a response. Explanations can also be sought in the dominance of engineering solutions, such as the control of emissions from individual motor vehicles and the mitigation of road traffic noise by roadside barriers, in traffic noise policy, often to the exclusion of other approaches. Limits to the effectiveness of these are examined further below.

Answers to the second question include some hope that the recent European Directive on environmental noise may provide a new look at the road traffic noise problem, with its emphasis on mapping of immissions throughout entire urban areas and its requirement for the development of noise management plans. More speculatively, the concept of *soundscapes* may provide a refreshing approach, with its stress on *design* rather than *noise control* in managing some aspects of the road traffic noise problem in our cities. These matters are also touched on below.

Limits to the effectiveness of engineering approaches

The limiting of emissions from individual motor vehicles has been a major strategy in the control of road traffic noise. Australia, as elsewhere, has regulated new vehicle noise levels since the late 1970s through application of Australian Design Rules (ADRs) for vehicles. Changes in these rules successively reduced the emissions from individual vehicles, but since last revised in 1989, the limits imposed by the ADRs has lagged behind overseas trends and become substantially less stringent than those established overseas [7]. New limits for vehicles in Australia will take effect from 2005.

Surely increasingly stringent noise emission limits on individual vehicles will lead to a reduced exposure of the population to road traffic noise levels? Not so, according to the most comprehensive study of the effect of noise emission regulations [8]. The I-INCE report found little effect of reducing vehicle emissions. For light vehicle traffic, at constant speed, there has been no significant improvement in the noise emitted by the traffic stream, and for heavy vehicle traffic at constant speed there has been an improvement[1] of about half the vehicle emission improvement, but very little at high speed. The reasons for this are many fold, but include: the absence of tyre/roadway noise considerations in test procedures; conservative emission limits in the early years of regulation; the time it takes for vehicles to be replaced; increasing size and power of heavy vehicles; and the lack of realism and representativeness of driving conditions of the test conditions for vehicle emission limits [8].

Irrespective of the reasons, the I-INCE study provides convincing evidence as to why there should be no expectations that current high levels of exposure to road traffic noise in Australian cities will be reduced in the future through the technical solution of vehicle noise limits - even if these are about to be tightened.

Another dominant engineering strategy to reduce exposure to road traffic noise has been the construction of roadside noise control barriers. A very large amount of effort, and funds, have been expended on this strategy, particularly to limit exposure to noise from newly constructed roadways.

As necessary and as beneficial as much of this expenditure has been, particularly where new roadways have been constructed through urban areas, this engineering solution is capable of tackling only the tip of the iceberg of the urban traffic noise problem, leaving much of the highly noise exposed population untouched. The reason is that most of the highly exposed urban population is unprotectable by any strategy that sees the mitigation of road traffic noise to consist primarily in the provision of noise barriers, or walls, between the vehicle sources and the dwelling receptors.

Unprotectable – because barrier walls are effective in reducing line-source noise at point receptors only where the walls are continuous over significant distances, and where vehicular access is not required through the line of the wall. In all but exceptional circumstances, such walls can only be constructed along what are generally termed no-access roadways, and in Australian cities these tend to be freeways and a very limited length of major arterial roadways. Only a small proportion of dwellings in Australian cities are located adjacent to such no-access roadways. Most roadways in urban areas in Australia, be they arterial, sub arterial or collector roadways, are "immune" from this form of road traffic noise mitigation because vehicular access is required to properties fronting

[1] These refer to changes (or the absence of change) in traffic stream noise measures such as L_{eq}. There will of course be larger improvements where traffic stream noise measures are based on peak noise levels, such as for the assessment of sleep disturbance.

the roadway or because it is not possible to construct continuous lengths of acoustic walls.

Some idea of the limited potential for application of roadside wall mitigation in Australian cities can be obtained from data in Brown and Bullen [4]. They collected information on which organisation had jurisdiction over the roadways that were the source of road traffic noise exposure. In each State, certain roads are designated as state-controlled roadways, or "declared" roadways, and are the responsibility of the respective State road authority. The rest of the city's road system is the responsibility of the local government or municipality. Figure 6 shows noise exposure according to whether the noise was generated from State-controlled roadways or from local government-controlled roadways for two cities.

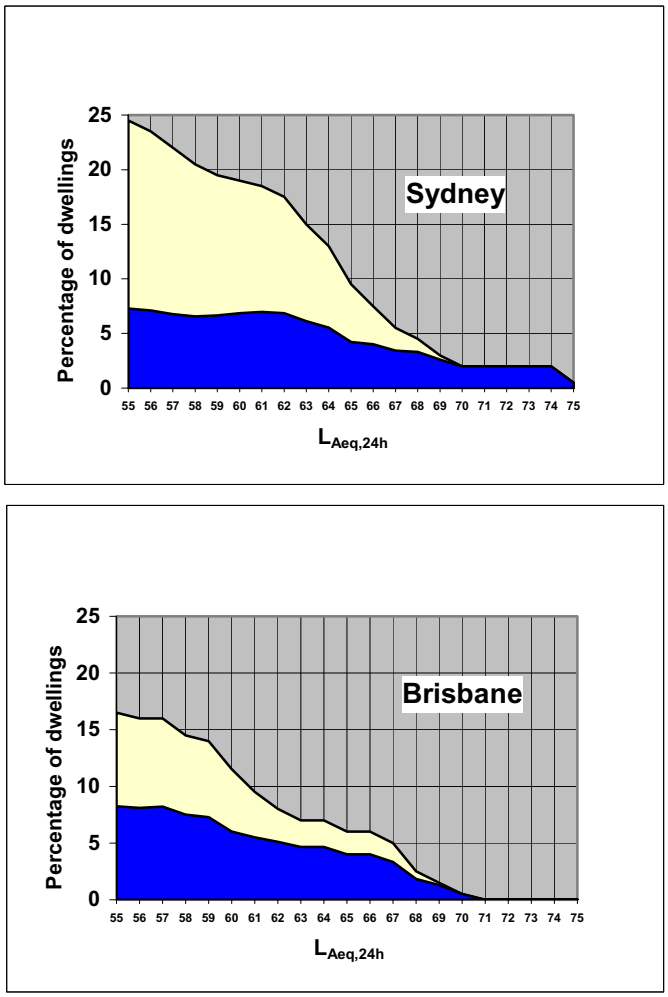

Figure 6. Jurisdictional responsibility for the roadways generating noise exposure in Sydney and Brisbane. The lower line shows the cumulative noise exposure of dwellings where the noise is generated from State-controlled roadways alone. The upper line shows the cumulative noise exposure where the noise is generated from either local authority roadways or State-controlled roadways [4].

Figure 6 can be used to demonstrate that many dwellings exposed to high levels of noise are along roadways for which noise levels cannot be mitigated by a noise wall strategy. Very little of the local authority-controlled system would consist of no-access roadways (and in most cities, only a relatively small proportion of the State-controlled roadways too would be no-access roadways). The potential for the use of barrier walls to control noise at the majority of dwellings subject to high road traffic noise exposure is thus severely constrained. Figures 4 and 5 further illustrate this point. Dwellings with high noise exposures in Gold Coast City can be seen to be distributed widely across the City's road system, very little of which consists of no-access roadways.

New Approaches?

Faced with these realities, we must continue to work with other well-known strategies to reduce exposure to high levels of road traffic noise such as land use planning, traffic management, dwelling insulation, compensation etc. Such strategies are well documented and will not be canvassed further here. However, beyond this often-quoted litany for traffic noise management, are there new ideas that can be explored? There are three suggestions:

- the European Directive on Environmental Noise;
- the inclusion of noise as one of six indicators in the pursuit of *Sustainable Mobility*;
- the concept of *soundscapes* and *soundscape design*.

The first two are not new control approaches *per se*, but it is likely that both will engender new impetus and commitment to managing road traffic noise exposure.

Directive 2002/49/EC of the European Union (Assessment and management of environmental noise) [9] provides a common approach to environmental noise across the EU and includes the four elements of harmonisation of noise indicators and assessment methods, noise mapping, the preparation of action plans, and informing and consulting citizens. At first sight the Directive appears to offer little that is new, but there are several important elements that are of interest.

There is a requirement for strategic noise mapping for all cities over 250,000 population by 2007 (and over 100,000 by 2012). This has triggered a spate of new developments in noise mapping of European cities and, given the dominance of road traffic noise in urban areas, it represents an unprecedented effort in very detailed mapping of road traffic noise across whole urban connurbations. While noise mapping has been common practice for decades, the emphasis on mapping immissions (exposure) compared to the mapping of noise emissions (see Brown and Affum [10]) is a critical

change in emphasis. For example, the Birmingham Noise Mapping project [11] undertaken as something of a test case for the Directive, provides detailed maps down to a grid of ten metres over a large urban area using a Sound Immission Contour Mapping (SICM) system. The Directive requires these maps to be used to estimate population exposures to noise – something that has not been available previously at such resolution.

The Directive also requires that action plans be prepared to reduce noise exposure, and that each action plan should contain estimates of the reduction of the number of people affected by each particular mitigation measure. Such an approach will focus attention on the real nature of the problem of road traffic noise in cities and, in the longer term, redirect attention away from ad-hoc solutions that have seen most effort at reduction directed to the "tip" of the road traffic noise exposure "iceberg" through noise barriers on no-access roadways.

Another new approach is the inclusion of noise from transport (including road traffic noise) as one of the small list of indicators adopted by the OECD as a result of a six-year multi-national project to develop a vision, measurement criteria, and policy strategies that might lead to an environmentally sustainable transport system by 2030 [12, 13]. Noise was included, together with emission of major air pollutants and greenhouse gases, and land take, to reflect the wide-ranging health and environmental effects of transport. While this inclusion of noise exposure as a major sustainability indicator will have little *immediate* effect on road traffic noise exposure in cities, in the longer term it means that traffic noise will be given a much greater prominence in development and implementation of future transport policies and plans.

Finally, and speculatively, I introduce the concept of *soundscapes*, and *soundscape planning*, as a potential contributor to the management of road traffic noise in cities. *Soundscape planning* is a complementary approach to *noise management*. In the latter, sound is seen as a by-product, a waste to be managed but, by contrast, soundscape planning approaches sound as a resource, one to be utilised and, as in the sustainable use of all resources, one whose depletion or degradation is to be avoided.

Soundscape planning is not only about quieting. It is directed at special places where the opportunity may exist, through appropriate management of sound, to increase human enjoyment.

The vision for soundscape planning of urban space has been well established for several decades, but to date there appears to have been little attempt to implement this vision, at least amongst those best positioned to do so - planners, landscape architects, engineers, acousticians and others involved in the planning and design of the built environment. The immediate need is to educate designers and managers about both the need and potential for consideration of the acoustic environment as an integral, and positive, component of the planning process. Brown and Muhar [14] provide a pragmatic approach to soundscape planning for design of urban space.

While the immediate prospects for the adoption of soundscape planning in cities is restricted – for example to specific housing projects, or some public spaces - soundscape planning has the potential to capture imaginations. If acoustic environments that people prefer can be designed and implemented as demonstration projects, they may provide the catalyst for a much-needed wider interest, and reinvigoration, in managing road traffic noise problems in residential environments.

Conclusions

The fight to manage the problem of high exposure of dwellings in cities to road traffic noise is not being won. Various studies confirm that unacceptably high proportions of urban populations remain exposed to high levels of traffic noise. Both individual vehicle emission controls and roadside noise barriers have played significant roles in managing road traffic noise to date and it is likely that, without them, the situation would be worse. However, it must be recognised that these two strategies cannot contribute further to reducing current levels of exposure in the community.

Other well-known strategies to manage this problem - land use planning, traffic management, dwelling insulation, compensation etc – exist, but we have applied, or at least recited, these as solutions for many years, but obviously with little impact on overall outcomes. These strategies need to be bolstered and earnestly utilized. New ideas need to be introduced, and the experience in Europe arising from the application of the EU Directive on environmental noise, and the inclusion of noise as a transport sustainability indicator, must be closely monitored, and the useful parts of these adopted. There is also potential to experiment with ideas of soundscape planning in our cities as a way to reinvigorate our management of urban traffic noise problems.

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