ROAD NOISE BARRIERS: EXPERIENCE ON WESTERN ARTERIAL IN BRISBANE

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ABSTRACT

In order to reduce the impact of traffic noise on the suburban infrastructure, noise barriers have been constructed on the Russell Terrace - Jerrang Street section of the Western Arterial in Brisbane. This section of the arterial is a new facility constructed through a residential area. This paper presents a brief resumé of the Department's previous experience with noise barriers, the circumstances leading to the decision to implement these devices on the Western Arterial, the type of barrier used, the design of the barrier (both acoustically and structurally), construction details, and the cost. The results of "Before" and "After" noise studies are given together with the results of surveys conducted within the community of interest concerning the effectiveness of the barriers. The conclusions from the work indicate that the methods adopted are appropriate.

INTRODUCTION

1. Road Authorities in Australia are becoming increasingly aware of the effects of road traffic noise in urban areas. In most States it is not uncommon to find noise predictions and studies being undertaken to allow noise impacts to be assessed. To varying degrees these concerns have been translated into expenditure on noise attenuating devices in selected areas.

2. In Australia, the most visible steps in the installation of noise attenuating devices have been taken by the Road Construction Authority of Victoria (RCA Vic). Saunders (1978) described the practice of the then Country Roads Board which was to restrict installations to new freeways and expressways. However, a recent brochure (RCA May 1985) describes a new program to progressively treat existing freeways and expressways built prior to 1977. The program is estimated to cost $ 6 million over 6 years. The efforts of other Australian road authorities are somewhat more modest than this at the present time.

3. The Main Roads Department (MRD) Queensland has had an active interest in noise measurement and study for about ten years. These activities have been largely aimed at establishing the validity of noise prediction methods, and obtaining data on noise levels and community response to enable informed discussions between the Department and various community groups. The work undertaken by Brown and Law (1976), and Brown and Hollingworth (1978) is typical of these activities and was largely related to new freeway facilities. MRD Queensland had some early experience with earth mound noise barriers in 1977 when these were installed on the South East Freeway in Brisbane. However, in this case their provision was related to the opportunity to provide protection due to the ready availability of spoil from earthworks operations rather than as a result of deliberate noise studies.

4. Recently, a new section of arterial roadway has been constructed by the Department in Brisbane. In part, the roadway runs through a residential area and the design included some 1500 m of timber fence specifically to reduce road traffic noise

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effects at adjacent dwellings. This paper describes the planning and design of this barrier and an evaluation of its effectiveness. Specifically it covers:-

(a) a review of the practices of MRD Queensland, in relation to traffic noise impacts of roads in urban areas;

(b) a description of the project location, and the design and installation of the barrier;

(c) the results of the noise predictions and measurements undertaken to evaluate the acoustic change resulting from the new roadway and the installation of the barrier;

(d) a summary of two surveys undertaken to gauge the reaction to the noise barrier both from residents living adjacent to the newly constructed section and from users of the road facility.

The objective of the paper is to provide another point on the graph of Australian road traffic noise experience.

MRD QLD APPROACH TO TRAFFIC NOISE INVESTIGATIONS

5. Investigations are not carried out on every new or improved road facility. They are mainly carried out in urban areas as follows:-

(a) For major facilities to determine noise level changes and to predict community responses;

(b) Where property resumptions are required, and traffic noise may be a factor taken into account in assessing compensation for injurious affection.

6. MRD Queensland has adopted the L_{10} (18hr) as an adequate measure of road traffic noise. The DoE or CORTN method (Department of Environment, 1975) is used to predict this scale and where measurements are undertaken, they are carried out in accordance with the Australian Standard 2702-1984. Both "before" and "after" measurements and/or predictions are carried out whenever possible. Measurement is always the preferred method. However, this may not always be possible as owners could be reluctant to allow measurements to take place on their property. In such cases predictions can always be carried out, but it is desirable to obtain some measurements in order to be able to accept the predictions with confidence. Brown and Hollingworth (1978), Saunders and Jameson (1978) and Saunders et al (1983), justify the use of the DoE prediction method under Australian conditions.

7. MRD Queensland has not adopted a "cut-off" level for road traffic noise exposure (as, for example, the 68dB(A) L_{10}(18hr) adopted in the UK Noise Insulation Regulations, 1975). A single cut-off ignores the very important fact of the variation in noise sensitivity of people throughout the community. In marking its assessments, MRD Queensland prefers to use estimates of percentages of people "not bothered", "bothered" and "seriously bothered" at different levels of noise as adopted by Lassiere (1976). Hollingworth (1979) describes an example of this type of approach.

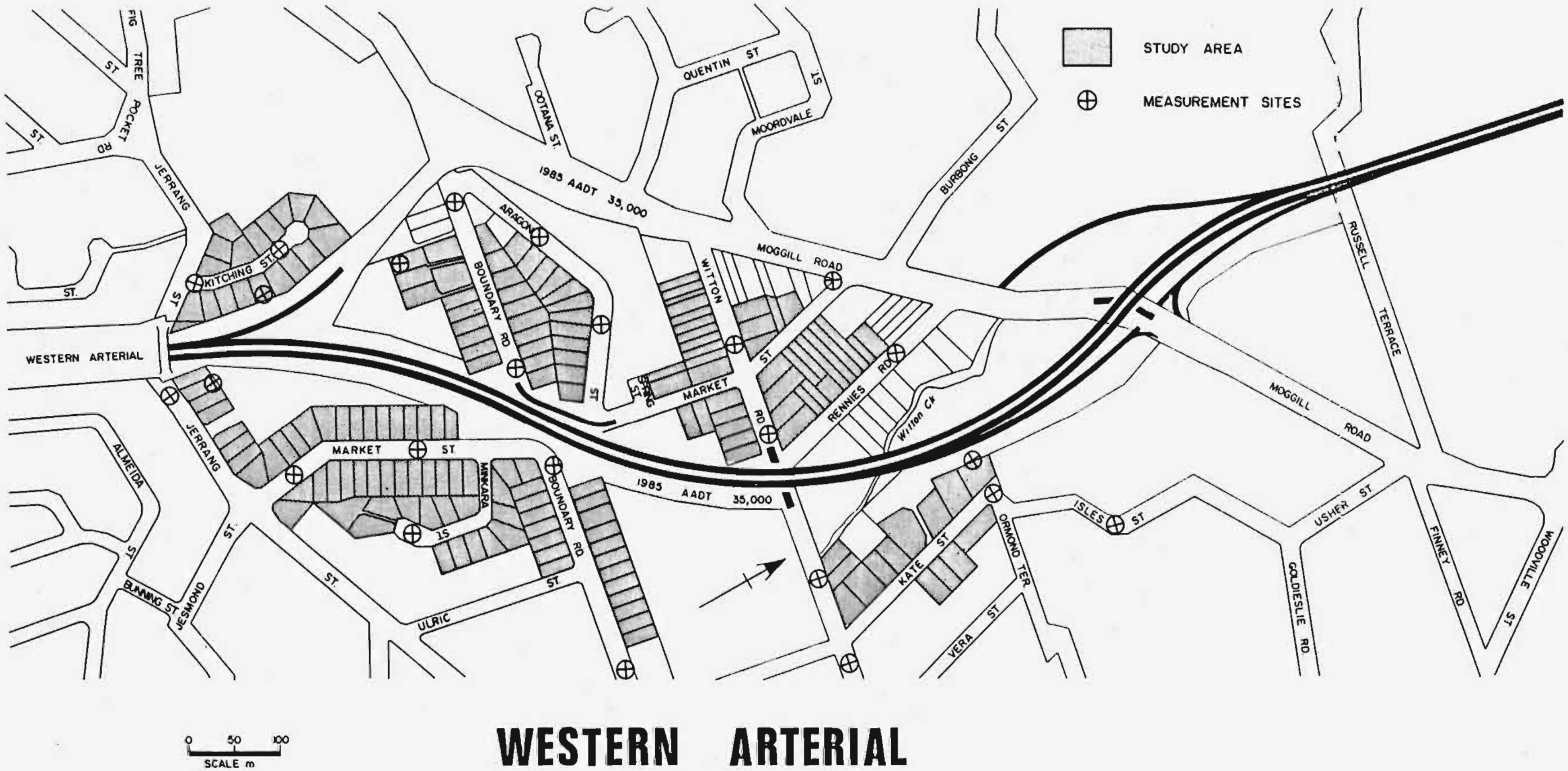
8. Basically the method determines the number of residents in the surrounding suburban community exposed to traffic noise levels within given cell widths for the range of noise levels 54dB(A) and upwards. This is achieved by predicting noise levels out beyond the first line of houses until the predicted noise level is equal to either the existing L_{10}(18hr) level, or 54dB(A), which ever is the greater. The existing, or "before" levels, are obtained by measurement. Multiplication of these cell numbers by the relevant community response probabilities (Lassiere 1976) allows estimates of the number of residents in each of the "bother" response categories above. Summation of these numbers over all cell widths then allows the total impact to be estimated. In these analyses, 5dB(A) cell widths were used as the community response data was taken from Harland (1977). More recent analyses by the Department adopt 2dB(A) cell widths, consistent with Lassiere (1976). As to whether or not ameliorative measures e.g. barriers etc. should be used, the Department prefers not to be constrained by a fixed policy. After examination of the results of impact studies, a decision is taken as to whether or not ameliorative measures in the form of traffic noise barriers are to be implemented. Currently, these measures are only considered for a new road facility through a residential area, and not to an improved, existing facility. In these cases it is considered that the adjacent residences are already affected to some degree by traffic noise.

WESTERN ARTERIAL PROJECT

BACKGROUND

9. The Western Arterial in Brisbane is a north-south arterial located to the west of the central business area. Over its length of approximately 25 km, it varies from 2 and 4 lane freeway standard, to 2 and 4 lane surface arterial standard. The project section lies in the suburb of Indooroopilly, about 8 km to the west of the central business district. The detailed section, from Moggill Road to Jerrang Street, is shown on Figure 1. This section is new construction on a deviation and has been built to 4 lane, divided, grade-separated, arterial standard.

10. This particular link had been planned since the early 1970's and the Department had been acquiring property on a low key basis, largely in response to hardship cases. Such cases are typically those where sales cannot be effected due to the fact that they would be physically affected by the



WESTERN ARTERIAL
MOGGILL ROAD TO JERRANG STREET

Fig. 1 - Locality Plan

proposed construction. In 1978 Main Roads issued a brochure showing the proposed route. This issue resulted in a public meeting later that year at which local residents voiced a number of concerns, including traffic noise impacts. At that meeting an undertaking was given that the matter would be investigated and steps taken to install noise barriers if appropriate.

CONSTRUCTION AND TRAFFIC DETAILS

11. Stage 1 of the link from Moggill Road to Jerrang Street involved construction of full formation, but pavement on one carriageway only. The eastern pavement was to carry two-way traffic. Stage 1 construction commenced in early 1983, and was opened to traffic in December 1984. Stage 2 consisted of pavement and structure duplication of the western carriageway, and was opened to traffic in December 1985. Typical cross sections are shown in Figure 2.

12. The AADT on the link is about 35,000. On the adjacent section of Moggill Road (see Figure 1), a 4 lane, divided surface arterial, the AADT is 35,000.

NOISE IMPACT ASSESSMENT

"Before" Noise Levels

13. Eighteen hour (0600 - 2400 hours) noise level measurements were made at various locations in the study area adjacent to where the new arterial was to be constructed in order to determine the noise climate resulting from traffic on existing streets. The defined study area, shown in Figure 1, extended approximately 150 metres away from the proposed construction and included some 155 dwellings. In all, 24 measurement sites were required to cover the study area adequately. From these measurements the "before" noise levels were interpolated for each dwelling in the study area. Measurement sites are shown on Figure 1.

"After" Noise Levels

14. "After" noise levels, both with and without barriers, were predicted at various locations (55) in the area of interest. From these both post-construction/pre-barrier, and post-construction/post-barrier predicted levels were interpolated for each of the 155 dwellings.

15. The before and predicted after noise levels at the 155 dwellings in the study area are summarised in Table I. The results are presented in the 5dB intervals used in the impact assessment.

TABLE I

NUMBERS OF DWELLINGS IN THE STUDY AREA EXPOSED TO EASH NOISE INTERVAL (N = 155)

Noise Interval (dBA)	Before Measurements (dBA)	After Predictions (dBA)	
		Without Barrier	With Barrier
50 - 54	33 (22%)	0 (0%)	10 (6%)
55 - 59	63 (41%)	26 (17%)	76 (49%)
60 - 64	54 (35%)	54 (35%)	52 (34%)
65 - 69	5 (3%)	57 (37%)	17 (11%)
70 - 74	0 (0%)	18 (12%)	0 (0%)

It can be noted that without the barrier, the predictions indicated that the noise exposures would have been increased considerably.

Impact Assessment

16. An assessment of the impact of the roadway was made using these measured and predicted levels. Using the method described by Hollingworth (1979), each group of houses within a 5dB(A) cell width was split up into the number of dwellings which residents were expected to have "seriously bothered", "bothered" and "not bothered" responses to the new source of noise. This analysis indicated:-

(a) Without a barrier, the impact was estimated as:-

17% Seriously Bothered;
45% Bothered; and
38% Not Bothered.

(b) With a preliminary barrier design, the impact was estimated as:-

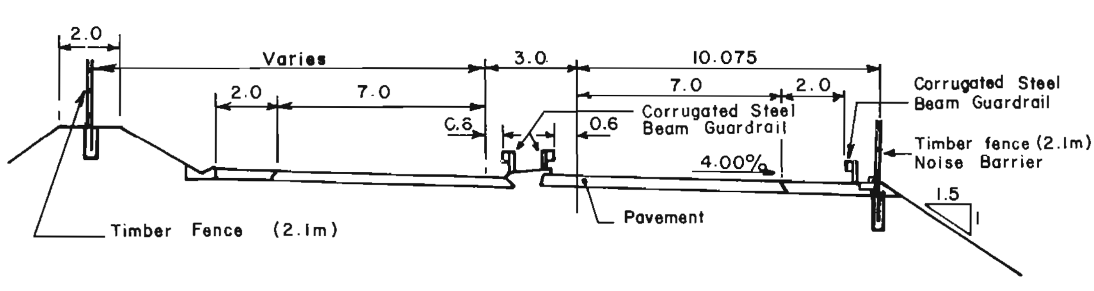


Fig. 2 - Typical Road Cross Section

10% Seriously Bothered;
42% Bothered; and
48% Not Bothered.

In addition to this estimate of community response, it can be seen from Table I that the percentage of dwellings in the 65 - 69 and 70 - 74 noise intervals reduced from 49% without the barrier, to only 11% with the barrier. The improvement was considered to be adequate justification for detailed design to be undertaken.

NOISE BARRIER DESIGN

17. Following the impact assessment, the final locations and heights of barriers were refined with the design objective being to maintain the post-construction/post-barrier acoustic conditions in the adjacent community as close as possible to the pre-construction noise climate (bearing in mind cost and aesthetics).

18. The visual impact of the barrier on the adjoining suburban community and the road user was considered, leading to a choice of a timber fence, and timber fence/earth mound combination. The timber fence consisted of hardwood weather boards placed vertically. The actual location of the mounds and fences was restricted to some degree by right-of-way limitations, as property had been originally acquired without recognition of the possibility of barriers. It was considered that the maximum height of a timber barrier should be 2.1 m to retain a reasonable appearance. Safety for moving traffic was considered when designing the location of the barriers. Maintenance of the barrier, maintenance associated with adjoining landscaping, and replacement of materials damaged by any impact were also considered. Steel was chosen for the fence posts, and they were designed for a wind load with a five year return period. This step in economy was taken as it was considered that any bending of posts could be easily rectified. Other components were designed for a wind load with a twenty year return period.

19. Details of the construction of the barriers are shown in Figure 3, and some typical views are shown in Figure 4. The total cost of the barriers was about $250,000. This consisted of:-

(a) 1500 m of timber fencing at a total cost of $125,000;

(b) Additional earthworks for mounds at a total cost of $125,000.

EVALUATION

20. The barrier, and part of the procedure used to assess the potential impact of the barrier, were evaluated in several ways:-

(a) The accuracy with which the noise prediction procedure estimated the post-construction/post-barrier noise levels throughout the community were compared with the noise levels measured in the "after" measurement program.

(b) The effectiveness of the barrier in reducing noise levels was estimated by comparing (predicted) noise levels to which dwellings would have been exposed if the barrier had not been build with the noise levels measured in the "after" measurement program.

(c) The total effect of the new roadway with barrier on the acoustic environment of the study area was evaluated by comparing the "before" and "after" noise levels' measurements.

(d) The effectiveness and other characteristics of the barrier from the point of view of nearby residents were evaluated by a resident survey.

(e) Opinions of road users concerning the barrier were obtained by a user survey.

ACCURACY OF THE PREDICTION MODEL

21. Figure 5 is a scatter diagram plotted for each of the 155 dwellings as follows:-

(a) Predicted. Post-construction/post-barrier predictions interpolated to each dwelling.

(b) Measured. Post-construction/post-barrier measurement interpolated to each dwelling.

Many of the points are co-incident. The scatter of points in Figure 5 is generally in accordance with the results of Saunders et al (1983). This gives confidence in the 155 predictions. Simple regression analyses were conducted on these data, and the results are shown in Table II.

PREDICTED = 10.39 + 0.831 MEASURED (1)

PREDICTED = 1.006 MEASURED (2)

For the normal regression in (1):

t_A (H_0 : A = 0) = 3.745 and

t_B (H_0 : B = 1) = 3.601

This is highly significant, and thus H_0 is rejected.

For the regression forced through the origin in (2):

t_B (H_0 : B = 1) = 2.007

This is significant at the 5% level, but not at the 1% level.

22. Figure 6 is a frequency distribution of the differences between the measurements and the predictions described in

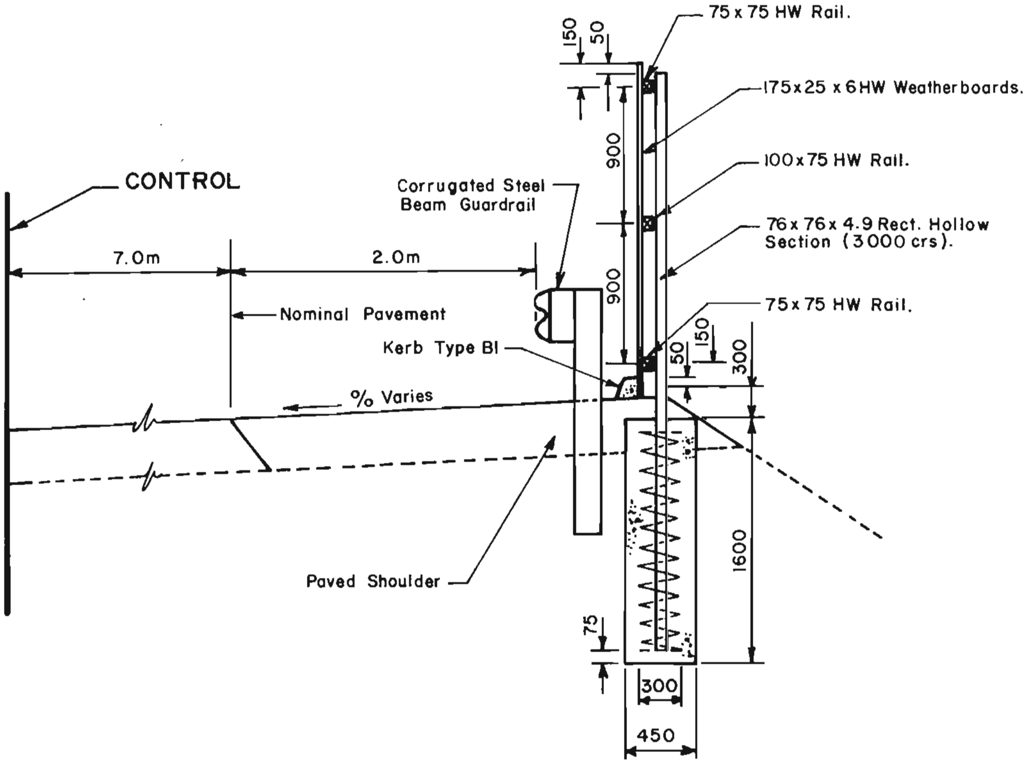


Fig. 3 - Typical Noise Fence Details

paragraph 21 at each household. This distribution has a mean of 0.4dB(A) and a standard deviation of 2.19dB(A). These results are similar to those of Saunders et al (1983) i.e. the DoE model tends to overpredict marginally. The essential difference in the data in this work and that in Saunders et al (1983), is that in this work the noise values for each location were interpolated from a small number of actual sites, while the Saunders et al (1983) represent actual sites. Interpolation is the practical method in impact studies of this sort, and it is reassuring to see the replication of the results.

23. Although the regression line (1) is a reasonable fit, the statistics indicate that some overprediction is present. Since this confirms the findings of Saunders et al (1983) as indicated in paragraph 22, no confidence has been lost in the prediction methods adopted in this work.

TABLE II

RESULTS OF REGRESSION OF FIGURE 5
(Predicted V's Measured)

Regression	Parameter Values Constant (A)	Parameter Values Slope (B)	R^2	F Values (1,153)	Standard Error of Estimate	Comment
Normal	10.39	0.831	0.672	313	2.10	Highly significant
Forced through origin	-	1.006	0.999	113,500	2.10	Highly significant

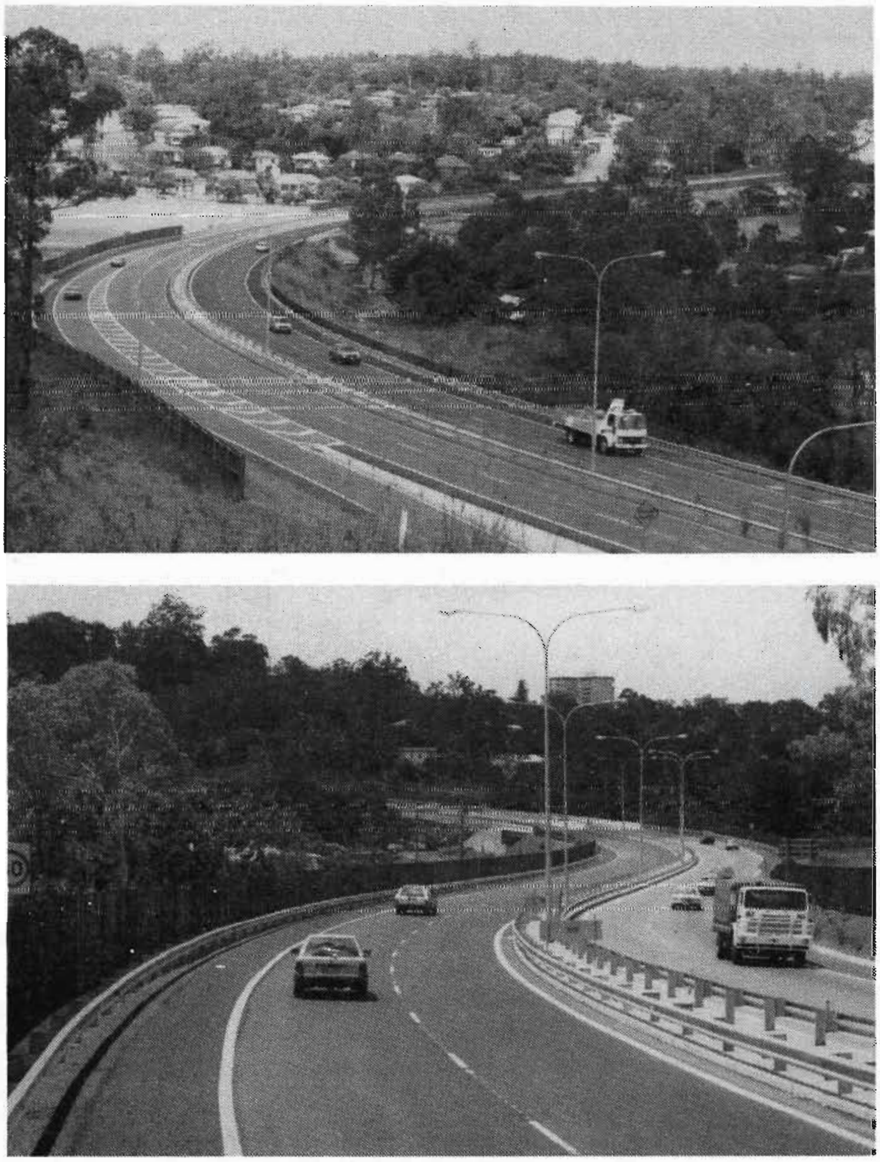
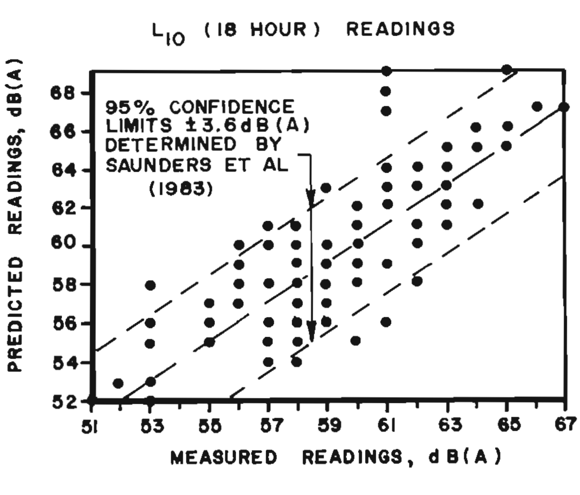


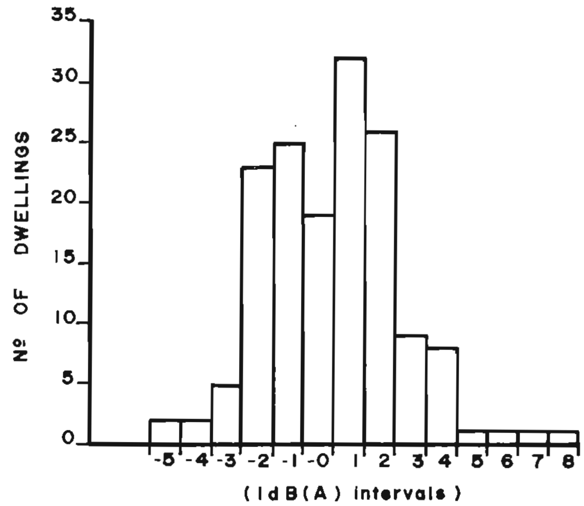
Fig. 4 - Views Showing Barrier Details and Road Environment



POST CONSTR / POST BARRIER PREDICTED NOISE LEVELS PLOTTED AGAINST MEASURED LEVELS

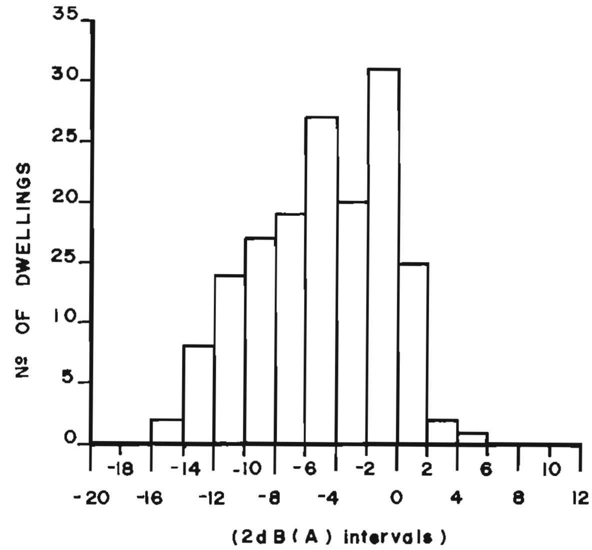
LEVELS SHOWN ARE INTERPOLATED FOR 155 LOCATIONS IN STUDY AREA.

Fig. 5 - Scatter Diagram



DIFFERENCES BETWEEN
POST CONSTR./ POST BARRIER PREDICTIONS
AND
POST CONSTR./ POST BARRIER MEASUREMENTS
(PREDICTION ACCURACIES)

Fig. 6 - Histogram of Differences



DIFFERENCES BETWEEN
POST CONSTR / PRE-BARRIER PREDICTIONS
AND
POST CONSTR / POST BARRIER MEASUREMENTS
(BARRIER EFFECTS)
[PREDICTIONS HAVE 95% CONFIDENCE LIMITS OF ± 4.4dB(A)]

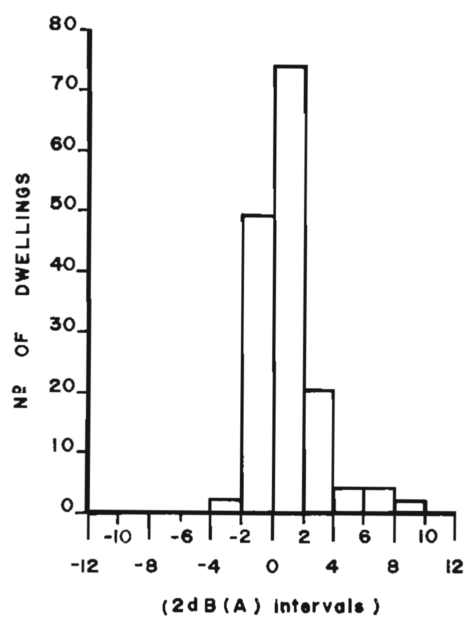
Fig. 7 - Histogram of Differences

EFFECTIVENESS OF BARRIER

24. Figure 7 is a frequency distribution of the differences between post-construction/pre-barrier predictions interpolated to each dwelling, and post-construction/post-barrier measurements interpolated to each dwelling. Given the conclusion in paragraph 23, Figure 7 represents a substantial improvement given a barrier compared with no barrier. In making this statement, recognition needs to be given to the fact that the predictions have 95% confidence limits of ± 4.4dB(A).

STUDY AREA ACOUSTIC ENVIRONMENT

25. Figure 8 is a frequency distribution of the differences between pre-construction measurements interpolated to each dwelling, and post-construction/post-barrier measurements interpolated to each dwelling. This analysis indicates that on balance, about 30 houses are worse off due to the presence of the road and the barriers. The great majority, about 123, appeared to have suffered no significant change. The mean of this distribution is 0.9dB(A) and the standard deviation is 2.0dB(A). A t test shows that at the 5% level of significance, the mean is significantly different from zero. However, it is questionable if this order of difference is discernable by residents. The next section reports on opinions of residents.



DIFFERENCES BETWEEN
PRE-CONSTR. MEASUREMENTS
AND
POST CONSTR./ POST BARRIER MEASUREMENTS
(ACOUSTIC ENVIRONMENT)

Fig. 8 - Histogram of Differences

OPINIONS OF RESIDENTS AND ROAD USERS

Background

26. It was considered useful that the opinions of residents of the facility be obtained to see if perceptions were consistent with the results of the physical studies. In addition, the opinions of users on the purpose and appearance of the barriers were also sought. These surveys were conducted in late 1985 and are reported in full in Brown (1985). Only the techniques and main findings of these surveys are reported here. The first study ascertained the opinions of residents who live adjacent to the new section of roadway concerning the effectiveness and appearance of the noise barrier. The second ascertained the opinions of a selected group of road users concerning the appearance of the barrier and any effect on driving task.

Survey of Residents

27. The study area was the same as that area for the noise measurements and is shown in Figure 1. The format of the study was household interview using a structured questionnaire. The target was 100% of households in the study area.

28. All interviews were conducted on weekdays and Saturdays in the last two weeks of November. Interviews were attempted with one respondent (over 17 years of age) from each dwelling in the study area - a total population of 155 dwellings - with the sex of the respondent to be interviewed at each dwelling determined before the survey (the male : female ratio of respondents successfully interviewed was 45 : 55). Each interview lasted approximately 10 minutes. All respondents had been previously advised by mail that an interviewer would call, and up to four calls back were made to contact respondents not at home. These procedures, together with the local community awareness of the new roadway and interest in the purpose of the survey, resulted in a good response rate (89%). Response statistics are as follows:-

population	155	
dwelling used for pretest	1	
vacant (e.g. for sale)	6	
available for interview	148 =	100%
refusals	12	8%
no respondent sighted	3	2%
no English	1	1%
completed interviews	132	89%

29. Of these 132 completed interviews, 90 (68%) were with respondents who had lived in that dwelling for more than 5 years, 8 (6%) with respondents who had lived there for less than 5 years but who had moved in before the new road construction had started, 17 (13%) who had moved in during the construction period and 17 (13%) who had moved in since the roadway was opened to traffic. As can be seen in Table III, the sample was a good representation of the population of dwellings in the study area in terms of potential noise exposure from the new roadway.

TABLE III

NOISE EXPOSURE OF THE STUDY SAMPLE AND POPULATION (Predicted Noise Exposure If The Barrier Had Not Been Constructed)

	POPULATION (n = 155)	STUDY SAMPLE (n = 132)
55-59dB(A)	26 (17%)	20 (15%)
60-64dB(A)	54 (35%)	48 (36%)
65-69dB(A)	57 (37%)	48 (36%)
70-74dB(A)	18 (12%)	16 (12%)

30. Forty-two percent of respondents in the study area reported the Western Arterial alone as noise source, 34% the Western Arterial together with other roadways, and 18% reported a roadway other than the Western Arterial. The remainder noted no roadway as noise source.

31. The questionnaire used in the home interview survey was developed specifically for the survey and pretested within the study area. The questionnaire sought unprompted responses from respondents concerning any complaints they had about their area, respondents' knowledge of and opinions about the effectiveness and appearance of the noise barrier, other opinions that respondents held on effects of the new roadway, and also their opinions of the barrier as drivers.

32. The results from this resident survey can be summarised as follows:-

(a) There was widespread knowledge amongst residents (74%) that the fence on the Western Arterial had been constructed specifically to reduce noise.

(b) Majority opinion was that the fence was effective in reducing levels of road traffic noise from the Western Arterial. 62% of respondents thought that it reduced noise, 5% that it increased noise and 20% that it had no effect. Residents who would have been most exposed to freeway noise thought the fence effective.

(c) Resident opinion on the appearance of the fence (from the dwellings) was mixed, with half (52%) indicating that it was reasonably attractive and over one third (27%) indicating that it was reasonably

unattractive.

(d) Many residents through that it was too early to comment categorically on the landscaping works. At this stage 43% were pleased with the appearance.

(e) Other than noise and appearance, residents reported opinions on a wide range of good and bad effects associated with the freeway. Good effects were primarily improvements in the local roads and access. Bad effects were primarily reduced access and perception of reduced property values.

Survey of Road Users

33. Several methods of surveying opinions of road users of the new section of the Western Arterial were considered in the design of this study. These included:-

- roadside interview.
- roadside observation of number plates with subsequent tracing of user addresses and mail interviews.
- telephone interview throughout the Brisbane area.
- telephone interview in the "catchment" of the Western Arterial but further west from the central business district than was the study area.

The latter method was selected for simplicity and cost-effectiveness, but in the knoweledge that the relationship between the surveyed sample of users and the population of users of the Western Arterial would remain unknown. Some differences between the sample and the population can be postulated. The sample is probably drawn from an area of higher economic status then the population, and may use the roadway with a different frequency and purpose of journey. For example, the sample is likely to use the roadway for journey-to-work/school/shopping and recreation purposes whereas the population of users may have a much higher proportion of drivers who use the roadway for commercial purposes. Despite this, it is difficult to find convincing arguments as to why the opinions concerning the noise barrier held by the sample of road users should be different from those held by population of road users.

34. The area selected for the telephone survey was based on the Jindalee telephone exchange - a dormitory area approximately 5 km to the south west of the project location and directly served by the Western Arterial. The survey sample was randomly generated from a population of telephone subscribers with telephone numbers in the range 376 - 1000 to 376 - 8999. As the purpose of the present survey was to sample "users of a roadway" rather than "residents of a particular geographical area", an assessment of the bias introduced by the exclusion of non-telephone subscribers and by the inclusion of dwellings with multiple telephones and of business premises is not warranted.

35. At each telephone connection made, the interviewer attempted to speak with an adult. Telephone calls were made between 4 pm and 7 pm on weekdays and Saturdays during the last two weeks of November 1985. Up to three calls back to numbers that did not answer or where no adult was present were made on subsequent days (though no attempt was made to complete these calls back after the quota was reached). The interviewer initially ascertained if the respondents knew of the new section of the Western Arterial (or asked to speak to someone else in the household who did) and if they used it either as a driver or passenger. These two conditions had to be met before proceeding with the interview. Sampling was to continue until an arbitrarily chosen quota of over 200 responses were obtained (eventual sample size was 235). Interviewers recorded respondents' answers over the telephone direct into a data base at a computer terminal. Table IV is a summary of the responses to this survey.

TABLE IV

TELEPHONE SURVEY RESPONSES

No. of Telephone Numbers Dialed	424	
no connection available	34	
no answer *	97	
No. of Potential Interviews	293	= 100%
refusals	22	8%
could not identify study area	5	2%
no English	8	3%
no adult available	12	4%
Successfully Commenced Interviews	246	84%

(male:female ratio 46:53)

(* "no answer" has arbitrarily been taken to mean that the telephone subscriber was not a potential interviewee (i.e. that the premises were unoccupied during the study period). This obviously inflates the response rate as some of these "no answers" could have been contacted with more calls).

36. The results from this survey can be summarised as follows:-

(a) The noise barrier is clearly a significant feature in the road landscape. The sample of road users contacted included both regular and very infrequent users of the Western Arterial. Only 4% of road users could not identify the fence.

(b) Knowledge of the purpose of the barrier is widespread amongst road users. 42% identified its purpose as a noise barrier. Others (24%) suggested a wide variety of purposes for the fence.

(c) The majority of road users thought the barrier to be of reasonable appearance from the roadway (72%), with 23% of the opinion that it was reasonably unattractive.

(d) Opinion as to whether the barrier affects users' view from the road is mixed. 69% of users reported no adverse effect; 29% that the view was adversely affected.

(e) Most drivers on the new section of the Western Arterial reported that the barrier did not distract them in any way nor did it increase the driving task (87%). However, 13% did indicate that there was some effect.

CONCLUSIONS

37. This paper has outlined a practical approach to the question of noise barrier installation. Initial measurements and assessments were primarily aimed at the installation question, and not at a research undertaking. However, the results of comparative measures and the residents' and user surveys are encouraging. The following conclusions have been drawn:-

(a) The assessment procedures are adequate for practical application;

(b) The results are consistent with those of other studies thus supporting the validity of the initial assessments;

(c) The barrier designs have been successful in that a major noise generator has been introduced into a residential area with minimal adverse noise effects;

(d) The design of the barriers appears to have been an adequate compromise between acoustic requirements and aesthetics.

REFERENCES

Australian Standard, AS 2702 - 1984. Acoustics - Methods for the Measurement of Road Traffic Noise. Standards Association of Australia.

BROWN, A.L. and LAW, H.G. (1976). Effects of Traffic Noise: South East Freeway, Brisbane. Proc 8th ARRB Conf., Perth.

BROWN, A.L. and HOLLINGWORTH, G.H. (1978). Prediction of Freeway Noise Levels (L10): An Evaluation of the U.K. Department of Environment Procedure. Proc 9th ARRB Conf., Brisbane.

BROWN, A.L. (1985). Western Arterial Noise Barrier: Opinions of Residents and Road Users. Institute of Applied Environmental Research, Griffith University, Brisbane.

Department of Environment, U.K. (1975). Calculation of Road Traffic Noise. HMSO London.

HARLAND, D.G. (1977). Units for Exposure and Response to Traffic Noise. TRRL Supplementary Report 297.

HOLLINGWORTH, G.H. (1979). An Alternative Method to Traffic Noise Evaluation and its relevance to Traffic Noise Control. Australian Road Research (ARRB). Vol. 9 No. 3.

LASSIERE, A. (1976). The Environmental Evaluation of Transport Plans. Department of the Environment, U.K. Research Report No. 8.

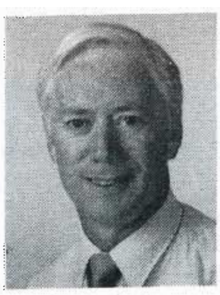
Road Construction Authority of Victoria (1985). Noise Barriers on Older Freeways. Brochure, May.

SAUNDERS, R.E. (1978). Traffic Noise - Its Effect on Road Design. Proc of Seminar on Noise and Vibration Control. The Society of Automotive Engineers - Australasia.

SAUNDERS, R.E. and JAMESON, G.W. (1978). An Approach to Traffic Noise Studies. Proc 9th ARRB Conf., Brisbane.

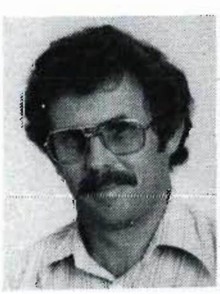
SAUNDERS, R.E., SAMUELS, S.E., LEACH, R. and HALL, A.M. (1983). An Evaluation of the U.K. DoE Traffic Noise Prediction Method. ARR No. 122, ARRB.

The Noise Insulation Regulations, U.K.(1975). S.I. 1975/1763. HMSO London.



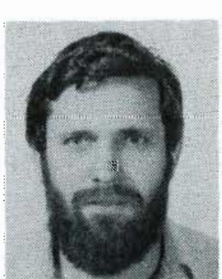
S. Golding

Stephen Golding has worked with the Queensland Main Roads Department since initial graduation in 1967. During this period he has served in Departmental offices in Rockhampton, Emerald and Brisbane. Currently he is the District Engineer responsible for the Metropolitan North District, centred in Brisbane. Previous principal postings include Highway Design Engineer, Highway Planning Engineer, and Engineer (Urban Planning). He has served on a variety of NAASRA, ARRB, Institution of Engineers (Australia), and Institute of Transportation Engineers committees. He is the author of a variety of papers, mainly in the transport planning area. His major external interest is the Army Reserve, in which he currently holds the rank of brigadier.



A.M. Hall

Arthur Hall has been employed by Main Roads, Queensland since 1966 and commenced work as a Cadet (Engineering Drafting) and studied Civil Engineering, part time, at the Queensland Institute of Technology. He graduated in 1972 as a Civil Engineer. Since graduation he has been attached to the Highway Design Branch of the Department. His field of work has included planning and design of urban and rural roads and environmental aspects of road design, specifically road traffic noise and landscaping. He was a member of the NAASRA Working Group on Traffic Noise Prediction Evaluation.



A.L. Brown

Lex Brown lectures in Environmental Planning in the School of Australian Environmental Studies at Griffith University. His primary interests are in acoustics and land use planning. He obtained his qualifications in Civil Engineering and Urban Studies at the University of Queensland, and worked in the Civil Engineering Department, University of Queensland, on ARRB sponsored projects on road traffic noise.