AN ASSESSMENT OF THE RELATIONSHIP BETWEEN THE $L_{10(18HOUR)}$ NOISE LEVEL PARAMETER AND OTHER ROAD TRAFFIC NOISE LEVEL PARAMETERS

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Abstract

Historically, the extent of intrusion of road traffic noise at residential locations has been quantified by the $L_{10(18hour)}$ noise level parameter. Well-researched prediction algorithms exist for this parameter. In recent times, various regulatory authorities have attempted to set standards for acceptable levels of road traffic noise emission in terms of many other noise level parameters (eg. $L_{Aeq,1hr\ night}$). At present, there are few if any validated prediction algorithms for any of these other noise level variables. Rather, the most practical means of making accurate predictions is to condense all of the alternative parameters to equivalent $L_{10(18hour)}$ values and use the lowest $L_{10(18hour)}$ value to set the acceptance standard. This paper examines the results of continuous noise level monitoring at 35 sites with the objective of determining the typical relationships between the alternative parameters and the $L_{10(18hour)}$ parameter. The practitioner, when confronted with the requirement to make predictions of the extent of road traffic noise intrusion in terms of parameters other than $L_{10(18hour)}$, may then make use of these results to establish a first order assessment of the likely equivalent predicable $L_{10(18hour)}$ value which may be used instead of the non-predictable alternative variables.

Introduction

In recent times, various regulatory authorities in Australia have set criteria for acceptable levels of road traffic noise intrusion on residential developments in terms of a large number of noise level parameters. In addition, the same authorities have required that compliance with these noise level limits be met under road traffic conditions that are expected to prevail at some future time, commonly ten years hence.

For the noise assessment practitioner, there are two methods that may be employed to establish the degree of future compliance with the noise level targets: (i) extrapolation from direct measurement and (ii) calculation using accepted prediction algorithms.

Extrapolation allows the values of all measurable noise level parameters to be established. This is achieved usually by continuous logging of noise levels at selected representative locations on the subject site over a reasonable time period, typically 24 hours. The major shortcoming of this approach is the practical constraint that accompanies the relative lack spatially of measurement data, especially when determinations are required to be made over large areas of land. It is simply not feasible to undertake monitoring at more than a few locations: certainly not many dozen or even several hundred locations that would be needed to adequately cover a typical residential development (ie less than 10 ha in area). The current level of noise in all parameters of interest can be established, but only at a small number of locations.

In view of this, it is far more usual to adopt the second method: calculation using accepted prediction algorithms. Prediction algorithms for road traffic have been available for several decades. They have wide acceptance in Australia and elsewhere. The most commonly used are the Calculation of Road Traffic Noise (CRTN '88) algorithms developed by UK DoE[1]. These algorithms can yield moderately accurate results for the $L_{10(18hour)}$[2] and $L_{A10,1hr}$[3] noise level parameters, both at any particular location on a site as well as in terms of noise level contours across the site. Their major drawback is that they do not allow prediction of any other parameter to be made directly.

As a result, while there are two methods available to establish the degree of future compliance with the noise level targets, each has definite advantages - but both suffer from significant shortcomings. One method can assess noise levels in all manner of parameters, but at a limited number of locations only. The other can be used to make predictions at as many locations as desired, but only for one or two noise level parameters.

What is required is a means of coupling the advantage of one method with that of the other to overcome the failings of both.

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[1] "Calculation of Road Traffic", UK DoE, HMSO, 1988.

[2] $L_{10(18hour)}$ is the arithmetic mean of each of the eighteen hourly $L_{A10,1hr}$ sound pressure levels measured between 6:00am and 12:00 midnight on an average weekday where $L_{A10,1hr}$ is the sound pressure level measured in dBA that is exceeded for 10% of the specific one hour period.

[3] $L_{A10,1hr}$ is the sound pressure level measured in dBA that is exceeded for 10% of the specific one hour period.

With this aim in mind, this paper attempts to quantify the offset values of each of several common road traffic noise variables against the more commonly adopted $L_{10(18hour)}$ noise level parameter. In doing so, it is hoped that these offset values may prove useful in allowing the practitioner to make informed predictions of the likely level of noise intrusion onto a site in terms of more noise level parameters than simply $L_{10(18hour)}$. Or conversely, and perhaps more usefully, these results may allow the multiple requirements of some regulatory authorities, often written using many different parameters, to be condensed down to the one easily and more accurately predicted parameter: $L_{10(18hour)}$.

Noise Level Parameters

At present, there is wide range of noise level parameters currently in use in Australia to either set limits for acceptable levels of noise intrusion or to be used at establish the appropriate limit using another noise level parameter. These include, but are not limited to the following:-

- $L_{10(18hour)}$ is the arithmetic mean of each of the eighteen consecutive hourly $L_{A10,1hr}$ sound pressure levels measured between 6:00am and 12:00 midnight on an average weekday where $L_{A10,1hr}$ is the sound pressure level measured in dBA that is exceeded for 10% of the specific one hour period. For the purposes of this study, this definition has been extended to allow the $L_{10(18hour)}$ value to be calculated as the arithmetic mean of each of the seventy-two consecutive $L_{A10,15min}$ sound pressure levels measured between 6:00am and 12:00 midnight.
- $L_{Aeq,24hr}$ is the energy equivalent sound pressure level measured over a typical 24 hour period on an average week day.
- $L_{Aeq,1hr\ night}$ is the maximum rolling average $L_{Aeq,1hr}$ value from 10:00pm to 6:00am which, for the purposes of this paper, is determined as the logarithmic average of any four consecutive fifteen minute data samples (ie $L_{Aeq,15min}$) within the specified time period. In NSW, a slightly different nomenclature and definition has been adopted for this parameter for the night time period, $L_{eq,1hr}$: "the highest L_{eq} noise level for any hour during the period 10pm to 7am."
- $L_{Aeq,1hr\ day}$ is the maximum rolling average $L_{Aeq,1hr}$ value from 6:00am to 10:00pm which, for the purposes of this paper, is determined as the logarithmic average of any four consecutive fifteen minute data samples (ie $L_{Aeq,15min}$) within the specified time period. Again in NSW, the a slightly different nomenclature and definition has been adopted for this parameter for the day time period, $L_{eq,1hr}$: "the highest L_{eq} noise level for any hour during the period 7am to 10pm."
- $L_{Amax\ night}$ is defined in this paper as the arithmetic average of the maximum noise levels ($MaxL_{A,15min}$) due to motor vehicle passbys measured over the period 10:00pm to 6:00am.
- $L_{A90(8hour)}$ is defined as the arithmetic mean of each of the eight hourly $L_{A90,1hr}$ sound pressure level values measured between 10:00pm and 6:00am on an average weekday where $L_{A90,1hr}$ is the sound pressure level measured in dBA that is exceeded for 90% of the time over the specific one hour period. For the purposes of this study, this definition has been extended to allow the $L_{A90(8hour)}$ value to be calculated as the arithmetic mean of each of the thirty-two consecutive $L_{A90,15min}$ sound pressure levels measured between 10:00pm and 6:00am.
- $L_{A90(18hour)}$ is the arithmetic mean of each of the eighteen hourly $L_{A90,1hr}$ sound pressure levels measured between 6:00am and 12:00 midnight on an average weekday where $L_{A90,1hr}$ is the sound pressure level measured in dBA that is exceeded for 10% of the specific one hour period. Again, for the purposes of this study, this definition has been extended to allow the $L_{A90(18hour)}$ value to be calculated as the arithmetic mean of each of the seventy-two consecutive $L_{A90,15min}$ sound pressure levels measured between 6:00am and 12:00 midnight.
- $L_{10(12hour)}$ is the arithmetic mean of each of the twelve consecutive hourly $L_{A10,1hr}$ sound pressure levels measured between 6:00am and 6:00 pm on an average weekday, extended again to allow the $L_{10(12hour)}$ value to be calculated as the arithmetic mean of each of the forty-eight consecutive $L_{A10,15min}$ sound pressure levels measured between 6:00am and 12:00 midnight.
- $L_{eq(15hr)}$ is the energy equivalent sound pressure level measured over the period 7:00am to 10:00pm on an average week day. (NSW)
- $L_{eq(9hr)}$, also designated as $L_{Aeq(10pm\ to\ 7am)}$ is the energy equivalent sound pressure level measured over the period 10:00pm to 7:00am on an average week day. (NSW)

Methodology

Since December 2001, data logging of road traffic noise levels has been conducted over typical weekdays at a large number of sites in SE Queensland. The results obtained at 35 of these sites have been examined to quantify the offset values In each case, the dominant noise source was road traffic on the nearby road.

Instrumentation consisted of the following:-

- Portable statistical noise logger: ARL type EL-215
- Calibrator: Rion type NC73

The sample interval was set at 15 minutes for monitoring at all 35 sites. The monitoring was conducted only under dry road conditions and calm to light wind conditions.

In all cases, the microphone height of the noise logger was 1.2-1.4m above ground level. Separation distance of the noise logger from the closest running lane was generally in the range 10m to 40m with the separation distance at only five sites exceeding 40m. (Maximum separation was 125m.)

Road types, surfaces and daily traffic volumes varied substantially across the roads sampled. Traffic speeds varied from 60 km/h to 100 km/h. A listing of the ranges of the numerical values of the relevant road parameters is presented in Table 1.

Table 1 – Ranges of Relevant Road Parameters

Parameter	Sample Size	Min Value	Max Value	Average Value
Traffic volume	35	2500	76400	21400
Percentage Heavy Vehicles	35	3%	20%	9%
Vehicle Speed (km/h)	35	60	100	85

The results of the measurements of each of the $L_{A10,15min}$, $L_{Aeq,15min}$ and $MaxL_{A,15min}$ parameters have been used to calculate the resultant $L_{10(18hour)}$, $L_{Aeq,24hr}$, $L_{Aeq,1hr\ night}$, $L_{Aeq,1hr\ day}$, $L_{Amax\ night}$, $L_{A90(8hour)}$ and $L_{A90(18hour)}$ values. For purposes of comparison, the $L_{Amax\ day}$ value (ie the arithmetic average of the $MaxL_{A,15min}$ levels measured over the period 6:00am to 10:00pm) has been calculated as well. Results for the $L_{10(12hour)}$, $L_{eq(15hr)}$ and $L_{eq(9hr)}$ parameters were not obtained.

The offset value for each parameter was calculated by simple subtraction of the value of the particular parameter from the $L_{10(18hour)}$ value. The offset value datasets were analysed to yield the maximum, minimum and arithmetic average values as well as the 90% and 95% confidence intervals.

Resultant Offset Values

The results of the analysis of offset values are presented in Table 2 below.

Table 2 – Offset Values for Each Noise Level Parameter -v- $L_{10(18hour)}$

Parameter	Min	Max	Ave.	Std Dev^n	Confidence Intervals			
					90%		95%	
$L_{Aeq,24hr}$	-5.1	-1.6	-3.6	0.8	-5.0	-2.3	-5.2	-2.0
$L_{Aeq,1hr\ night}$	-7.5	0.7	-3.4	2.7	-7.8	1.1	-8.7	2.0
$L_{Aeq,1hr\ day}$	-1.7	2.9	0.4	1.2	-1.6	2.3	-1.9	2.7
$L_{A90(18hour)}$	-24.6	-5.3	-13.3	5.3	-22.1	-4.6	-23.7	-3.0
$L_{A90(8hour)}$	-36.6	-10.9	-22.8	6.3	-33.2	-12.5	-35.2	-10.5
$L_{Amax\ day}$	8.4	17.0	11.5	2.2	7.8	15.1	7.1	15.8
$L_{Amax\ night}$	2.9	22.4	8.2	3.9	1.8	14.5	0.6	15.8

(Positive value = value of parameter is greater than $L_{10(18hour)}$ value)

Discussion

From these results, it can be seen that the value of the $L_{Aeq,1hr\ day}$ parameter lies very close to $L_{10(18hour)}$ value, ie the average difference is only 0.4dBA. The standard deviation is relatively small as well with 90% of the values of the offsets between these two parameters lying within the range –1.6dBA to 2.3dBA.

Similarly, it can be seen that the $L_{Aeq,24hr}$ and $L_{10(18hour)}$ values are also fairly closely related: the average offset was –3.6dBA with a 90% confidence interval –5.0dBA to –2.3dBA.

Analysis of the offsets of the $L_{Aeq,1hr\ night}$ parameter yielded a larger standard deviation value than was the case for either $L_{Aeq,1hr\ day}$ or $L_{Aeq,24hr}$. Almost universally, the maximum $L_{Aeq,1hr}$ value at night occurred during the hour from 5:00am to 6:00am. Small and even positive offset values were encountered at sites where the daily traffic flow was well established by 5:30am.

As might be expected and as demonstrated by the larger standard deviation values, the $L_{A90(18hour)}$ and $L_{A90(8hour)}$ parameter values (s = 5.3dBA and 6.3dBA, respectively) are less strongly linked to the $L_{10(18hour)}$ values. While the average values may be useful in providing a notion of the likely differences between the values of each of these parameters and that of $L_{10(18hour)}$, the confidence intervals are of such width that the only reliable way of determining the actual $L_{A90(18hour)}$ and $L_{A90(8hour)}$ values in any particular situation would be to conduct direct measurements.

Of course, any application of these offset values to predict the future values of the non-predictable noise level parameters assumes that the offset values remain constant over ten years.

While this assumption may have some validity for $L_{Aeq,24hr}$, $L_{Aeq,1hr\ night}$ and $L_{Aeq,1hr\ day}$, it is unlikely to be appropriate for $L_{Amax\ night}$. The value of $L_{Amax\ night}$ is sensitive to both the traffic volume at night and the measurement sampling period. If the offset between $L_{Amax\ night}$ and $L_{10(18hour)}$ is to be constant over a number of years, the distribution of traffic volumes during the full 24 hour period would need to remain constant as well. For roads which are lightly trafficked at present, this is unlikely to be the case[4]. In view of this, and given the wide confidence intervals, there may be little point in trying to predict future $L_{Amax\ night}$ values at all.

4 A similar criticism could be levelled at the $L_{Aeq,1hr\ night}$ parameter as well. While this would be justified up to a point, the $L_{Aeq,1hr\ night}$ value is almost always recorded in the hour between 5am and 6am. The traffic volumes at these times would be expected to track the daytime volumes quite closely: sufficiently so that any errors resulting from the assumption of constancy of offset would be generally quite small.

Difference Values for Measured and Predicted $L_{10(18hour)}$ Levels

The data that was logged at each of the 35 sites of this study formed part of a larger study of the impact of road traffic noise intrusion onto each particular site.

As part of the analysis conducted at each site, a SoundPLAN noise model was prepared to allow the extent of road traffic noise intrusion onto the site to be assessed. In each case, the noise levels at the logger location were predicted using the SoundPLAN model adopting the particular road traffic and site-specific parameters current at that site at the time of the data logging.

The values of the differences between the predicted and measured $L_{10(18hour)}$ noise levels have been calculated and the results analysed. They are presented below in Table 3.

Table 3 – Difference Values Predicted $L_{10(18hour)}$ -v- Measured $L_{10(18hour)}$

Parameter	**Min**	**Max**	**Ave.**	**Std Dev^n**	**Confidence Intervals**			
					90%		**95%**	
Predicted -v- Measured	-2.1	2.7	0.7	1.0	-1.0	2.3	-1.3	2.6

(Positive value = predicted value was greater than measured value)

Suggestions for Further Analysis

The collection of noise level data at more sites in SE Queensland is an on-going matter. The results presented above, while useful, have been based on only a fairly modest set of data. Improvement to the accuracy of the conclusions could be gained by the inclusion of the results of future logging exercises in the larger dataset.

Future analyses may also include determination of the offset values for each of the $L_{10(12hour)}$, $L_{eq(15hr)}$ and $L_{eq(9hr)}$ noise level parameters as well as a consideration of the effect of the change to the value of the $L_{Aeq,1hr\ night}$ parameter to take account of the inclusion of the hour from 6:00am to 7:00 in the definition of this variable by EPA NSW.

Finally, subsequent analyses may deem it appropriate to investigate the relationships between (i) the separation distances and the offset values and (ii) the road traffic volumes/road hierarchy and the offset values.

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