Evening Noise Levels; A case for shoulder periods?

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Non-refereed

Abstract

Provisions to control unreasonable noise emissions include the ability to establish and, if appropriate, require compliance with rules setting permitted noise levels. This includes the Christchurch City Council's City Plan (May 1995), which has rules with noise level standards. These restrictions form part of controls pursuant to the Resource Management Act 1991 designed to maintain the peaceful amenity of residential neighbourhoods – an important environmental health consideration.

If standards in the City Plan are to effectively maintain acoustic amenity then they should not be significantly louder than ambient sound levels. As ambient sound levels significantly vary over a day the applicable standards should reflect such variation. An investigation examined ambient daytime sound levels in Christchurch's residential areas. In particular consideration was given to the possibility that ambient noise levels reduce during the early evening period (1800 to 2200 hours) so as to warrant an adjustment of the applicable standards during that period.

Introduction.

At the editor's request, information about ambient sound level monitoring in the Christchurch City Council's (CCC) area has been provided for publication. This article is an edited version of a report regarding sound level monitoring conducted at sites representative of residential areas throughout the CCC area during 2000 and 2001.

Data obtained during environmental monitoring was examined to determine if the permitted daytime noise levels in the CCC's City Plan represent an appropriate control. In particular, the suitability of noise rules applicable during the early evening period (1800 to 2200 hours) was considered

Background Literature

Increasing numbers of complaints concerning unreasonable or excessive noise reflect increasing levels of noise pollution. Most years the CCC receives increasing numbers of complaints from people exposed to intrusive noise levels (Annual Report 1999, CCC Environmental Services Unit). This follows a global trend noted by the WHO Expert Task Force, 2000, which states "The growth in noise pollution is unsustainable because it involves direct, as well as cumulative, adverse health effects. It also adversely affects future generations, and has socio-cultural, esthetic and economic effects."

Adverse public reaction and the receipt of complaints concerning noise has been closely associated with the extent that the noise exceeds, or is intrusive above, accepted or background levels. The characterisation of the intrusiveness of noise by way of 5 dBA steps, and with particular consideration as to the early evening period, is described in some authoritative literature regarding noise assessment. For

Amount in dBA by which adjusted measured noise exceeds the acceptable level	Public reaction	Expression of public reaction in a residential situation
0-5	Marginal	From no observed to sporadic complaints
5-10	Little	From sporadic complaints to widespread complaints
10-15	Medium	From sporadic and widespread complaints to threats of
15-20	Strong	From widespread complaints to threats of community
20-25	Very Strong	From threats of community action to vigorous community
25 and over	Extreme	Immediate direct community and personal action

Table 1: Estimated public reaction to noise.

example, Bies and Hansen (1996), outline the intrusiveness of noise emissions in Table 1.

Bies and Hansen (1996) also include an adjustment (adapted from Australian Standard, AS1055) to the baseline acceptable daytime level that is applied to the early evening period (1800 to 2200 hours). This is a reduction of 5 dBA compared with daytime levels (0700 to 1800 hours). A further reduction of 5 dBA is considered appropriate from 2200 hours onwards.

NZS 6803:1999 Acoustics – Construction Noise, also appears to recognise that an intermediate reduction in noise emissions is appropriate during early evening hours. This standard recommends that construction noise levels permitted during daytime hours reduce by 5 dBA after 1800 hours. A further reduction, essentially to ambient levels, is recommended after 2000 hours.

In contrast to the above literature, the current New Zealand Standard NZS 6802:1999 (Acoustics – Assessment of Environmental Noise) provides guideline noise limits that differentiates only between day and night-time periods.

The commonly used cumulative noise index, Ldn, weights night-time noise levels 10 dB more than daytime levels. Berglund and Lindvall (eds., 1995) state that this is partly a response to the perception that community noise is more annoying during night-time than during daytime. They also note that cumulative noise indices that take annoyance at evening times into account (usually between 1900 and 2200 hours) add 5 dB to the measured sound pressure levels relating to that period. For example, in both the USA (California) and sometimes in Europe, a community noise equivalent level (CNEL) incorporates a 5 dB penalty for emissions between 1900 and 2200 as well as the 10 dB night-time penalty. Suter (1991) considers that this illustrates the importance of communication and relaxation during early evening hours. It is also noted in New Zealand Acoustics (Vol. 13, No. 1) that the European Union now requires the development of noise maps for significant urban areas, and this involves a L_{den} parameter (day-evening-night level), rather than a L_{dn} parameter (day-night level).

The simple differentiation between daytime and night-time periods, with night-time periods confined to likely hours of sleep during late evening and early morning hours, may be a somewhat rudimentary control designed to meet minimum expectations. Such an approach may not necessarily be sufficiently refined to properly maintain

amenity during a period such as early evening hours. This could have particular significance when it is noted that a sociological study conducted close to Australian airfields established that residents considered the need for non-interference by noise to be most important between 1800 and 2300 hours (Bullen and Hede, 1983, cited in Berglund and Lindvall (eds.), 1995). Similarly, a study of residents in communities surrounding two French airports noted that residents expressed greatest annoyance between 1900 and 2300 hours (Francois, 1977, cited in Suter, 1991).

The Christchurch Situation

The transitional District Plan (CCC section), which was an applicable control before the implementation of the 1995 City Plan, included a 5 dBA reduction specifically relating to early evening periods. A further reduction applied after 2300 hours.

Currently applicable noise level standards are established in the CCC's City Plan, 1995. Residential areas (known as Living Zones) are considered the most noise sensitive zones (Group I zones), and have daytime standards that permit considerably louder levels than for those set for night-time periods (2200 hours to 0700 hours the following day). Permitted standards are set out in Table 2.

The noise levels permitted in the City Plan reflect the usual diurnal variation of ambient noise. However, this is achieved with a single and substantial step (7 to 10 dBA), whereas the change in ambient sound levels on and hourly basis is unlikely to be more than 2-3 dBA.

As previously mentioned, acoustic amenity is sometimes assessed by comparing the level of a particular noise emission with the background noise level (L_{90}) at the locality. A noise emission significantly exceeding the ambient background level (e.g. by more than 10 dBA) could be unacceptable. Thus, if a noise emission permitted by the CCC's noise rules significantly exceeds the ambient background sound level at a locality it could be that such noise is actually intrusive. Such a situation is the converse effect intended by noise rules.

	Daytime	Night-time
L_{10}	49 dBA	42 dBA
L_{eq}	50 dBA	41 dBA
L_{max}	75 dBA	65 dBA

Table 2: Permitted Noise Levels for Group I Zones, Christchurch City Council – City Plan (1995).

It could be that the CCC's noise level standards, with their simple division of the 24-hour day into two periods (night and day) and adjustments at 0700 and 2200 hours, does not provide appropriate protection of acoustic amenity during the early evening period. As indicated in some literature, an intermediate adjustment for the early evening period when daytime noise levels reduce and approach ambient night-time levels may be warranted.

Essentially, levels established as part of legislative controls should reflect the ambient noise of the locality they are designed to protect. Ambient sound level monitoring is a key procedure to ensure that this is actually the case.

Equipment, Sites and Measurements

Calibrated Bruel and Kjaer model 2236 sound level meters were used to obtain two data sets of ambient sound level measurements. These were:-

- A paired set of morning observations (0700 to 1200 hours) and afternoon observations (1200 to 1800 hours) obtained during the winter of 2000, and
- A paired set of afternoon and early evening (1800 to 2200 hours) observations obtained during the summer of 2001.

Both data sets related to the same sites.

Measurements were undertaken in accordance with NZS 6801:1999 Acoustics – Measurement of Environmental Sound.

The sound level measurement periods were in accordance with clause 6.6.3.2 of NZS 6801:1999. This clause advises that the "measurement sample time shall be of sufficient duration to obtain an Leq reading which has stabilised to a value that varies by no more than 1 dB from a mean value." Measurement periods were usually at least 2 minutes, and sometimes up to 10 minutes. The total of measurement periods of the data was 5 hours and 8 minutes. Other monitoring has established that observations obtained using this method provide ambient sound level measurements representative of extended periods.

The ambient sound level measurements were undertaken by CCC officers having recent experience and familiarity with the sound level meters, as well as relevant provisions of NZS 6801:1999, the Resource Management Act 1991, and the City Plan. Information and observations were recorded on a checksheet.

The observations recorded

included the parameters used in the CCC's 1995 Plan rules (i.e. L_{10}, Leq, and Lmax), as well as the ambient background level - measured as the L_{90}. The predominant ambient noise noted was associated with vehicular traffic movements on roadways. In no case was apparent non-compliance with City Plan rules noted.

An "open space" (e.g. park or reserve) was selected from each of the grids used by Pathfinder Maps (Christchurch Street Directory, 5th edition, 2000) to index the Christchurch area. This provided a selection of 23 sites with observation positions distributed relatively uniformly over the Christchurch City area. Of the 23 such sites, 21 were considered representative of Group I (most noise sensitive) zones and suitable for the study. Two sites were not considered representative of Group I (most noise sensitive) zones. These were in, or near, the Central City zone of Christchurch, which is a Group III (least noise sensitive) zone. Data from these two sites was excluded.

Open spaces are generally located (as a matter of policy) within residential areas. This was confirmed by noting the zoning at, or near, the observation site.

Generally, the above methodology is considered to provide a citywide representation of daytime sound levels at Group I zones.

The sound level measurements recorded on checksheets were transferred into Microsoft Excel spreadsheets for consideration by way of statistical summaries and tests.

	L_{eq}	L_{10}	L_{90}	L_{min}	L_{max}
Overall average	50.3	52.8	42.7	40.6	63.6
Morning average	51.0	53.4	43.8	41.9	64
Afternoon average	49.7	52.2	41.7	39.4	63.2

Table 3: Average ambient sound level measurement, dBA, in Group I zones.

Results

Winter 2000 data

Table 3 sets out the averages of observations in Group I (most noise sensitive) zones. Morning and afternoon observations are separated. The differences between the morning and afternoon averages do not exceed 3 dBA, and no statistically significant difference is noted (t-test, 95% C.I.).

No significant difference is noted between those sites in a rural setting compared to those in a

	L_{eq}	L_{10}	L_{90}	L_{min}	L_{max}
Avg. observation, winter 2000 (am & pm)	50.3	52.8	42.7	40.6	63.6
Avg. observation, summer 2001 (pm only)	50.0	51.7	43.7	41.4	63.4

Table 4: Averages of ambient daytime sound level measurements; dBA.

residential setting. (Both rural and residential settings are Group I – most noise sensitive zones).

As expected, there is a close correlation between the L_{10} and Leq parameters, with 95% of the variability between these two sets of observations explained by a linear relationship. The average Leq observation is 2.5 dBA less than the average L_{10} observation.

Summer 2001 data

Data obtained during the afternoon period of the summer 2001 survey was compared with the data obtained at the same sites during the morning and afternoon periods during the winter of 2000. There is no significant difference between the average values of all parameters (t-tests, 95% C.I.). The difference between the sets of averages does not exceed 3 dBA. It was considered that the data obtained during the afternoon periods of summer 2001 is representative of ambient sound levels during both winter and summer months in Group I zones, and for daytime periods between 0700 and 1800 hours. A summary of these average observations is set out in the Table 4.

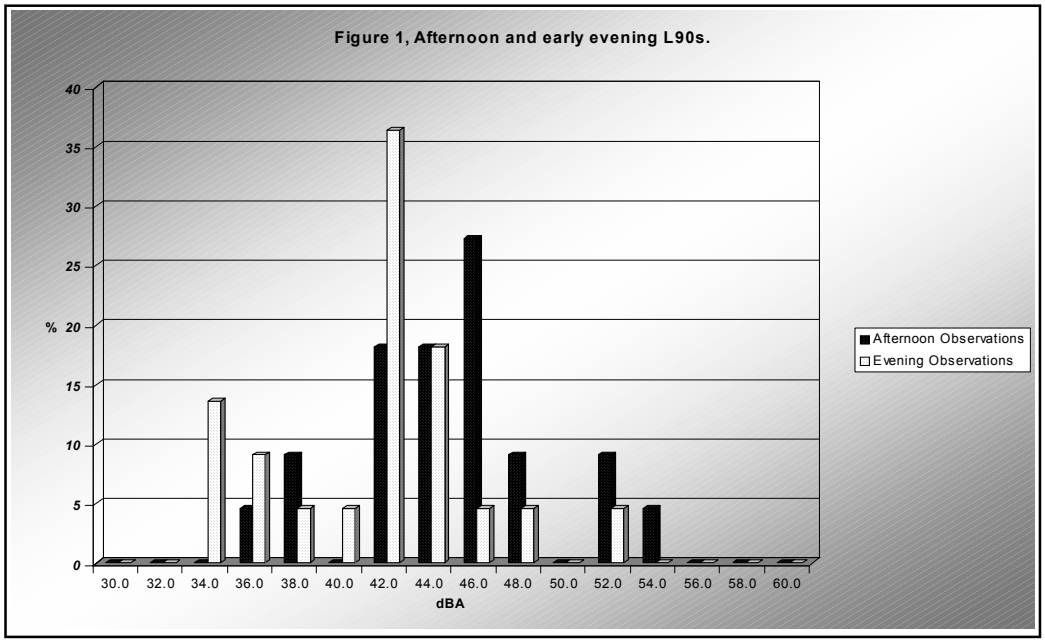
The average sound level measurements observed during afternoon periods (summer 2001 survey) were compared with the average sound level measurements obtained during early evening periods (summer 2001 survey). These results are set out, and compared, in the Table 5.

The average L_{10}, Leq, and Lmax observations during the afternoon are no more than 2 dBA louder than the early evening average observations. Such a difference is unlikely to be noticeable, and is not statistically significant different (t-test, 95% C.I.). It is also noted that there is no significant difference in the variability between the afternoon set of observations and the early evening set of observations for these parameters (*F*-test, 95 % certainty).

	L_{eq}	L_{10}	L_{90}	L_{min}	L_{max}
Afternoon (1200 – 1800 hours) average	50.0	51.7	43.7	41.1	63.4
Early evening (1800 – 2200 hours) average	49.1	50.2	40.3	38.1	64.5
Difference (Afternoon – early evening)	0.9	1.4	3.4	3.2	-1.1

Table 5: Average afternoon sound level measurement compared with average early evening sound level measurement; dBA.

However, the average L_{90} and Lmin value observed during the early evening period is notably different to the average afternoon L_{90} and Lmin observations. Both of these parameters are more than 3 dBA quieter during the early evening, and this is a statistically significant difference (t-test, 95% C.I.). The difference between the afternoon L_{90} observations and the early evening L_{90} observations is illustrated in Figure 1. It is also noted that there is a significant difference between the variability



between the afternoon set of observations and the early evening set of observations for the L_{90} observations (*F*-test, 95 % certainty).

	L_{eq}	L_{10}	L_{max}
Permitted daytime level. City Plan rules for Group I zones	50	49	75
Average ambient observation. (All data from Group I sites)	50.0	51.9	63.8

Table 6: Comparison of City Plan rule levels with average ambient sound level measurement; dBA.

Discussion

Ambient Levels

The data indicates that ambient noise levels, measured by way of the Leq, L_{10} and Lmax parameters, is not significantly quieter during the period of 1800 to 2200 hours when compared with the ambient noise levels of the preceding daytime period.

However, there appears to be a significant reduction in the ambient background (L_{90}) noise levels after 1800 hours. This reduction could increase the relative intrusion of particular noise emissions. As indicated in Table 2, such an increased difference between the background (L_{90}) level, and a noise emission measured by way of the L_{eq} or L_{10} parameter, could increase the likelihood of complaints. This aspect is discussed further in the following section, in relation to permitted City Plan levels.

Comparisons relating to City Plan levels

The City Plan rules for noise levels during daytime periods in Group I (most noise sensitive) were compared with the average daytime ambient observations. The comparison is set out in Table 6.

The average Lmax observation is significantly quieter (i.e. more than 10 dBA) than the permitted daytime level of 75 dBA. Only 4 of the 84 ambient sound level observations included Lmax levels exceeding the City Plan level. The exceedance of those 4 observations is relatively minor – less than 2 dBA.

The average ambient Leq observation is not significantly less than the permitted daytime level. It appears that there is little need to consider a reduction of the permitted Leq levels during any portion of the daytime period between 0700 to 2200 hours.

As noted in the preceding section, the average background (L_{90}) sound level is quieter during the early evening period. This reduction of background noise could give rise to increased intrusiveness of particular noise sources. This would be obvious when particular emissions are measured by way of the Leq and L_{10} parameters.

Differences between the average ambient L_{90} observations during the various observation periods and the City Plan permitted daytime level of 50 dBA Leq are set out in the Table 7.

These differences can be compared with the categories of Table 1. Although the early evening average ambient background (L_{90}) levels are notably quieter than the preceding daytime period it appears that the reduction of background levels is unlikely to be associated with significantly increased levels of complaint.

	Difference
Winter, 2000. Overall (am & pm)	7.3 dBA
Summer, 2001. Afternoon only	6.3 dBA
Summer, 2001. Early evening only	9.7 dBA

Table 7: Average differences between background sound level and the City Plan rule of 50 dBA (Leq).

Conclusion

Amendment to the Christchurch City Council's City Plan (1995) does not appear to be warranted in order to provide particular protection of acoustic amenity at Group I (most noise sensitive) zones. This observation also applies during the early evening period (1800 – 2200 hours).

Given that relevant New Zealand Standards have discontinued use of the L_{10} parameter, and there is a close correlation with the Leq parameter, it appears that ongoing use of the L_{10} parameter in the City Plan is somewhat redundant.

Limitations

The above results and discussion arise from observations predominantly relating ambient traffic noise. It could be that other noise sources and emissions (such as those with tonal character, or associated with a different activity) engender different responses and/or community reactions. It could also be that certain sites within the Christchurch City Council's Group I (most noise sensitive) zones are significantly quieter that the averages noted in the above data. In any event there should be regard for the "best practicable option" provisions of section 16 of the Resource Management Act 1991.

(Continued on page 28)

(Continued from page 22)

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