Effective noise objectives for industrial and resource developments – setting, compliance assessment monitoring and audit

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ABSTRACT

As a part of government approval of industrial and resource development projects, limits for noise emissions received in surrounding communities is a required activity. Governments have policies and regulations to set limits which are usually based on either achieving acceptable sound levels for amenity or health, often based on WHO guidelines. Limit conditions based on ambient sound levels become difficult for resource or industrially intensive areas, such as the Hunter Valley in NSW, for both governments and communities if policies are not followed. Monitoring is typically required to demonstrate compliance and specific methods may also be required for this. Demonstrating compliance with limits can be difficult despite extensive permanent monitoring systems. Auditing of the monitoring system and reported results may be rare. This paper reviews typical approaches to setting approval limits in some Australian and Canadian states/provinces and how they are typically monitored to assess for compliance. Limit conditions should be like effective specifications – have a sound level objective, location and conditions for assessment, and method, tolerance and reporting requirements. Some difficulties observed in recent projects are discussed improvements to make both limit conditions and monitoring more effective are suggested.

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1. INTRODUCTION

Regulation of noise emissions from industrial sources (including industry, mining, ports, power plants & wind farms) generally takes two different approaches. Either the assessment is based on the potential for annoyance (e.g. New South Wales) or protection of health (e.g. Tasmania, Alberta). Annoyance-based criteria accept that some percentage of the population will be annoyed, no matter how low the objective is set. Health-based criteria appear to follow the WHO guidelines for sleep such that night-time external sound levels are not greater than 40 dBA (1). Sometimes they are mixed.

Use of the health based criteria provides a relatively simple method of calculation and assessment of compliance for an existing or proposed development – either the objective is achieved at the receptor or not. Use of the annoyance based approach tends to rely on the difference between existing background sound levels and proposed project sound levels and provides a much more complex method of calculation of objectives and still allows for annoyance to occur in some percentage of the population; this also allows for legal challenges to the setting of objectives or assessment of compliance because of the need to allow for existing sources and other factors. Regulators are not immune to challenges to annoyance-based criteria for specific projects. The community can also become annoyed at the sometimes convoluted approaches to determining objectives. The process also takes significant time and cost in preparation of noise impact assessments.

The author has been engaged in standards development and environmental noise assessment for resource and industrial projects in Australia, Africa, India and China for over 30 years. Relatively recent developments in attempts at regulation of wind turbine noise have again highlighted the variation in annoyance potential for these industrial developments. Mining developments have also had approval conditions reviewed by the courts and found in some cases that those conditions were made outside of the applicable policy.

At the same time, the current almost completed revision of ISO 1996.1 includes the use of community tolerance level (CTL) to indicate the likelihood of annoyance for different types of noise generating activity (although the main focus appears to be mainly for transportation sources) (2). For

example, for a day-night sound level L_{DN} of 45 dB, the percentage of the exposed population highly annoyed ranges from 0 to 8% (upper 95% confidence interval). Industrial noise is said to have the same effect as road traffic noise using this method.

A recent paper by Fredianelli and Licitra (3) regarding wind noise limits commented that for sources such as wind turbines with potentially short-term fluctuations in sound levels, "the population is not satisfied by long term limits for a source that feels strongly annoying only few times in particular conditions and remembers those situations in time". Some jurisdictions try to allow for short-term event noise with limits such as L_{AMax} or $L_{A01,1min}$, yet these are considered to not be effective when there are often similar event levels found from other ambient environmental noise sources (e.g. road traffic, birds and animals) to those from a specific source (such as industry) in the same time periods. The issue of providing long-term noise objectives when the public can be annoyed by short-term occurrences remains and these are difficult areas to regulate, especially with multiple sources.

So one approach to regulation might be, why bother with annoyance? Why not regulate night-time noise based on health effects related to sleep disturbance, as advised by the WHO guidelines?

This paper reviews the basis for setting noise objectives in jurisdictions in Australia, compares them to those from Canada. The proposal is that a change in criteria setting to a health-based approach would be simpler, not increase annoyance, less costly and quicker than the current annoyance-based approaches. Problems identified in a recent court case are also discussed.

2. WHO guidelines

Two documents are relevant. The 1999 "Guidelines for Community Noise" and the 2009 "Night noise guidelines for Europe" (4). In the 1999 document, sleep disturbance is noted as one of the adverse health effects of environmental noise. Uninterrupted sleep is said to be a prerequisite for good physiological and mental functioning, and the primary effects of sleep disturbance caused by noise are: difficulty in falling asleep; awakenings and alterations of sleep stages or depth; and other effects. The recommended values for a good night's sleep are 30 dBA L_{eq} for continuous background noise and individual noise events exceeding 45 dBA $L_{Max,fast}$ should be avoided. Lower levels may be disturbing depending on the nature of the source (i.e. annoying characteristics such as tonality or impulsiveness). These are internal sound levels. For noise with a large proportion of low-frequency sound, a lower guideline L_{eq} value is recommended.

For sound levels outside dwellings to allow people to sleep with windows 'slightly' open, the recommended value is 45 dBA, assuming a 15 dB reduction outside to inside. The L_{eq} value is for the night period of 8 hours.

The 2009 document notes that health-based guidelines originated in part from the EU Directive 2009/49/EC relating to the assessment and management of environmental noise (abbreviated as END). It considers 'the best criterion for choosing a noise indicator is its ability to predict an effect. Therefore, for different health end points, different indicators could be chosen. Long-term effects such as cardiovascular disorders are more correlated with indicators summarizing the acoustic situation over a long time period, such as yearly average of night noise level outside at the facade ($L_{night,outside,1y}$), while instantaneous effects such as sleep disturbance are better with the maximum level per event (L_{Amax}), such as passage of a lorry, aeroplane or train.

From a practical point of view, indicators should be easy to explain to the public so that they can be understood intuitively. Indicators should be consistent with existing practices in the legislation to enable quick and easy application and enforcement. $L_{night,\ outside}$, adopted by the END, is an indicator of choice for both scientific and practical use. Among currently used indicators for regulatory purposes, L_{Aeq} (A-weighted equivalent sound pressure level) and L_{Amax} are useful to predict short-term or instantaneous health effects.'

A minimum period of 8 hours sleep is their minimal choice for night protection. However this would protect only 50% of the population and it would take 10 hours sleep to protect 80%. The report recommends that 40 dBA $L_{night,outside}$ is the lowest observed adverse effect level (LOAEL) – below this there is no significant evidence that biological effects observed are harmful to health. Above this adverse effects include self-reported sleep disturbance, environmental insomnia and increased use of somnifacient drugs and sedatives. Above 55 dBA cardiovascular effects become the major public health concern. In the range 40 to 55 dBA, many people have to adapt their lives to cope with the noise at night.

Based on these effects, the Night Noise Guideline is recommended to be $L_{night,\ outside}$ = 40 dBA, that is 5 dB lower than in 1999.

3. Basis of noise limits in Australia

3.1 Queensland

In Queensland, the "Environmental Protection (Noise Policy) 2008" (5) has objectives to protect to protect Queensland's environment while allowing for development that improves the total quality of life, … The environmental values to be enhanced or protected under this policy are —

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—

(i) sleep; …

Acoustical quality objectives are provided for sensitive receptors. For dwellings, the acoustic quality objectives for dwellings at night are indoor sound levels of 30 dBA $L_{Aeq,1hr}$, 35 dBA $L_{A10,1hr}$, and 40 dBA $L_{A01,1hr}$, for health and well-being in relation to the ability to sleep. These objectives are clearly health-based. Most other Australian states use external sound levels.

Despite this, the "Queensland Planning Policy noise manual" (6) sets objectives for roads for night-time 10pm to 6am as maximum $L_{Aeq.1hr}$ 60 dBA and L_{AMax} 80 dBA. Railways are higher with 65 dBA $L_{Aeq.24hr}$ and L_{Amax} 87 dBA. Another policy document, "Planning for noise control" (7) sets recommended night-time background objectives as minimum $L_{A90,1hr}$ 25 dBA for residential receivers in a rural area to avoid background creep.

3.2 New South Wales (NSW)

NSW "Industrial Noise Policy (INP) 2000" (8) provided recommended acceptable maximum sound levels for different areas containing occupancy. The basis of the limits is annoyance but possibly with some reference to health effects for night-time (when the minimum levels are considered). It notes the criteria in the document (*Section 2*) have been selected to protect at least 90 per cent of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90 per cent of the time. Provided the criteria in the document are achieved, then the Policy considers it is unlikely that most people would consider the resultant noise levels excessive. In those cases when the project-specific noise levels are not, or cannot be, achieved, then it does not automatically follow that those people affected by the noise would find the noise unacceptable. Having a subjective basis indicates annoyance rather than health effects.

Criteria are given as the lowest of either amenity levels or intrusive levels. For amenity, recommended acceptable sound levels for a residence in a rural or suburban area at night-time is 40 dBA $L_{Aeq,night}$. Intrusive objectives are the background 10% $L_{A90,15min}$ + 5dB. It is also considered that the minimum background $L_{A90,15min}$ is 30 dBA, allowing for a minimum intrusive objective of 35 dBA $L_{Aeq,15min}$. These minimum levels are similar to the WHO guidelines for outside noise at night.

The NSW "Road Noise Policy" (RNP) of 2011 (9) also has the noise assessment criteria based on annoyance. They are presented as 'being consistent with current international practice for managing traffic noise impacts.' However, achieving the noise assessment criteria would not guarantee that all people would find the resulting level of traffic noise acceptable. There can be a wide variation in individual reaction to noise. In this context, the criteria have been set approximately at the point at which 90% of residents are not highly annoyed by the noise". For residential receivers the night-time objectives are 50 dBA $L_{Aeq,1hr}$ for local roads and 55 $L_{Aeq,9hr}$ for new major roads and freeways.

3.3 Victoria

The Victorian "State Environmental Planning Policy N1" (SEPP N–1) (10) and "Noise in Regional Victoria" (NIRV) (11) aim to protect people from industry noise that may affect normal domestic and recreational activities including, in particular, sleep at night. Health is considered a beneficial use to be protected and the policies do this by setting the benchmarks for control of industry noise emissions and the procedures for noise measurement. However they also balance the need for operation of industry with the protection of sensitive uses – this is common with other environmental protection policies from different jurisdictions. Consequently, the level of protection they provide is not the same in all circumstances. Different levels apply depending on the planning land-use zoning and the amount of 'background noise' in the area. Night-time outside sound level objectives for premises are a minimum of 35 dBA $L_{Aeq,30min}$. in the greater Melbourne area and 32 dBA in regional areas (for rural living zones). These can be considered to be based on or similar to the WHO guidelines.

3.4 Tasmania

The Tasmanian policy specifically require protection of health. The "Environment Protection Policy (Noise) 2009" (12), also known as the Noise EPP, sets a strategic framework for noise management in Tasmania by focusing on objectives and principles for noise control, with human health as a value to be protected. It does not include implementation measures, which are dealt with through other instruments such as regulations and planning schemes.

The environmental values to be protected under the Noise EPP are the qualities of the acoustic environment that are conducive to:

- the wellbeing of the community or a part of the community, including its social and economic amenity; or
- the wellbeing of an individual, including the individual's health; and opportunity to work and study and to have sleep, relaxation and conversation without unreasonable interference from noise.

The policy was developed based on the 1999 WHO guideline and Australia's EnHealth Council report "The health effects of environmental noise – other than hearing loss" (13). Night-time sound levels for dwellings are given for inside, based on sleep disturbance and the same as the WHO guidelines (30 dBA $L_{Aeq,8hr}$ and 45 dBA $L_{Amax,fast}$).

3.5 South Australia (SA)

The "Environment Protection (Noise) Policy 2007" (14) for South Australia includes as its basis:

(b) to fix noise goals for most noise sources compliance with which will satisfy the general environmental duty under section 25 of the Act in relation to noise from those noise sources;

Section 25 of the "Environment Protection Act 1993" (15) requires a duty of care for the environment. "A person must not undertake an activity that pollutes, or might pollute, the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm." The Act includes promoting Ecologically Sustainable Development (ESD), and

(i) that the use, development and protection of the environment should be managed in a way, and at a rate, that will enable people and communities to provide for their economic, social and physical wellbeing and for their health and safety …

Indicative noise factors are given as objectives for different land-use areas, with night-time objectives being 40 dBA for rural areas and 45 dBA for residential areas, $L_{Aeq,15min}$. Given the similarity of the minimum night-time values to those of the WHO guidelines and basis including community health and safety, the assumption is a health based objective.

Wind farms are a special category and have their own guidelines (16), with the core objective to balance the advantage of developing wind energy projects with protecting the amenity of the surrounding community from adverse noise impacts. The general approach in setting noise criteria for new developments is to require compliance with a base noise level. This base noise level is typically 5 dBA lower than the level considered to reflect the amenity of the receiving environment. If the noise generated does not exceed the background noise by more than 5 dB the impact will be marginal and acceptable. The minimum outdoor sound level is 35 dBA for wind speeds of less than 5m/s. The allowable levels increase with increasing wind speed. So the basis for wind farms is annoyance, not health, although the minimum level is less than that given in the WHO guidelines.

3.6 Western Australia (WA)

The Western Australia "Environmental Protection (Noise) Regulations" 1997(17) sets levels above which received sound levels are considered to be unreasonable. No basis is given for the values, but the explanation booklet to the policy (18) notes "The regulations are fair. They set noise limits which have been carefully designed to ensure that noise from other premises is kept to acceptable levels. At the same time they are flexible enough to allow for reasonable economic, cultural and social activity to occur." and "The basis for determining the new assigned noise levels is the land use where the noise is received. The surrounding land uses are also included, through an influencing factor approach (as occurs in Victoria). Minimum outdoor sound levels for noise sensitive premises are 35 dBA L_{A10}, 45 dBA L_{A01}, and 55 dBA L_{AMax}, with the time period being the assessment period, 9-hours (from 22:00 to 07:00). Given these levels, it might be assumed they have a health basis.

In summary for Australia, most states have a health basis to their night environmental noise criteria. NSW and SA for wind farms have an annoyance basis to their criteria. No State's road noise policies approach the WHO recommended levels for night-time.

4. Canada – Alberta and Ontario

Policies from Alberta and Ontario are reviewed because of the similar system of government and resource development between Canada and Australia. For Alberta, the "Alberta Energy and Utilities Board Directive 038" (19) applies to energy and utilities facilities. It notes: 'This directive attempts to take a balanced viewpoint by considering the interests of both the nearby residents and the licensee. It does not guarantee that a resident will not hear noises from a facility; rather it aims to not adversely affect indoor noise levels for residents near a facility. The directive sets permissible sound levels (PSLs) for outdoor noise, taking into consideration that the attenuation of noise through the walls of a dwelling should decrease the indoor sound levels to where normal sleep patterns are not disturbed. The minimum objective for night-time sound level is 40 dBA.

Some cities in Alberta have noise included in community standards. The city of Calgary regulates noise through the "Community Standards Bylaw 5M2004" (20). Citizens have the right not to be disturbed by noise. Citizens have the responsibility to not make noise that disturbs others. Noise can include, but is not limited to, yelling, shouting, loud music, horns, power tools and air conditioners. This bylaw has a minimum objective for night-time sound level of 50 dBA $L_{Aeq,1hr}$.for continuous noise and 75 dBA $L_{Aeq,15min.}$ for intermittent noise. The bylaw requires no person to make or cause or allow to be made or continued any noise which disturbs or annoys a person, including any loud outcry, clamour, shouting, movement, music or activity. Whether any sound annoys or disturbs a person, or otherwise constitutes objectionable noise, is a question of fact to be determined by a Court hearing a prosecution. This doesn't apply to industry.

Ontario has separate guidelines for sound levels from stationary sources in rural and non-rural areas. For rural areas (21), no restrictions apply to any stationary source resulting in an $L_{eq,1hr}$ or a Logarithmic Mean Impulse Sound Level (L_{LM}) lower than the minimum values for that time period. For the night-time period 23:00 to 07:00 the limit is 40 dBA. For urban areas, the limit is 5 dB higher and doesn't apply to transportation corridors (22).

For mining activities, Environment Canada has a national environmental code of practice for metal mines (23) which include objectives for noise. The general objective of the Code is 'to identify and promote recommended best practices in order to facilitate and encourage continual improvement in the environmental performance of mining facilities throughout the mine life cycle, in Canada and elsewhere'. In residential areas adjacent to mine sites, the night-time L_{eq} should not exceed 45 dBA. Remote locations should work to achieve these objectives for off-site ambient noise to minimize the effect on wildlife. No basis is given for these levels although they mirror the 1999 WHO guidelines and would have been drafted prior to completion of the 2009 Europe night-time guidelines.

5. Typical approval conditions

Typical approval conditions for mining and industrial projects in NSW require the proponent to ensure that the noise generated by the project does not exceed criteria determined for the specific project. Limit conditions list sound levels at receiver locations in day, evening and night-time periods as $L_{Aeq,15min}$, with additionally a $L_{A01,1min}$ for night-time. Other requirements may include limits for offers of noise control treatment or acquisition. The criteria may not apply if the proponent has an agreement with a landowner. The noise criteria in the tables of the conditions apply under all meteorological conditions except the following:

(a) during periods of rain or hail;
(b) average wind speed at microphone height exceeds 5 m/s;
(c) wind speeds greater than 3 m/s measured at 10 m above ground level; or
(d) temperature inversion conditions greater than 3°C/100 m.

There will also be conditions for construction noise, noise management plans and compliance monitoring and reporting. There may also be conditions requiring non-operation of equipment at certain times or locations. A noise monitoring program is a likely component, that:

- uses a combination of real-time and supplementary attended monitoring measures to evaluate the performance of the project;
- includes a protocol for determining exceedences of the relevant conditions of this approval; and
- includes a program to monitor the actual sound power levels of the equipment on site, compare it with the benchmark levels used in the Environmental Assessment (EIS), and evaluate the effectiveness of any attenuation.

For compliance monitoring, the requirements can include:

1. Attended monitoring is to be used to evaluate compliance with the relevant conditions of the approval.
2. Unless otherwise agreed with the regulator, this monitoring is to be carried out in accordance with the relevant requirements for reviewing performance set out in the NSW Industrial Noise Policy (INP). These relate to:
    (a) monitoring locations for the collection of representative noise data;
    (b) meteorological conditions during which collection of noise data is not appropriate;
    (c) equipment used to collect noise data, and conformity with Australian Standards relevant to such equipment; and
    (d) modifications to noise data collected, including for the exclusion of extraneous noise and/or penalties for modifying factors apart from adjustments for duration.

An annual report must be provided which includes the results of the monitoring and any non-compliances and complaint history. Additionally for some projects, after two-years and then every three years after that, an independent environmental audit of the project may be required, which will include a noise assessment.

6. Difficulties with approval conditions

A 2013 decision in the NSW Land and Environment Court (regarding a coal mine in the Hunter Valley - Warkworth Mining) identified some difficulties in the setting of conditions similar to those given above (24). A proposed mine extension project was approved by the government. An appeal was made against the approval by affected residents and the appeal was upheld by the Court. Five issues related to noise approval conditions were raised in the judgment. These included too high background levels were allowed; criteria were set on what the mine could achieve, not according to what is acceptable in terms of the requirements of the Industrial Noise Policy; insufficient accounting for the effect of meteorology on noise levels; insufficient accounting for annoying noise characteristics; and combining the criteria for different mines.

A detailed discussion of the judgment is not intended here – the noise section occupied 19 pages and 165 paragraphs of it. But some points are relevant. The main one is if there is a policy which describes how approval conditions are to be determined, then it needs to be followed.

Regarding weather conditions for monitoring, the wording of the approval indicated that the noise limits did not apply during rain, hail, wind speeds above 3m/s and inversion conditions greater than 3^{o}C/100m, whereas the INP only requires that sound level data during these periods is not included. The view was that ‘while these exclusions might be inspired by the approach adopted in the INP for noise prediction and noise monitoring, they do not operate to exclude noise monitoring to determine compliance with the noise criteria during the excluded meteorological conditions but rather operate to exclude the applicability of the noise criteria during those conditions. This lessens the incentive for the mine to conduct its operations so as to keep noise emissions below the specified noise criteria. That would be the case in particular during periods of predicted continued rain when the noise criteria would not apply and there would be no limits to the noise the mine complex could emit.’ The conditions also allowed the wind speed to be measured at the mine, whereas there might be a different wind regime occurring at the residents.

As a comparison, the limit condition for noise for night-time in the approval was 40 dBA, which is higher than would be developed if the INP was used, based on intrusive sound levels (i.e. $10\%L_{A90,15min}$ + 5 dB). In comparison, the 2009 WHO guidelines have 40 dBA as reasonable for night-time. This is considered to demonstrate a problem that arises in using annoyance based criteria, where the method includes allowance for background sound levels which vary for different times of the year and for the number of sources operating affecting the receivers (i.e. other mines, roads, railways, etc.).

The judgment also found that monitoring by the proponent had not been adequate in the past. ‘The evidence of attended monitoring in the past is insufficient to allow the Court to draw any inference that attended monitoring in the future is likely to evaluate adequately compliance with the noise criteria. Past attended monitoring has been at too few locations on too few occasions.’ Many mines now run continuous noise monitors, as well as directional monitors to identify if noise received at a location is from their site or another, either voluntarily or as a condition of approval.

7. Preferred approval conditions and monitoring methods

It is considered that approval or limit conditions should be like an effective specification. This includes:

- A specific sound level parameter that can be measured or calculated as attributable to the Project;
- A specific location or locations where it is to be measured or applied;
- Specific conditions for measurement - operating and meteorological conditions, times of the day, seasons;
- Measurement methods – instruments, calibration, tolerance, sample periods, operator training;
- Reporting requirements – frequency of measurements and reporting, content of reports, audit.

7.1 Recommended limit and location

The first task is to select an acceptable sound level. Given that the WHO 2009 report notes that the lowest observed adverse effect occurs at 40 dBA $L_{Anight,outside}$, this is recommended to be the limit. A period of 1-hour rather than the full night period is not expected to compromise this objective and make measurement easier. For event sound levels, an $L_{A01,1min}$ not to exceed 55 dBA is recommended (to reflect 45 dBA $L_{Amax,internal}$ recommended in the 1999 guidelines but avoided in 2009, and allowing for a 10 dB façade reduction through open windows and the change to $L_{A01,1min}$ from L_{Amax}). Adjustments could be made for potentially annoying characteristics but these are recommended to be not greater than a total of 6 dB (3 dB for each effect up to 6 dB for multiple effects) making the objective sound level 34 dBA if adjustments are required.

By comparison to the CTL in the draft ISO/DIS 1996, an objective of 40 dBA allows for probably less than 5% of the exposed population to be highly annoyed, compared to the current approach in NSW of accepting 10% highly annoyed – although it is accepted that the methods to determine annoyance may be different. Objectives for other periods of the day could be 5 dB higher for evening and 10 dB higher for daytime. The limit is to be the total sound level from all sources. The contribution limit for individual sources will depend on the existing ambient conditions at the receiver and the existing and known expected number of sources, such that the limit is not exceeded.

The location for the limits to apply is at the dwelling or other noise sensitive receiver or within their vicinity. Where noise objectives are likely to be similar to or less than ambient sound levels, as is often the case, such as 35 dBA at night in an ambient of 40 dBA, measurements with the sources on and off will not be expected to show any significant difference at the receptor location, especially with a number of contributing sources. In these cases it is recommended that some alternative closer location or locations be sought in the directions of relevant receivers, where measurements can be made to allow compliance levels to be calculated using approved noise models. In these cases the objectives would also need to be specified for those closer locations. Preferably the alternative locations should be set where they are influenced mainly by the subject source rather than others (such as roads or railways or airports) but this can sometimes prove difficult. A location with at least 5 dB higher contribution sound level from the source than from ambient and other sources is recommended. The limits should apply under all typical meteorological conditions expected for the area.

7.2 Conditions for monitoring or predicting compliance

Meteorological conditions used in predictions and development of approval conditions for either planning or compliance monitoring should reflect the typical range of conditions occurring in the locality. The NSW INP requires predictions for meteorological conditions that occur for more than 30% of the time. For example, wind has to be within the range 1 to 3m/s in a particular quadrant direction for at least 30% of the time before it has to be included in predictive assessments. Similarly temperature inversions have to be a feature of an area on more than 30% of winter evening and night-time periods for it to be required in prediction assessment. This 30% requirement is considered too restrictive and provides a false sense of security for proponents. Wind and inversions have the potential to increase noise impacts at a receiver in the downwind direction. A prudent assessment would allow for such conditions if they are typical to ensure that objectives set are able to be achieved during them. At least 15% of the time is considered to be typical - that is more than 1 night per week on a statistical basis, and has been observed to be enough to cause significant annoyance in receiving communities where the objectives are exceeded under such conditions.

Methods of monitoring should follow the requirements of the relevant standards, codes of practice, or policy or regulation. These will include instruments, calibration frequency requirements, operator

skills and training and methods. It is also helpful for the person doing the monitoring to understand the subject site and the types of noise sources occurring, so that they can identify by listening if any of the sources are audible.

Recommended sample intervals are a minimum of 15 minutes for a combination of attended and unattended monitoring, within the day, evening and night. Unattended monitoring can show the range of sound levels occurring at a site. Attended monitoring helps to identify the sources contributing to those sound levels and is a recommended part of a monitoring activity. Generally, a two-week period of continuous unattended monitoring provides an adequate period to assess potential effects of weather patterns for a season at a site. Monitoring in each season can be relevant if they have specific effects, such as seasonal winds being in opposite directions. If this is not the case then winter is probably a better time of the year (in non-tropical Australia) to avoid higher levels of insect noise and include more enhancing propagation conditions. However if complaints occur then the monitoring should attempt to include the periods when they are most likely to occur, if that experience is in place.

Figure 1 shows a typical monitoring result from an industrial site (25) and includes $L_{Aeq,15min}$ and $L_{A90,15min}$, wind speed and rainfall.

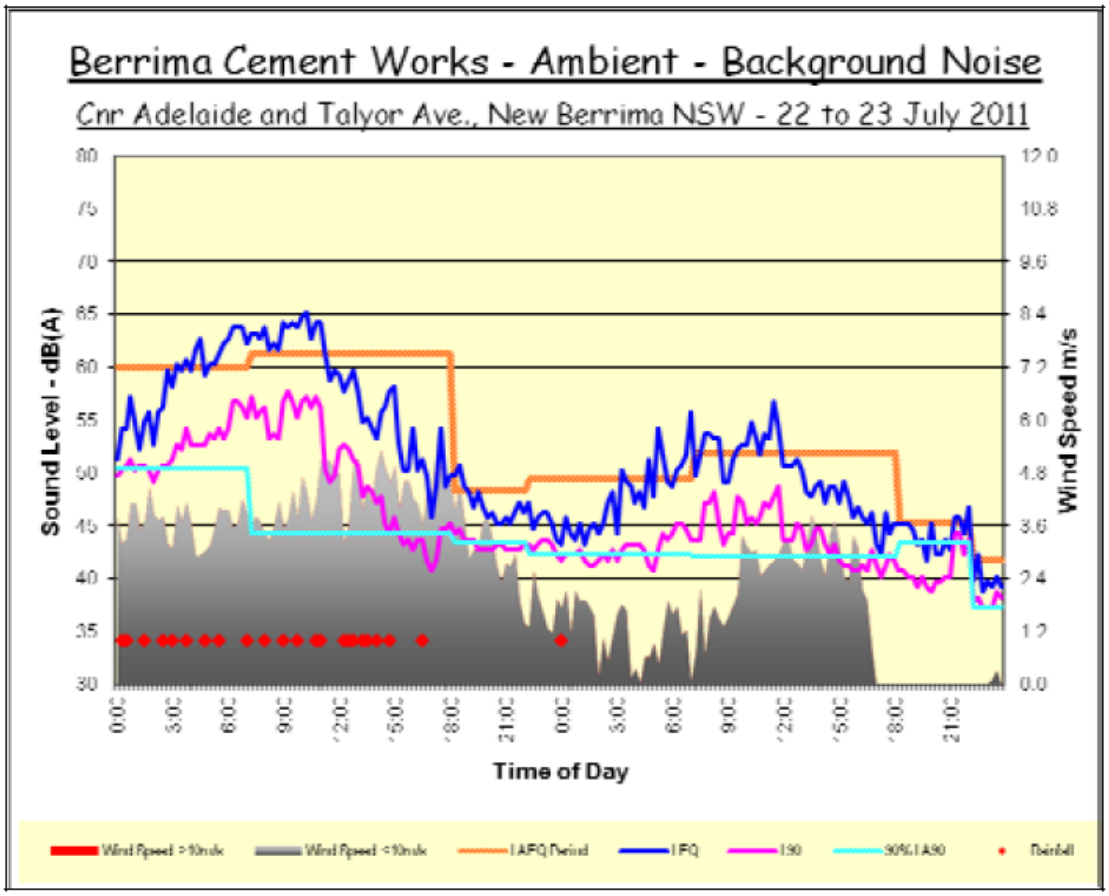

Figure 1: Typical long-term monitoring result for an industrial site for a 2-day period (25)

Monitoring systems that record sound levels over the long-term period to allow interrogation of results and potential sources of event or general periods of high noise can be helpful. All long-term monitoring results need to be related to meteorological conditions occurring at the time – wind speed and direction and rainfall are the key indicators. Operating conditions or plant at a specific source can also be included in the monitoring data to identify any potential effects on received sound levels.

Experience with permanently located continuous monitors has been problematical in the author's experience. Current approaches using the internet allow observation of results, but without reference to sources causing the noise they do not give the full picture. The public needs to have the ability to listen to the sounds occurring at the time to make the data relevant. Typical quarterly monitoring reports take significant time to compile but may not add to an exposed community's understanding, because they don't show the contribution levels from the project, only the total of all sources.

Those observing the results may see the sound levels exceeding contribution limits at times but not be aware that the subject source is not the cause of the exceedance. This can be especially the case at

shoulder periods in the morning and evening when limit levels may be low but general ambient sources (birds and insects, road traffic) have commenced or remain high. One recently observed site with this type of monitoring systems had alarms initiated for high event sound levels caused exclusively by birds, aircraft or rainfall.

Figure 2 shows an example of results from one recent on-line boundary noise monitor for a coal mine in NSW. The alarms at 11pm and near 2am were both for aircraft, and for 7pm it was for birds. But this data is only available to the operator at present, not to the public.

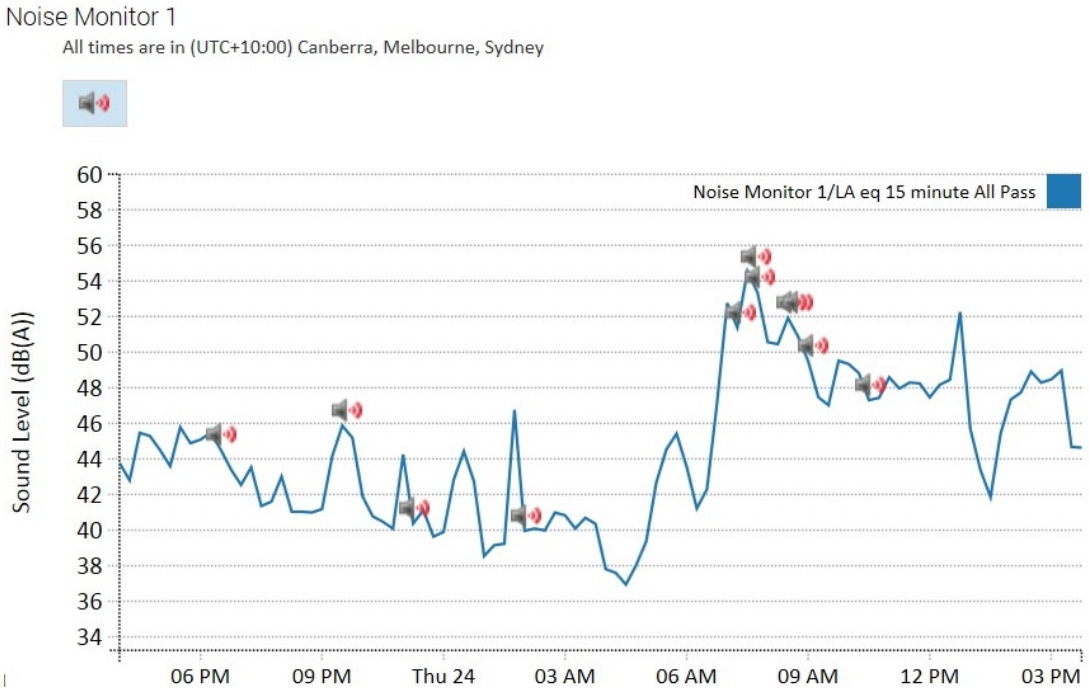

Figure 2: Output from a web-based noise monitor showing alarm times and levels

If the concerned neighbour looked at this figure and was informed that the contribution objective is 38 dBA at night-time, what does he think when for most of the night-time the sound level is above that? Yet at the time of this monitoring shown above, the mine was not operating at night-time. In the author's opinion, this shows the need for care with monitoring data and how it is presented. Also, the cost to implement these systems is significant and the time to interpret them adds to that cost.

Finally there is auditing. The affected public and operators need to have confidence that the results of the monitoring have been properly recorded, presented and analysed for relevance to conditions and the potential for annoyance. Statutory authorities are under increasing pressure to reduce staff and costs, but an experienced and rational regulator is an important part of a control regime to protect community health. Perhaps there is a need to allow for certified acoustical auditors independent of the projects, to assist regulators in the task of understanding those projects achieving limits and those that are not. There is currently no scheme in Australia, but something like the Certified Environmental Practitioner (CEnvP) run by the EIANZ would be helpful in this area for Australia.

8. Conclusions

Methods of setting limit conditions for noise immission from industrial and resource development in Australia and Canada are based on either annoyance or protection of health in the receiving community. Most appear to follow the health-based WHO guidelines for night-time noise. This approach is recommended for all jurisdictions because of the difficulties in allowing for the range of annoyance that can be caused in an exposed population. An objective of 40 dBA outside at night-time is recommended, as given by the WHO 2009 guideline for night noise in Europe. This sound level is the total of all received sound at a receiver.

Predictions for setting levels in approvals and predicting effects can include allowance for wind and atmospheric temperature inversions. It is recommended to allow for these if they are features of the local meteorological environment on more than 15 % of a day period (evening or night) in a season. Difficulties can arise for project operators if such conditions are dismissed as not being frequent

enough, because 30% might be suggested in policy documents and only calm stable conditions are allowed for, but higher levels occur resulting in significant annoyance and exceedance of limits. Where there are policies in place they need to be followed to avoid legal appeals, however more conservative limits can be accepted by proponents to protect neighbours and promote good relations.

Monitoring systems have developed allowing unattended on-line and continuous results to be presented. However, attended monitoring is an important component that needs to be included in this process. For on-line systems, results need to be accessible to the public.

Certified independent acoustical auditors could be one way to assist regulators maintain an effective review of compliance of projects with approval conditions.

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