Outdoor Event Noise Monitoring – Lessons Learnt and Recommendations for Future Events

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Abstract - Outdoor concert and festival music events generally operate under the local legislative requirements, while touring artists are only interested in achieving their desired 100 dBA at front of house operating levels. This paper reviews 13 years of experience and more than 200 outdoor concert events and festivals, in the capacity of noise monitoring and live management, and discusses the insights gained regarding the interpretation of noise criteria and ability to achieve practical outcomes.

In review of the various venues, limits, parameters and expectations of interested parties, one recurring factor stands out: the inconsistency of noise criteria parameters across different jurisdictions in Australia. This variability complicates the efforts of event operators to meet regulatory requirements, often leading to confusion, frustration and non-compliance. The paper discusses the variety of adopted parameters utilised for noise limits, which are generally set on behalf of affected sensitive receivers. By reviewing these issues against the wealth of event experience, this paper aims to contribute to more effective and efficient noise management practices in the event industry, aiming for regulatory adherence, operator comprehension, and the minimization of unreasonable noise pollution impacts, with an overarching focus on how the Acoustician operates under the various expectations.

1 INTRODUCTION

After more than a decade of working with outdoor amplified concert and festival music events (referred to as outdoor concerts), it has become apparent that the intent and application of noise limits is often lost in translation or execution to the detriment of all involved parties.

Through 13 years and more than 200 events, unique perspectives have been gained on the operation of outdoor concerts regarding setting and maintaining noise limits. Noting that these criteria have impact on various parties including but not limited to: event and venue operators; patrons; music production (mix engineers); performers; noise management or compliance monitoring personnel (often acoustic consultants); and off-site receivers.

Through a series of anecdotal accounts of specific outdoor concert events we endeavour to break down how various aspects of the noise limits and parameters utilised in different venues around Australia are identified to help or hinder the various interested parties. Further to this, we seek to contribute to the improvement in outcomes for all parties, but most importantly, to improve effective ability to control and maintain compliance, this paper summarises consolidated learnings from these experiences.

The various parties involved in the implementation, impact, and effectiveness of outdoor event criteria have their own individual desired outcomes and complications associated with the use of outdoor event criteria. It is noted that this paper overarchingly is interested in how the Acoustician operates under the various expectations.

The numerical noise level value utilised in criteria have not been discussed, as they generally pertain more toward the frequency of occurrence and location. However, discussion on different noise parameters used in criteria is provided. For a more comprehensive guide to managing an outdoor concert, a good starting point is (Cirrus Research, 2022).

2 ANECDOTES

From 13 years of outdoor concert events, below are a series of anecdotal happenings and the lessons learnt.

2.1 One Bad Egg

During a music festival held in an urban area of NSW, shaking walls/windows at the nearest houses to a then barely known DJ in the early afternoon via the mix engineer ignoring the dBC limits placed on FOH long enough for significant residential complaints to arise, resulted in reduction of noise goals for the entire event by 10 dB in subsequent years. The site eventually moved. While ignoring the limit was not the only factor, it was likely a significant contributor and seemingly based on a single DJ set (likely less than 1hr). Returning years later as an international headliner artist, playing under the restricted noise limits and due to unfavourable weather elevating levels off-site by 10-15 dB, the audience was often louder than the music.

Learning: community perception can be that of a single excessive period deeming the entire event "out of control". Furthermore, reducing limits as a form of punishment can cripple the feasibility of these events. It was not the dBC limit being inadequate that caused the valid complaint, it was the limits being ignored by the mix engineer. In this instance a fine could have been a preferred regulatory response.

2.2 Hearing Aids and Headaches

A complainant 1.5km away from an event site, with 'slightly audible' noise levels external to their residence, felt noise was egregious as they were unable to hear the television when sitting inside with windows and doors closed. It was identified their hearing aid amplified low-mid frequencies and by closing-up the house the C-weighted L_{eq} minus A-weighted L_{eq} parameter value internally was perceptible and then further amplified.

At the same site, a resident complained of the music causing a significant headache, and where usually acceptable, on the day of the event, it was too much to bear. Later that day the same resident was jubilant to share the music on their balcony with visiting friends.

Learning: noise criteria are generally based on statistical acceptance of the greater community, but as always noise is subjective, and individual situations unique. Where identified as affected, these individuals could be flagged for further consideration (e.g. alternative accommodation or compensation).

2.3 Rural Resident

Residents located more than 5km away from a multi-stage festival in NSW were feeling impacted enough to request noise monitoring. A half-hour drive away from highly affected areas was required, to then discover it was necessary to stand perfectly still and stop breathing in order to hear the subtle music influence at that location. It was discovered that due to it being a rural area the resident felt "shouldn't the noise criteria make it inaudible". It was then recommended to coach the complaints line operators in appropriate dialogue, and not promise monitoring.

Learning: not every squeaky wheel requires significant attention. Some can be handled with words.

2.4 Inversion Layer and Topography Influence

Contrary to the rural resident anecdote above, sometimes unique weather conditions can result in high noise levels travelling a significant distance. Simultaneous measurements at locations 1 km and 6 km from and in-line with the orientation of the main stage of music festival were undertaken. With both locations on exposed hills, well above the surrounding terrain, the measured levels were almost identical. It was suspected that noise was propagated under perfect weather conditions (including wet ground surfaces, reflective cloud cover, and a natural

amphitheatre at the complaint location) which at the distant location were 20 dB higher than usually measured, and 10 dB higher than the worst-case predicted value using ISO 9613.

Learning: weather can have dramatic influences on large scale focused amplification systems. It is unclear in most legislation if it would be intended to reduce the volume when compounding meteorology is elevating noise by such a significant and unexpected amount.

2.5 Specific Frequency Criteria

For a NSW based music festival, the production staff had a keen interest in working the criteria to best suit their mixing desk volume levels (L_{eq} in A and C-weighting), to appease their touring artists. Once an understanding of the necessitation to achieve an unweighted 63Hz criteria with no restrictions on the 31.5Hz 1/1 Octave band, they instructed their mix engineers to push all their bass outside the 63Hz band (generally 40Hz or lower). The approach clearly did not benefit the resident, potentially increasing bass levels at residences.

It is noted, as presented in (Air Noise Environment, 29 June 2017), a significant reduction in complaints occurred after implementation of a 63Hz noise limit, however this also coincided with implementing a dBA limit and promoting significant management awareness of FOH noise levels at the same time.

Review of an unweighted 63Hz limit was established as providing a good representation of bass contribution from historic drum-kit based band noise (Parnell & Sommer, November 2018). However, many modern artists utilise electronic simulated bass which can include significant perceptible volume at 31.5Hz or 40Hz in the 1/1 octave band below the 63Hz 1/1 octave band. Further to this, a popular electronic bass ‘highlight’ moment utilised by artists in recent decades is a broad bass note sustained for 2-7 seconds covering 31.5Hz through 80Hz to 125Hz.

Learning: acoustic consultants may need to review beyond the established criteria to maintain the intent of the criteria and avoid community impact or complaints. This can further be an issue where computational modelling standards (ISO 9613-2:2024(en)) don’t accommodate frequencies below 63Hz, which are further excluded in some of the broadest datasets available (Støfringsdal, 2018) including 170 Pop/Rock/Jazz music events.

2.6 Too Many Criterion

While operating under a venue specific noise management plan created to appease every aspect of the ACT EPA noise goals, it was identified there were far too many parameters, often in conflict with one another. While easy enough to measure and review against compliance at the end of a period, it was found excessively complicated to manage and adjust 3-concurrently operating musical stages, all playing different styles of music, and impacting on the various limits (L_{10}, C-A, octave band tonality adjustments).

The challenges were partly due to the event being identified as borderline to comply (including requesting a higher limit at the outset but settling for a lower limit due to the encouragement from Council to utilise the venue) and resulting in the operator desiring to always operate “as near as possible to the limit”. This was further complicated by a different criterion being triggered for every new performance, and sometimes just between tracks.

Learnings: specifically, operating under the above event limits highlighted that C-A criteria doesn’t reasonably work without a fixed limit, as the further you travel from the site, the greater the differential and at some point, the C-A exceeds. Additionally, the L_{10} criteria over a 10-minute period didn’t highlight that via diligent management, where a limit breached in the first 1-2 minutes and volumes were swiftly reduced, the L_{10} for the period was unchanged. Much of the requested criteria appears to have been extracted from existing local legislation not necessarily appropriate for the temporary nature of a major entertainment activity.

2.7 High Ambient Noise

During a multi-stage festival in Victoria, it was identified that the most impacted receivers were near the bus-terminal established for the event. It was suggested to park the buses that were temporarily not in use as a noise barrier (care of the receivers being all single-story housing). While this aided to reduce the contribution from the amplified event noise, it then became difficult to isolate the noise from the event levels from the buses and patrons departing, and maintaining consistent FOH ended up being the focus of noise management.

Learning: sometimes the solution to minimise impacts to the residents, results in complications for the acoustician.

2.8 Temporal Wind Influences

Occurring in both urban and rurally locations, stable consistent, or high gusty wind can wreak havoc on the off-site noise levels. These conditions generate complaints that *"they've suddenly turned it up"*, wild spikes of L_{Aeq} due to a tiny percentage of elevated noise during a 5 to 15-minute period, and momentary L_{Amax} values jumping 10-25 dB due to shifting winds. While this generally occurs in a specific area of influence, no resident wants to hear *"it's only affecting a few properties, and it's only temporary"*.

While the music and even bass were very clear, it did not seem any fault of the event operators who hadn't adjusted their volumes. Many legislative areas leave no 'buffer' or allowance for meteorological influences, while others have up to 5 dBA allocation and vague identification that measurements in winds greater than 5 m/s are unreliable.

Learning: it is important to establish a reference FOH measurement and ideally limit, and once again, wind/weather can have substantial influences on measured values. Often implemented for major venues in Australia such as the strategies described by (Henry & Marchuk, 2016).

2.9 Stage Monitors

In several incidents, stage monitors have been operated to higher volumes than the main system. The FOH mix engineers often don't have access to adjust these, and further don't want to alert the band to the fact their volumes are being controlled. Most mitigation design is focussed on screening the main system and can ignore stage monitors. Acoustic consultants may identify a preferred orientation of the speakers, however they are often dictated by the side the stage is loaded and where their system can be located.

Learning: it is important to evaluate the system being used, and ideally have some input early in the design, however, this rarely occurs in practice with the noise monitor contracted after the fact.

2.10 Rogue Operators

Near conclusion of a major touring artist event, the acoustic consultant diligently informs the mixing staff that curfew is in 10-minutes, who are then observed relaying the message to the headline artist on stage. The lead singer, then touches his ear-piece and cheerfully announces to the audience that he's been instructed that the venue has a strict curfew, and then being fully aware of the significant fine associated with breaching, announces; *"…but this is rock n roll"* and plays an entire track after curfew. Further complicating matters, then informed they can't be fined for the same infarction twice during the same "event", they proceeded to breach curfew the following night.

It is the venue's responsibility to maintain control and demonstrate the venue can keep within limits to benefit the community. However, the rumoured quarter of a Million dollar fine likely helped the local community in the end.

Learning: post-event reporting can be crucial in painting a picture of what occurred and potentially worth informing the residents of actions taken post event via fines (rather than the belief that it was accepted behaviour) and enforcing the “pull the plug” isn’t as easy as it sounds when 80,000 patrons, and significant revenue is on the line.

2.11 Indiscernible Music

Being stationed over 500m from a festival with 3 major concert stages, 10 minor venues, and 20+ music playing food vendors and trying to identify which of these, or which combination of these are defining the noise levels. This situation was further complicated when training unfamiliar staff in the differences between ‘disco’, ‘rock and roll’, and ‘drum and bass’, and asking them “what style of music do you think it is”, to be met with, “it sounds like a freight train” and discovering they could hear the diesel light generator located half-way between the site and themselves.

Learning: noise is often referred to as a dark art, because there is so much “feel” and experience required to evaluate constantly changing parameters and convoluted sources.

2.12 Budget Cuts and Venue Restrictions

Whether it’s mitigation measures (hay bales no longer being allowed under stages due to fire concern), or the quality of the system (highly focused cardioid speakers versus the 70’s system pulled out of an old hall), or removal of distributed speakers from a previous year’s operation.

The client is often confused why they can’t achieve the same volume they did the previous year, when significantly beneficial noise controls are no longer included in their event design or budget.

Learning: a client may not be as acutely aware of where the money goes in achieving good noise mitigation, it is our job to remind them, and then be the scapegoat when they forget and wonder why they must turn the volume down after they promised big things to their contracted artists.

2.13 Musical Style

Humans and noise are truly enigmatic. Operating at a NSW venue, illicit language and high bass content from a performer operated to levels occasionally breaching criteria for a NSW venue and resulted in a multi-page list of resident complaints. Contrary to the first artist, a second artist exhibiting gentle vocals with electronic bass and piano crescendo operated to similar volumes in both dBA and dBC parameters and received only a single complaint from a shift-worker. Accurately describing music by style and then associated decibel and octave frequency content is extremely difficult as per the breadth of data in (Støfringsdal, 2018) and (Hayne, Mee, & Rumble, 2005) identifying 200+ commonly referenced genres.

Learning: again, noise is subjective. You can take an educated guess on what people will and won’t accept, but it’s hard to get good statistics on events only occurring a specific venue only once a year.

2.14 Once Bitten Twice Shy

On several occasions under trying conditions, mix engineers have thrown their hands in the air saying that it’s all too difficult to achieve compliance while putting on a show at reasonable volumes for the paying customers, and ignoring further direction until intervention via a person of superior standing (e.g. production or event manager).

In a specific event a colleague was stopped by a very large entourage security guard and refused entry back to the FOH mixing desk to advise on compliance, as the operator had instructed their head of production that they can’t work under these conditions (below their desired volume, which was, well above the limits).

Learning: ensure you have the understanding of the team, regarding the intent and requirement to comply with a limit. Identify who is responsible and liable for maintaining it. Pre-plan an escalation procedure and hierarchy.

2.15 Direct Conflict (playing double agent)

On many events, once a production manager understands there are nuances to certain criteria, they may request to "work around the criteria and achieve the highest volume possible". Specific instances include: (1) Being asked to avoid known hot spots during peak songs on your roaming monitoring rotation. (2) Equalising the bass to be dominant in 40Hz when a 63Hz 1/1 Octave Band criteria is in place. (3) Production identifying that loggers are clock synchronised and starting their loud acts in the final 3-minutes of the previously ambient period (against a 15-minute L_{eq} criteria). (4) Ignoring bass volumes completely where only a dBA limit is enforced.

This provides a direct conflict in achieving the intent of the criteria, to minimise impact on sensitive receivers. These occurrences can lead to friction where the production team are the paying client, and the acousticians' knowledge that complaints are most likely to arise from the loudest and or bassiest periods, driving complaints which are often the ultimate tool of review over all measured data. Significant diplomacy and calm patience are required in getting the production team to desire to do what is best, when there are additional decibels at stake.

Learning: knowing the science and technology is one thing, but psychology and diplomacy are often required to make it all work in a human world. A rolling L_{eq} measurement provides a greater review of actual impacts.

2.16 Irritating Pedestrian Behaviour

Pedestrians, patrons, residents, even passing cars when seeing a microphone (identified by the wind-shield) often feel the need to exhibit one of a few behaviours; yelling into the microphone and asking how loud they were, or simply laughing or honking a car horn; asking loud and clearly "are they complying" thus ruining one of your measurements; talking on and on and then asking "so, how does the technology work to cut out the other noise".

Learning: politely learning how to deal with a variety of personality types quickly and quietly to both highlight you are working for the community and need quiet, but also desiring to inform residents of how the work you do is to their benefit, is often easier said than done, and complicates collecting continuous, reliable data.

2.17 Irrational Residential Behaviour

A colleague was once attending a residential complaint in an urban apartment complex. The resident insisted levels were significantly louder in their elevated apartment and seemed harmless enough. Upon entering their apartment to measure the noise and being told the levels were high but within their allowable limits, the resident deadbolted the door and insisted they would not allow the acoustic consultant to leave until the music volume was reduced. Compounding the issue was a lack of mobile phone signal in the tower. This resulted in far stricter OH&S requirements for monitoring staff from that day forward.

Learning: when viewed as the governing body, and when emotions run high due to the subjective nature of noise limits, the job can be dangerous.

2.18 Summary

As highlighted by this handful of anecdotal accounts of the nuances and complexities of effectively selecting and maintaining a noise criterion, simplifying the parameters and execution of management is desirable.

3 NOISE COMPLIANCE PARAMETERS

Further to the various anecdotes, consideration of the many parameters, durations, weightings, adjustment factors, etc. utilised in the various criteria throughout Australia, there have been pros and cons to each. The table below aims to provide a glancing summary of the positive and negative aspects of a broad list.

Table 1 – Noise Parameter Review

Parameter	Positive Aspects	Negative Aspects
L_{Fmax}* / L_{Smax}	Focuses on the loudest moments and restricts them (good for receivers). Can be reviewed in high ambient conditions.	A transient event (bird squawk or car door) can easily taint the data. Requires live observation.
L_1	As per L_{max}.	As per L_{max}, (excluding confusion).
L_{10}	Can better isolate continuous music from erroneous sources.	Continuous erroneous sources will still potentially increase levels. Ignores 90% of the time potentially being compliant.
L_{eq}	Considers the rise and fall of music Many touring artists construct their set in anticipation of Leq limits.	Erroneous sources, or temporal weather influences can unduly increase. Continuous live observation required to identify and exclude erroneous data.
C-A	Suitable at a boundary or FOH location. Or as a fixed dBC level relative to A.	Unsuitable at distance, as the further the signal travels the C-A only increases.
A-weighted	Defines audible noise very well.	Better utilised as a fixed C value. Predominantly complaints arise from bass content and dBA can be tuned away from the bass to some extent.
C-weighted	Defines low-frequency, and internally levels (more than dBA). Systems often emit more dBC in all directions compared to dBA.	Is not well understood by the lay person.
$L_{eq,oct(63Hz)}$	Focuses on typical rock band bass drum.	Often modern electronic generated bass music has “broad band” bass from 31.5Hz through 125Hz.
Octave Bands	High degree of focus on impact and audibility.	Very difficult to live monitor and will be constantly changing with music styles and individual songs. Live touring artists do not want to be equalized.
Short Duration	High level of constraint and assurance of sustained compliance.	Don’t factor in variability of performances. Performers not leaving enough headroom.
Long Duration	Operators have time to adjust when levels are creeping. Modern predictive algorithms can estimate future L_{eq}.	Potentially impact residents for long periods before an issue is identified. Operators are less cognizant of maintaining control.

** Additionally, there can be confusion where historic Lmax criteria is established for a site, which may be in reference to non-integrating analogue instrumentations, desiring an L1 or L10 reading.*

4 CONCLUSIONS AND RECOMMENDATIONS

In considering the various end users and benefactors of outdoor event noise criteria, and overarching intent to provide guidance to avoid excessive noise, an approach that is understood by all users is preferred. Based on a cross examination of the experiences of utilising noise compliance parameters, some broad recommendations for effective noise management have been identified.

Early acoustic consultant involvement is critical to identifying sites that are highly constrained and giving valuable input into site mitigation and optimisation or excluding a site from consideration. The venue volume limit/s should consider the scale, frequency of use, and location. Criteria should build on a review of a variety of regulations specific to events, not only local legislation, like that of (Perna, Padois, Dumoulin, Doutres, & Dupont, 2019).

Longer term average noise criteria, such as a 15-min L_{eq} provide more allowance for the dynamic nature of music. However, to maintain control and identify impending breaches, it is recommended to review the rolling 5-minute L_{eq}. Touring artists often anticipate and plan their sets based on achieving a 15-minute or 1-hour L_{eq}, at the mixing desk. Due to the prevalence of complaints arising from excessive bass content, it is recommended that a dBA and dBC limit be established. A review of specific frequency-based criteria can be useful but should also be evaluated by the acoustician as to their relevance, e.g. if the frequency in question is not the defining factor.

There will remain venues and locations that may require nuanced approaches to reasonable criteria, however rationalising the external target to an L_{eq} at the mixing desk will provide the most effective management tool. This will further provide (1) the venue/production/acoustician an ability to demonstrate the commitment to maintaining a consistent operational volume (below the limit) where external factors may result in high off-site noise levels, and (2) provide regulators a greater understanding of the cooperation exhibited by venues, while dealing with complications. This may also identify outlier events where one period did not adhere and prosecute them rather than the entire event/venue/production (e.g. a single artist at a music festival hosting 10 to 100 artists).

Once values are in place, it is important to ensure the event and system are calibrated, ideally establishing upper limits during sound checks and monitored continuously to maintain levels below that limit. Providing notification when levels are approaching the limit (within 2 or 3 dB) can give time to adjust prior to exceedances being logged. Refining noise management plans is common practice, as well as breach fines considering the circumstances.

Allowance for weather impacts should be built into the limits e.g. (Noise Policy for Industry, 2017) which provides a 5 dBA allowance during ‘very noise-enhancing conditions’, and it should be acknowledged that these are outside the control of the event and a factor of an outdoor activity. Where applicable, allowance for some leniency regarding compliance could be provided in case of highly unusual weather, typically considered post-event.

Inform the community that music may be audible and to varying volumes; however, it is being reviewed and adjusted as necessary, with penalties in place where ignorance of the limits is demonstrated. It is further suggested not to understate the complexity of noise monitoring and management. No matter the noise limit and efficacy of maintaining compliance, there may remain a vocal minority to complain “not in my backyard”, and this also needs to be factored into the narrative provided to regulators reviewing event compliance.

Implementing an L_{eq} limit does not exclude the acoustic consultant from reviewing various parameters best suited to achieve the desired noise targets during the creation of a Noise Management Plan and defining a relative L_{eq} value.

By focusing on clear, manageable criteria and effective communication among all parties involved, noise management at events can be improved, ensuring compliance while enhancing the event experience for everyone and keeping the arts alive.

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