Soundscape design applications for entertainment noise

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ABSTRACT

Four case studies are presented that demonstrate soundscape methods for assessing noise impacts and proposed regulation and mitigation strategies for entertainment noise impacts. One is the use of soundscape methods to assess bass noise impacts from entertainment establishments in a medium size city. Second is the use of soundscape methods to assist an established entertainment district in revising their noise ordinance to address urban growth and a vital mixed use plan. Third is a large amphitheater that received numerous noise related complaints each time it was used. Soundscape methods were used to assess noise impacts particularly bass noise intrusions into the community. Fourth was a small city that was experiencing revitalized growth due to entertainment establishments and some residential infill projects. The residents began to complain about the entertainment establishments. Soundscape methods were used to assist the community is establishing a rational basis for noise ordinance sound level limits.

1. INTRODUCTION

The concept of *soundscape* or *acoustic landscape* was originally developed by *Schafer*[1], *Truax*[2] and others. However, there is little evidence of its application and adoption in the field of urban planning and particularly entertainment noise and noise ordinance development in North America.

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The primary points of departure a soundscape study of entertainment noise makes from a traditional noise study are fourfold. First, is that the acoustical information, the structure and the aesthetics, of the music listened to inside an amplified entertainment establishment and propagated to residences outside the establishment consists of a series of individual notes in the musical piece and each of the words or syllables in a song are specific acoustic events that can be recorded, measured, heard and interpreted. The inherent structure of a piece of music, the enjoyment and the composition of the piece rely on people hearing each of the notes played by multiple instruments and each of the words sung by one or more singers. If the words, notes, phrases, etc., are averaged together, the meaning and aesthetics of the composition are lost. Music is deliberately composed as a series of sounds separated by short periods of time to develop a rhythm or beat. These sounds are also deliberately arranged to occur in multiple frequency bands separated from each other both in time, space and pitch even when played simultaneously. "Our auditory systems, our nervous systems, are indeed exquisitely tuned for music. How much this is due to the intrinsic characteristics of music itself-its complex sonic patterns woven in time, its logic, its momentum, its unbreakable sequences, its insistent rhythms and repetitions, the mysterious way in which it embodies emotion and "will"-and how much to special resonances, synchronizations, oscillations, mutual excitations, or feedbacks in the immensely complex, multilevel neural circuitry that underlies musical perception and replay, we do not yet know.[3]"

Second is the involvement of focus groups of stakeholders to assist in defining the acoustical issues of concern through open discussions and through soundwalks to listen to the situations of concern, assist in developing measurement protocols, review proposals and to critically evaluate aural simulations of recommendations. Third is the combination of long term and short term acoustical measurements of overall A-weighted as well as octave or one-third octave band data of specific acoustic events as well as calibrated recordings that can be used for aural simulations and qualitative analysis of various acoustical situations. Fourth is an analysis of the soundscape and urban context to develop comprehensive acoustical, planning and design strategies to broadly address the complexities of the situations so that a rich urban fabric consisting of tightly integrated combinations of residences, work places, schools, entertainment establishments, areas of repose, various transportation modalities and other vital occupancies can thrive and nurture the highest quality of urbane life for all citizens. The soundscape studies typically provided a participatory process using aural and visual mechanisms to allow residents, business owners, city officials and other stakeholders to collaboratively develop the environmental qualities of their communities.

2. CASE STUDIES

The case studies demonstrate soundscape methods for assessing proposed planning, design regulation and mitigation strategies for amplified entertainment noise. One of the principles of New-Urbanism planning is a systematic layering of civic, entertainment, service, government, school, recreation, cultural and residential lifestyle typologies in one geographic locale. This is defined at an 'urban fabric'. The benefits of an urban fabric include: a reduced traffic volume due to groups of commercial and service-oriented facilities near residences; health benefits, due to the inclusion of park space and cycle paths linking residential and commercial areas; and a combination of infrastructural community facilities such as libraries, schools, health and leisure outlets interspersed amongst residential and commercial zones or areas. Poor urban planning, or a lack of planning can result in uncontrolled adjacencies, such as loud entertainment venues which are in a direct sound path with new or established residential neighborhoods. The issues of acoustical adjacencies in terms of urban planning and the possibility of soundscape

enactment, play a significant role in developing the intricate weave of the urban fabric. Consideration of the details and consequences of the soundscape should be included in each step of comprehensive plan development from regional plan, to districts within a community to the planning and zoning process for individual building projects as well as building permit plans review and substantial completion inspection prior to occupancy for each building project.

A. Case Study One: Deep Bass Thumping Noise Impacts in a Medium Sized City

As early as 1998, soundscape methods were used to assist a Blue Ribbon Committee on Deep Bass Thumping Noise develop recommendations for noise ordinance provisions to reduce complaints from residents in multiple areas of a medium size city from entertainment noise intrusions into their homes. Several districts in the city were experiencing redevelopment and expanded growth. Entertainment facilities with indoor dining and both indoor and outdoor amplified entertainment prospered. Both single family detached homes and multi-family condominiums followed the commercial development into the growing areas. Focus group meetings and soundwalks were taken with residents, law enforcement personnel, city commissioners, members of the committee and business owners to understand the nature of the neighborhoods and the full range of acoustical issues involved in the situation. A series of long term and short term acoustical measurements as well as calibrated recordings of amplified music events were taken during measurement loops where the consultants visited the sites in different districts of the city selected during the soundwalks over several weeks to document the soundscape during times when amplified entertainment occurred and when no entertainment events occurred.

A series of acoustical experiments involving evaluation of amplified music played at several proposed sound level limits were evaluated by residents in their homes. These experiments were also used to provide acoustical analysis of possible noise mitigation solutions to entertainment venue operators. A large, amplified entertainment venue sound system similar to those actually used by bands in several of the establishments was set up in the venue. Calibrated amplified music recordings were played through the system and residents were asked to evaluate the sounds heard in their homes at alternate sound levels. Simultaneous measurement of sound levels played at the source location and at the residences were also recorded. These experiments allowed residents and venue operators to tour each others facility to hear the sounds they made as the others did. This experiment opened the door to constructive dialogue among the various stakeholders as venue operators realized how loud the music sounds were in homes and residents realized how quiet some of the venues actually operated their sound systems.

A second set of experiments occurred at several venues during actual entertainment events. The venues agreed to allow the committee to stage experiments where sound system operators would adjust sound levels and equalization of the sound systems during live performances on weekend nights while the committee visited homes surrounding the venues to listen and evaluate the intruding sounds. Simultaneous acoustical measurements were made at the source locations and in the residences. It became apparent that some of the residents would register complaints when the music was just barely perceivable while in some instances severe intrusions of noise of 10-20 dB above ambient sound levels with noticeable vibration of building surfaces was recorded.

The city wanted to add C-weighted sound level limits to their noise ordinance as well as time of day restrictions on outside amplified entertainment. They did not want to purchase meters or train personnel to measure octave band sound levels. Statistical analysis of data collected showed typical C-weighted to A-weighted differences of 0 to 10 dB on average for

typical acoustical events in the soundscape including traffic, wind, residential air-conditioning units measured at the street or lot line, and other non-entertainment noise sources in the city. The C-A difference increased to an average of 13 to 20 dB with an average of 16 dB and more after midnight when amplified entertainment noise was present. Calibrated aural simulations of amplified music from various establishments played at various sound level limits with various A-weightings and C-weightings were first played for the committee as part of its deliberations and also in the public hearings that were used to review the committee recommendations for the revised noise ordinance language.

The final outcome of the process was that the committee recommended and the city approved both A-weighted and C-weighted sound level limits be included in the ordinance and most importantly that the ordinance would be enacted for a trial period of 6 months to allow business owners and residents to evaluate the consequences of the proposed changes. Once a final ordinance was adopted it would be necessary for business owners, venue operators and residents to modify their facilities and/or operations to comply with the law.

B. Case Study Two: The Use of Soundscape Methods to Assist an Established Entertainment District in Revising Their Noise Ordinance to Address Urban Growth and a Vital Mixed Use Plan

An entertainment district in a large city was originally redeveloped with many bars and night clubs with lively, amplified entertainment. The area was a National Historic Landmark District with red brick buildings, wrought iron balconies and narrow brick streets. This urban area had undergone some revitalization in recent years, and was at the time of the study a popular place to live, and work with upscale shops, mixed-use buildings, residential areas, and numerous dining and entertainment venues. Issues were two fold: noise generated from outdoor or partially-enclosed night club or bar venues where amplified music was being played, and noise from amplified music within fully enclosed establishments propagated to near by residences, hotels, art galleries and shops.

Figure 1: Photographic images depicting nighttime scene for the entertainment district both inside and outside the entertainment establishments.

The entertainment district extended for 8 blocks along 1 main street running in an east to west orientation. It extended for approximately 2 blocks on both sides of the main street to the north and south. Existing sound level limits within the district were 85 dBA measured at the center of the street. At the edges of the district, the local EPC noise rule of 60 dBA for residential areas in the day, and 55 dBA for residential areas at night, with 65 dB sound level limits in the 63, 125 and 250 Hz. octave bands became effective. Many of the residences were located in the area governed by the EPC noise rule. All of the entertainment establishments were located within

the special entertainment district. It became evident in focus group discussions first held with representatives of all stakeholder groups collectively and then, with members of each stakeholder group individually, that the noise issues and possible regulation opportunities were complex. Residents complained of excessive noise and low frequency vibrations entering their homes several blocks off the main street. Police officers suggested that once an officer or other official entered the area with a sound level meter, the volume of all sound systems was reduced until the officer left the area at which time the sound levels were returned to their original levels making enforcement difficult. The contribution of any individual establishment to the sound measured at any specific residence was also difficult to determine due to the large number of venues in the area contributing to the soundscape.

The overall goals of the study were to maintain a lively, vibrant atmosphere necessary for the entertainment venues to prosper; control the propagation of music into neighborhoods to reduce disturbances to residents; provide an acoustically safe environment for law enforcement personnel to work in; and maintain high quality audio inside the venues, not just loud audio. One of the primary problems encountered was that there are few practical methods to reduce noise propagating from open air venues short of audio system controls and some barriers. Many indoor venues had loudspeakers located in open windows propagating sound at high volume into the street. Many venues also had roofs and windows that had very low sound transmission losses serving almost as large openings from which amplified sounds propagated into the neighborhoods. Large window and glass door areas were left wide open allowing sound to escape from the venue. Many of the bands or disk jockeys with loudspeakers were located next to windows, plywood covered openings or by doors where sound could readily spread into the neighborhood.

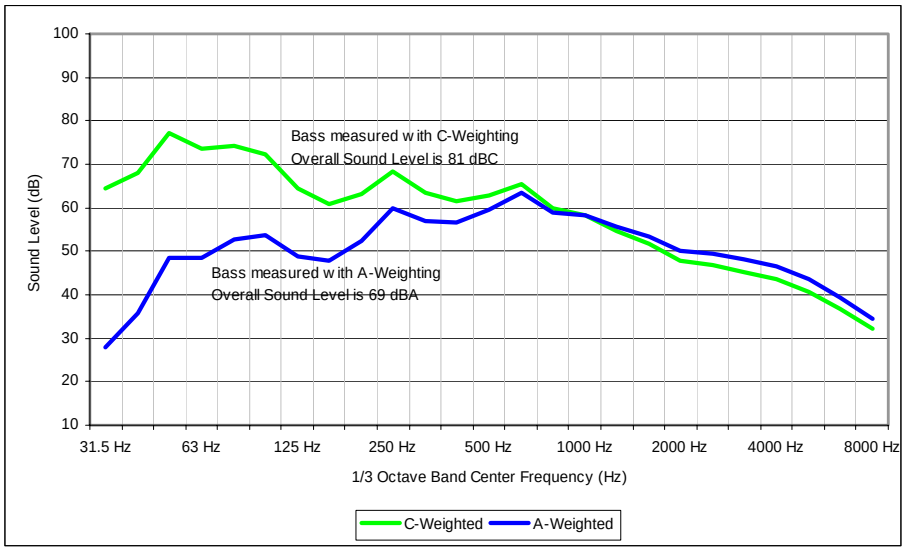

Figure 2: Graph showing a comparison of A-weighted and C- weighted sound levels at one of the residences.

Initial soundwalks were conducted with concealed sound level meters concealed in fanny packs or backpacks with miniature microphones located at the ears of the operators so documentation of the soundscape could occur as it actually operated. The measurements showed that the existing noise ordinance sound level limits of 85 dBA at the center of the street were regularly exceeded by multiple establishments with levels as high as 105 dBA measured in the street. Likewise, inside homes and in yards of homes outside the entertainment district, the octave band sound level limits of the local EPC noise rule were also exceeded on a regular basis

with sound levels of 80-85 dB measured in the 63 Hz. octave band measured inside homes 3 blocks or more off the main street. Multiple soundwalks were made with simultaneous measurements made at entertainment venues and residences so specific sources contributing to excessive sounds at specific residences could be identified.

B.1 Exterior noise levels:

The sound levels at which police officers who patrol the entertainment district are exposed to were measured by having 4 officers wear dosimeters for 4 weekends in one month. All of the officers were exposed to 8 hour time weighted average sound levels above 85 dBA and many were exposed to 8 hour TWA's >90 dBA. Indicating the severity of the noise environment in the area.

Residents were complaining of noise disturbances late at night inside their homes from clubs, in particular the deep bass, thumping sounds. Sound levels measured in the surrounding community substantiated these comments and demonstrated that the local Environmental Protection Commission (EPC) noise rule levels were exceeded outside and inside many homes, in yards and along the streets throughout the residential area. A proportion of the clubs identified as contributing to the excessive noise levels in the surrounding community had either partially enclosed structures, or outdoor patios where amplified music was playing.

B.2 Interior noise levels:

If people work in places with sound levels of 100 dBA, they should only be exposed to such noise levels for a maximum of 120 minutes, or else they can experience temporary or permanent threshold shifts in hearing. When people frequent night clubs playing amplified music, they also can experience temporary and permanent hearing impairment. It was suggested that the City could consider whether its citizens should be protected from this noise exposure by limiting sound levels inside clubs in addition to limiting noise propagating outside clubs to adjoining properties.

Methods to control the noise propagating from entertainment venues included reducing the maximum sound level limit in the noise ordinance, adding a C-weighted limit in addition to the A-weighted limit, moving the point of enforcement to the source property line rather than the center of the street, considering to remove the loudspeakers from windows or play them at lower levels, closing the windows and doors to reduce sound transmission out of the buildings, implementing multi-tiered audio system controls to reduce sound levels propagated inside the clubs and adding sound absorbent finishes inside clubs to reduce sound build up within the space. It was also suggested that noise issues be addressed during the design and planning phases of projects by having the city request an *Environmental Acoustic Assessment* be conducted prior to plans approval for new or renovated establishments in the area having either amplified music or noise-sensitive occupancies. Verification of the ability of new or renovated facilities to comply with noise ordinance provisions could be included as part of the Certificate of Occupancy process.

C. Case Study Three: Noise Monitoring at a Large Amphitheater

A 25,000 seat amphitheater was opened just outside the center of a large city near a major interstate highway. People from up to 4 miles away complained of excessive noise when events occurred at the amphitheater. Sound levels of amplified music were measured at an apartment complex approximately ½ mile away from the amphitheater as part of the noise study associated with the project. Observers at the apartment complex and an aural recording of amplified events

showed the music to be plainly audible with words and melodies as well as distinct bass notes heard at levels that were 10 dB or more above the ambient sound levels. Calibrated .wav files of the music events showed individual notes of music to be 80 dB and higher.

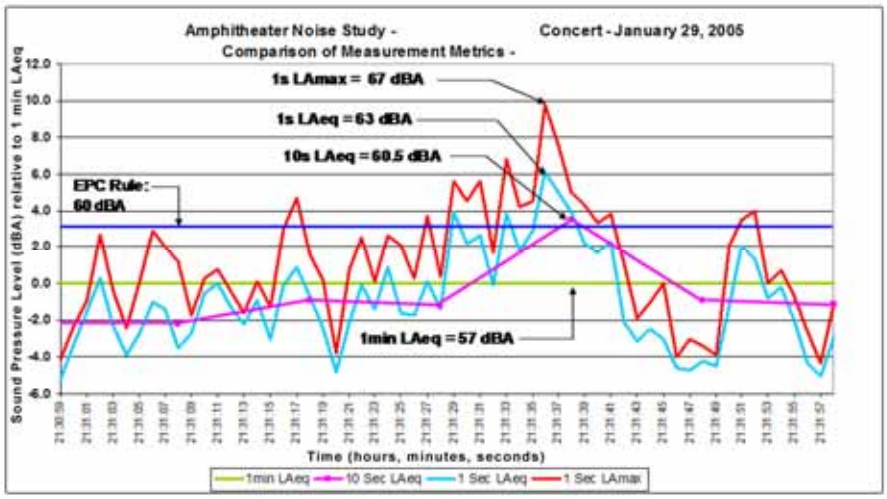

Figure 3: Graph comparing the various metrics of sound level measurements and their differing results.

When these events were averaged as Continuous Equivalent Sound Levels (Leq's) for 1 second they were measured at 63 dBA with an L_{MAX} of 67 dBA which represented a violation of the local noise rule. When the time was extended to 10 seconds, the Leq was 60.5 dBA. A 1 minute Leq was only 57 dBA when the ambient sound level was measured at 60 dBA and a 10 minute Leq was even less. The latter metrics would show no violations of the noise rule. A review of the data suggests that the use of averaging sound levels over extended periods of time such as Leq's might not be appropriate for some sound sources. The information content of the music occurs in very short time periods. The length of time for each musical note can be measured in milliseconds, not minutes. Therefore, an important element of a soundscape study becomes finding physiological and psychological bases for selecting measurement metrics to reflect what people hear and how they perceive the qualitative aspects of the soundscape.

D. Case Study Four: A Small City that was Experiencing Revitalized Growth due to Entertainment Establishments and some Residential Infill Projects

This case study involves the soundscape of a community controlled by localized areas of sound spill from individual hospitality establishments to specific residences.

Long term measurements were taken at multiple locations over a one month period. Short term measurements and aural recordings of specific acoustic events were taken at 18 locations every one or one and a half hours to map the local area as part of an analysis or 'soundwalk' of the acoustical issues on weekend and weekday nights to document the fluctuation of the soundscape of the community.

Figure 4: A plan showing the different acoustic zones of the entertainment districts, with 'M' and 'R' being the receiver locations, and 'E' being entertainment venues (source).

Sonic mapping and modeling was employed as a method of exploration and demonstration of sound paths from the source noise locations to the individual pockets of residences effected by sounds propagating from specific entertainment venues. These mappings were presented to the focus group sessions held with stakeholders to discuss acoustical issues relating to entertainment noise disturbances in the area, and the creation of a noise ordinance to maintain a delicate balance between the business, residents and city officials.

An interesting method was developed to analyze acoustical measurement data to use as a basis for setting overall A-weighted and octave band sound level limits for the noise ordinance which the city wanted to implement. Data were recorded over the period of a month at various locations around the city. The data were sorted into 3 groups: quiet ambient sounds which consisted of breezes blowing in the trees, insects, people talking, vehicles on roads in the distance, residential air-conditioning units at the property line, etc.; vehicular sounds and other louder sounds in the city; and sounds from entertainment venues. When the graphs for multiple recordings in each group were overlaid on each other clear separations could be identified between the quiet ambient and vehicular groups and the entertainment groups indicating that at many locations in the city the entertainment noise was 5-20 dB louder than the other sounds that constituted the soundscape. It was suggested that the points where the normal ambient sounds and vehicular sounds were separated from the entertainment sounds could be the vicinity of where sound level limits in the new ordinance could be established.

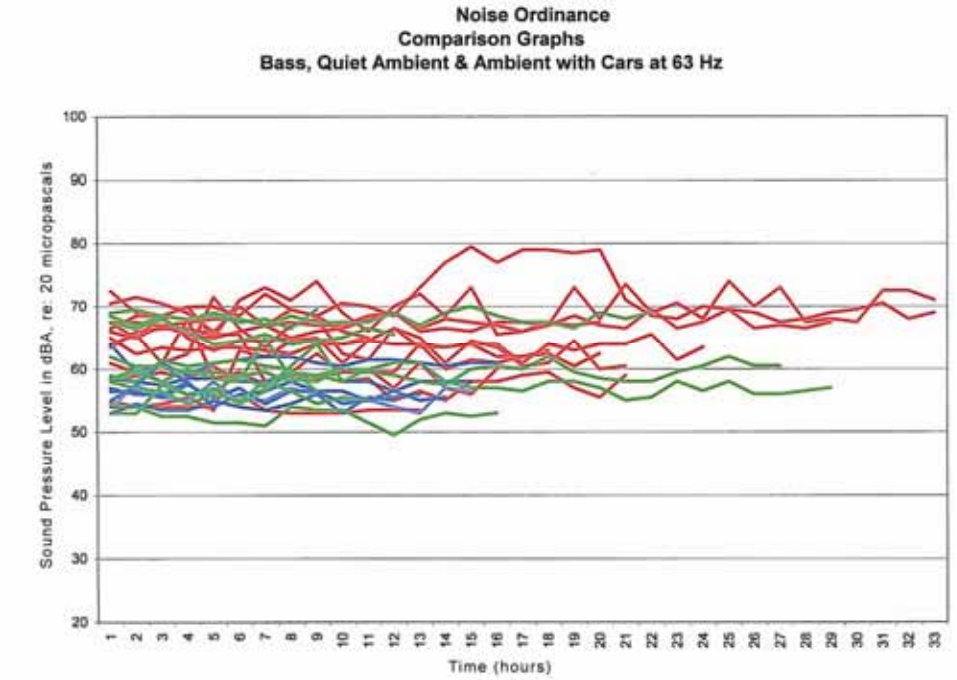

Figure 5: Graph showing noise ordinance comparisons between ambient sounds (blue), road traffic noise (green), and entertainment music noise (red) over time, at 63 Hz.

3. CONCLUSIONS

There are important questions that the regulation and mitigation of amplified entertainment noise in the soundscape of communities raise. The first is to develop acoustical metrics that adequately reflect the physiological, perceptual and psychological reactions of people to the sounds. Methods that actually capture the meaning, information and aesthetics of the music are perhaps required to adequately communicate the significant attributes of the music within the soundscape of a complex urban environment. Second is taking measurements with adequate detail, frequency and time information as well as sampling rates that subsequent analysis can be undertaken. Third is to view the soundscape of the city in its larger context and address the planning and zoning, building permitting process and post construction certificate of occupancy processes and link these 3 areas to the noise ordinance so venues are not planned, designed and constructed that can not effectively function as a vital part of the community soundscape within the confines of the noise rules of the community. The fourth is that any regulatory processes should seek to maintain the delicate ecological balance among all of the participants in the community soundscape so that vital, mixed-use, ecologically based, "green" communities can prosper.

6. REFERENCES

[1]R. Murray Schafer, "The Soundscape, Our Sonic Environment and the Tuning of the World" (Destiny Books, Rochester, NY 1977).

[2]Barry Truax, "Acoustic Communication" *(*Greenwood Publishing Group, CT 2001).

[3]Oliver Sacks, "Musicophilia: Tales of Music and the Brain" xi (Random House, Inc. Canada 2007).