There are sound recordings in this audio presentation that would be desirable to play back at calibrated levels.

To set up and calibrate playback equipment, click on the red speaker icon below, which will play a limited bandwidth of random noise.
An iPhone sound app, or $50 sound meter should be adequate to detect playback volume of about 75 dB.

Alternatively, the green speaker icon is a voice track of these instructions, which you can adjust to “indoor conversational levels”. (The amplitude of my voice may peak near 75 dB, but it will vary and thus is not intended for precise calibration but rather as a reference.)

You may click on the icons as often as needed.
Once the volume control has been set, maintain that level for the rest of the presentation.

Limited bandwidth
for 75 dBA.

Voice sample for
“Living Room
Preso”

Use “Arrow Keys” to
advance slides and audios.

Wise Associates

1409 E. Skyline Drive
Madison, WI 53705 USA
(608) 233-7683
stevewise@att.net

Steve Wise has been an independent noise control engineer since 1997, involved with projects internationally as well as locally, including dozens of sites in Madison. He has been a member of the ASHRAE Technical Committee on Noise and Vibration Control for 30+ years, including the last 15 years as editor of the Noise and Vibration Control chapters in the ASRHAE Handbook. The Handbook is distributed to the 50,000 HVAC member engineers in the Society.

A Madison resident since 1987, he worked for 10 years at Nelson Industries in Stoughton on various noise control product applications.

During 2009-2015 Wise Associates was involved in three different projects at Edgewood College on new and renovated buildings,. The College strove to adhere to a "no noise impact" goal for any new facilities, with respect to nearby residences. At the time, background ambient sound levels were established as low as 42 dBA, putting it among some of the quietest locales in Madison.

For each new potential noise source (fans/chillers/compressors/misc), an estimate of equipment sound power was analyzed with respect to the ambient sound levels and remedial designs were implemented as needed to keep the Monroe Street neighborhood quiet.

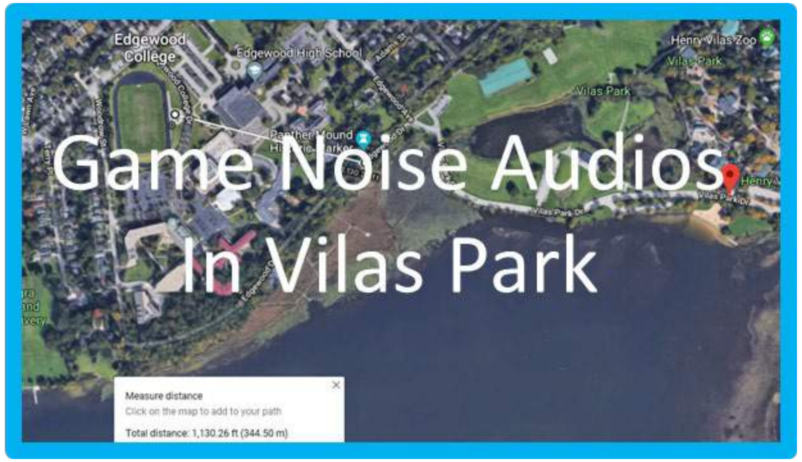
Against this history, there is concern now that the referenced project will create a significant disturbance in the neighborhood.

2019 Preso to Madison City Council

Assessment of Neighborhood Noise Impact

EDGEWOOD HIGH SCHOOL OF THE SACRED HEART

ATHLETIC STADIUM SEATING & CONCESSION STAND REDEVELOPMENT



World Health Organization
(WHO) Neighborhood

Average night noise level over a year Lnight, outside	Health effects observed in the population
Up to 30 dBA	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects a re observed. Lnight,outside of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
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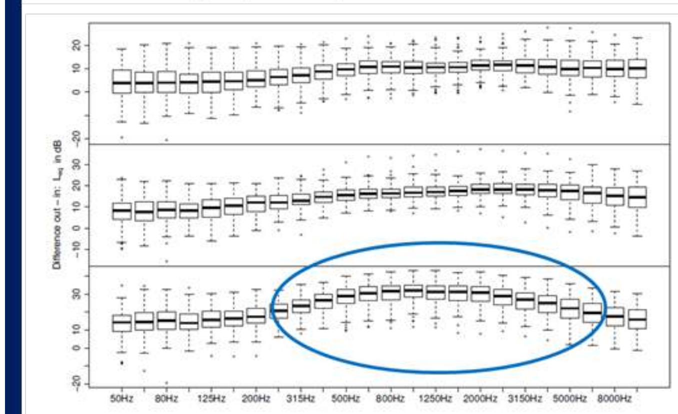
Outdoor vs Indoor
Windows Open vs Closed

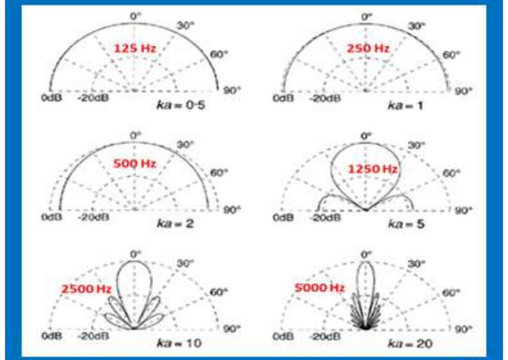

International Journal of Environmental Research and Public Health

MDPI

Article

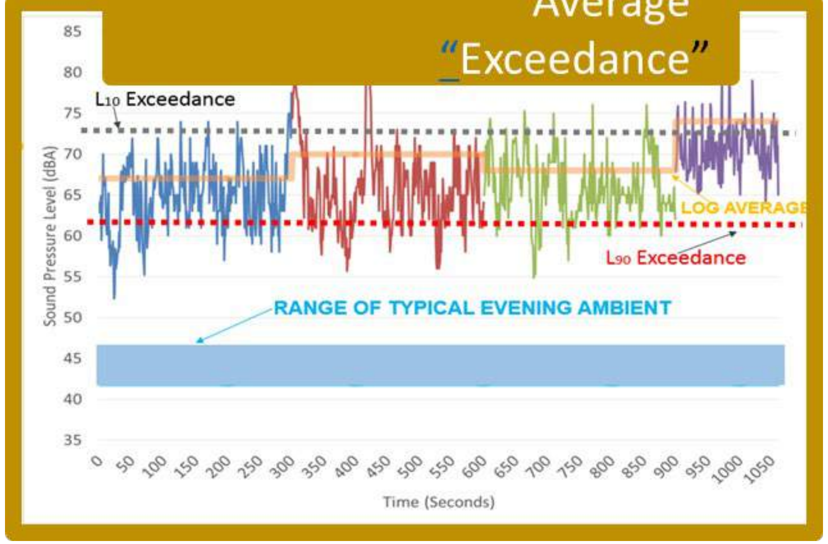
Differences between Outdoor and Indoor Sound Levels for Open, Tilted, and Closed Windows

Figure 5. Outdoor–indoor differences for the open (top), tilted (middle), and closed windows (bottom) for all valid measurements. Boxplots show the median (horizontal line in boxes), 25% and 75% quantiles (lower and upper boundaries of boxes), whiskers comprising the data within 1.5 times the interquartile range, and outliers outside the whiskers for each one-third octave band.

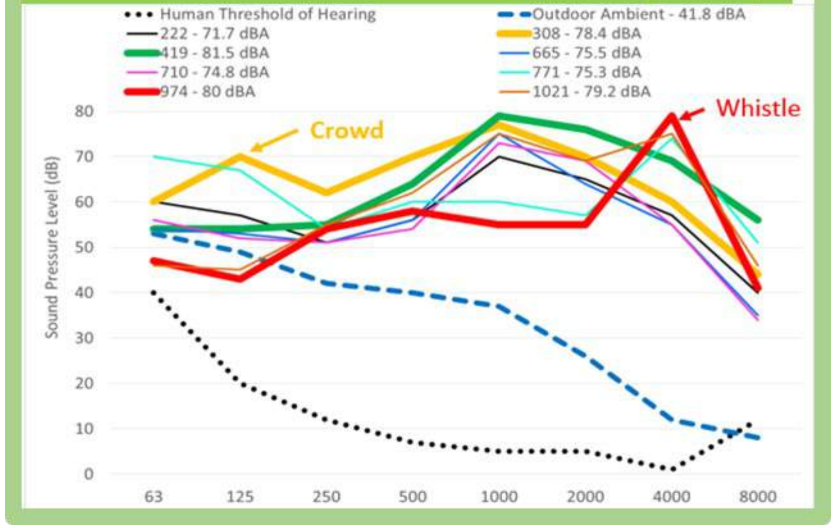


PA System
Directionality

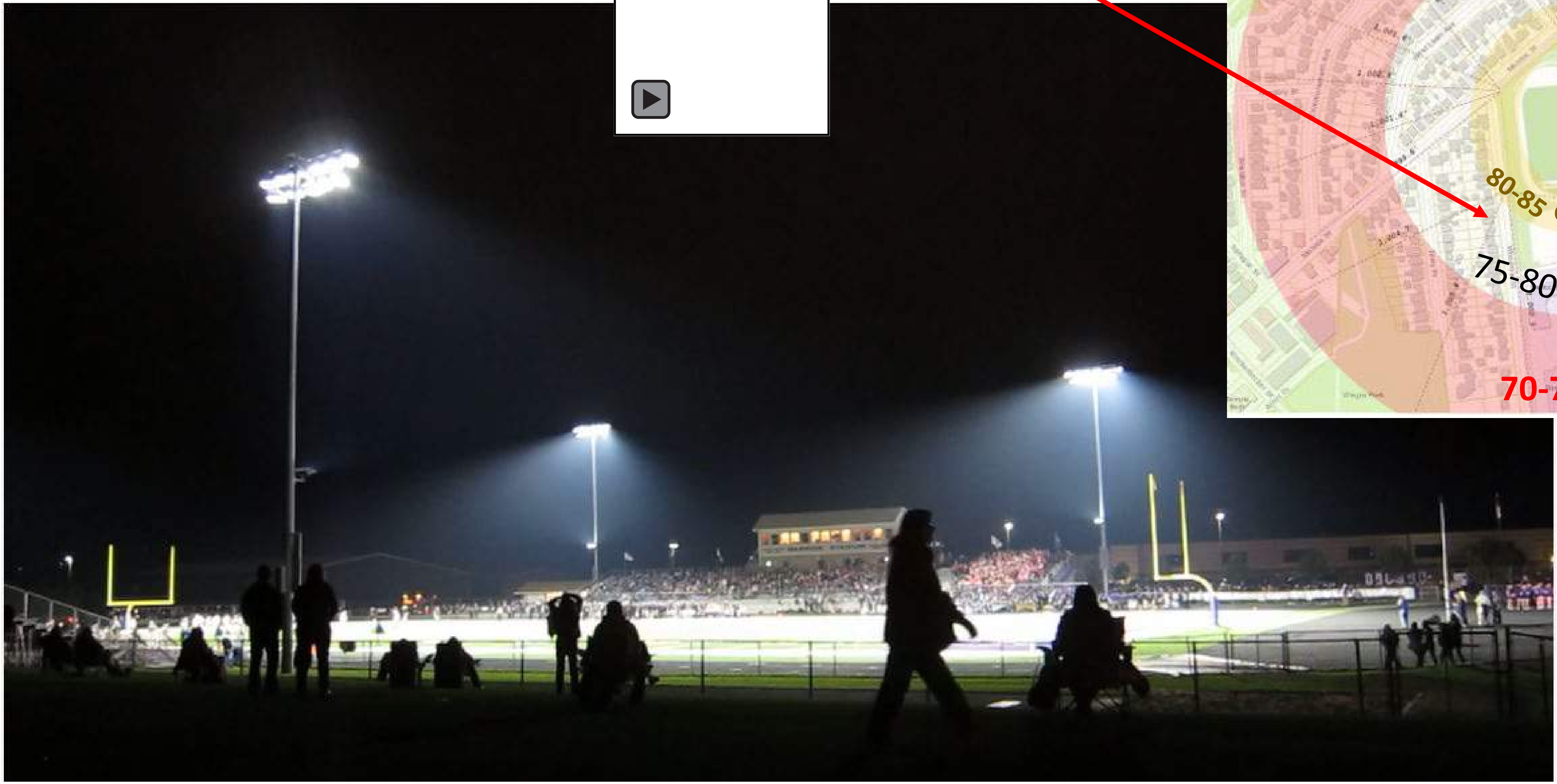
Definitions: dBA
"Average"
"Exceedance"

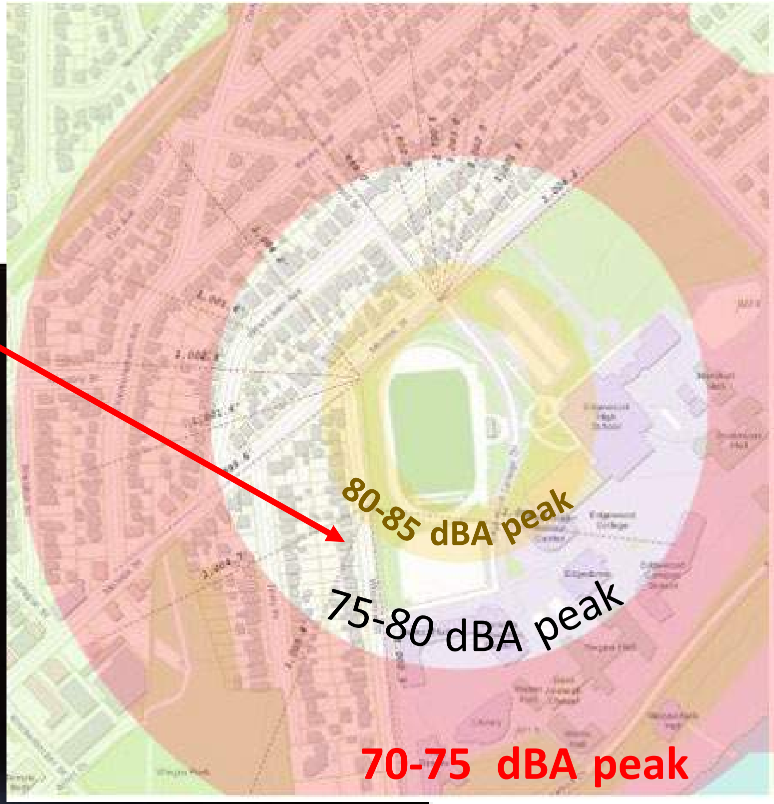


Sound Level Graphs vs Time
vs Frequency



Noise simulation
from this location





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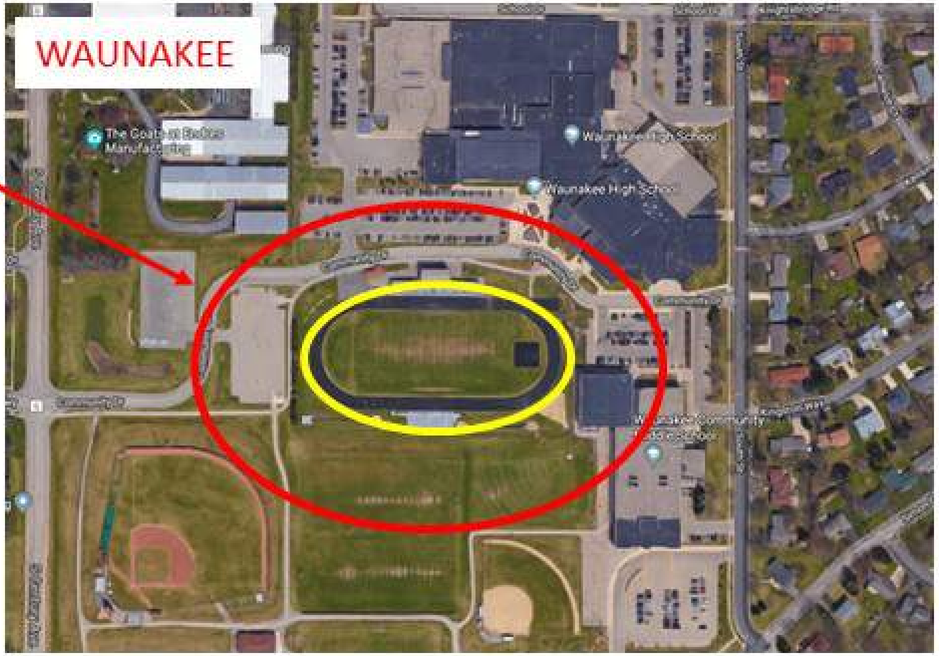
500 ft contours of **80+ dBA** peak noise level (at Edgewood and other nearby venues)

Few have homes in the vicinity.



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Assessment of Neighborhood Noise Impact

EDGEWOOD HIGH SCHOOL OF THE SACRED HEART

ATHLETIC STADIUM SEATING & CONCESSION STAND REDEVELOPMENT

Herein an attempt is made to quantify the noise impact from events in the redeveloped stadium. Sound measurements were taken during a football game at a comparable high school facility in Waunakee. Results and conclusions from those measurements are detailed in the following pages, along with snippets from other stadium noise studies.

Equipment used in the collection of sound readings was an HP 3569A Frequency Spectrum Analyzer and an ACO Pacific ANSI Type 1 microphone/pre-amp, with calibration certified by Scantek, Inc. Data was logged at one second intervals. Post analysis includes time plots, frequency spectra, and *exceedance* calculations.

***At a distance of 500 feet from the center of the grandstand, which is the radius of the closest homes along Woodrow Street and Monroe Street for the subject project, peak noise levels exceeded 80 dBA*, which can be startling as it is an increase of 40 dB above ambient.**

dBA is the standard unit of sound amplitude is the decibel (dB), a logarithmic measure of the physical magnitude of **overall air pressure variations**. This overall sound pressure reading is “A-weighted” to de-emphasize the lowest frequencies due to the fact that the human ear‘s sensitivity to sound amplitude is frequency-dependent; it is more sensitive to sounds in the mid-to-high-frequency range than to sounds with much lower frequencies.

Most real-world sounds (e.g., a dog barking, a car passing, etc.) are complex mixtures of many different frequency components each having different amplitudes. When the average amplitude of such sounds is measured with a sound level meter, it is common for the instrument to apply adjustment factors to each of the measured sound‘s frequency components. These factors account for the differences in perceived loudness of each of the sound‘s frequency components relative to those to which the human ear is most sensitive. Because the human ear is not equally sensitive to a given sound level at all frequencies, a special frequency-dependent rating scale has been devised to relate noise to human sensitivity. The A-weighted decibel scale (dBA) provides this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. The unit of A-weighted sound amplitude is also the decibel. In reporting measurements to which A-weighting has been applied, these are generally labeled dB(A) to make this clear.

It is useful to know the sound amplitude including low frequencies, by using **dBC** “C-weighting” rather than dBA-weighting factors. Then, sound can be evaluated with spectral graphs of linear sound pressure by frequency band, and so one can see graphically why various types of noise can have the same dBA level and yet sound different.. Since human hearing ranges typically from 20-20,000 Hz, it is convenient to group the frequencies in octave bands, where the bands are identified by the center frequency, which doubles for each successive band.

Since environmental sound levels can vary over time, it is often useful to know the degree of variability at a particular location over any measurement period. This variability is specified in terms of statistical sound levels (Ln), where n is the percentage of time these levels are exceeded during the measurement period. For example, L10 indicates a sound level that is exceeded 10 % of the time, and L90 is exceeded 90 percent of the time.

Aerial views of Edgewood Stadium, with nearby homes, and Waunakee High School Stadium where sound measurements and recordings were recently obtained.

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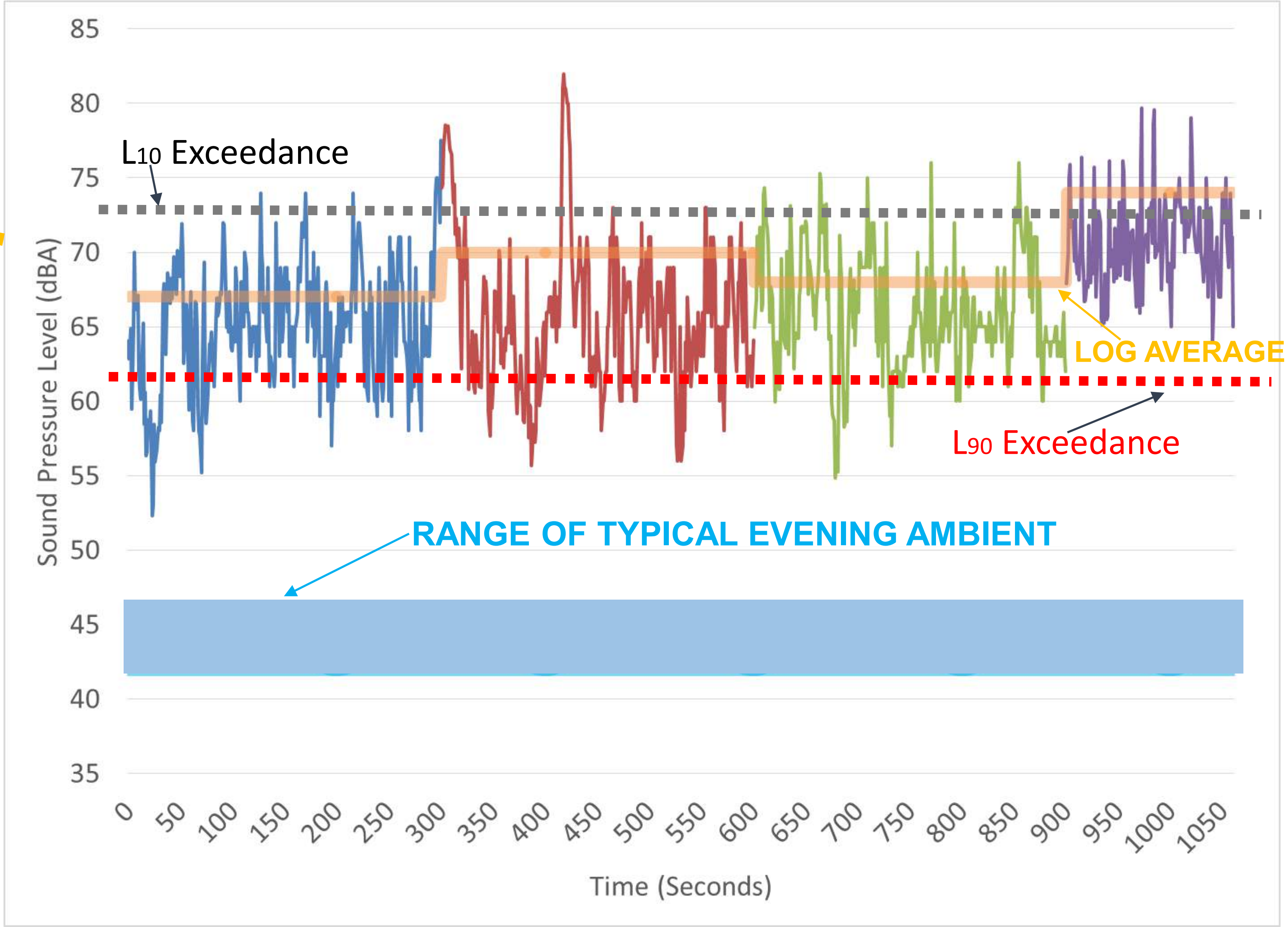

This plot of sound pressure level over time captures nearly 20 minutes of noise measured during nearby football games (Waunakee vs Baraboo - Oct 19).

These calibrated noise measurements were made about 500 feet **(X)** from the top of the main grandstand, at an angle away from and behind the face of the PA speakers, which are directional.

The prevailing ambient sound along Woodrow Street is indicated by the thick blue line at the bottom of the graph, which shows a range of 42-46 dBA. The game-time crowd, PA, and music yield peaks in the undulating plot line. Note how the time-averaged overall sound level is well above ambient, and yet that value does not reflect the full annoyance of the peak modulating noise.

For the data shown, the log-average for each segment (common for sound level time averages) ranges from 67-74 dB, the 10% exceedance (L_{10}) is 73 dB), and the 90 % exceedance (L_{90}) is 61 dB – all compared against the prevailing 42-46 dB ambient.

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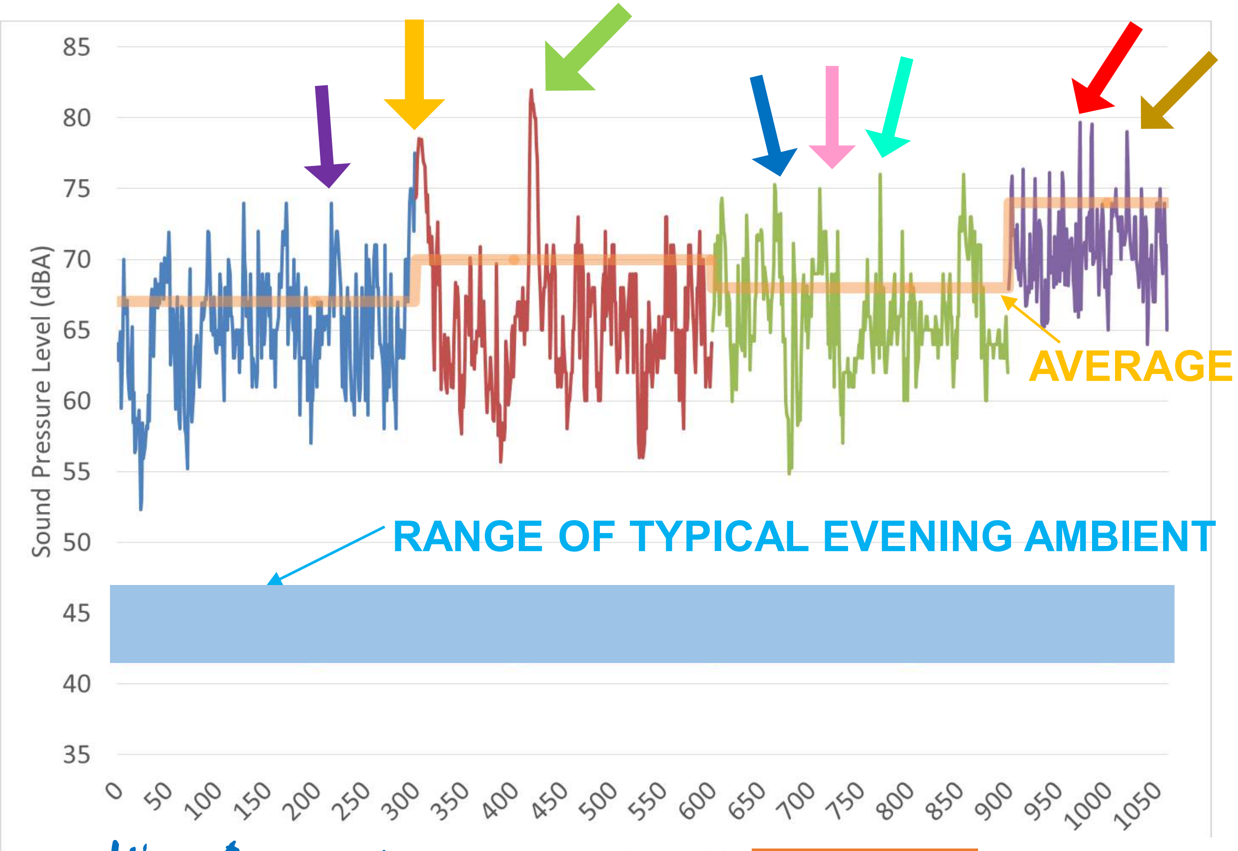
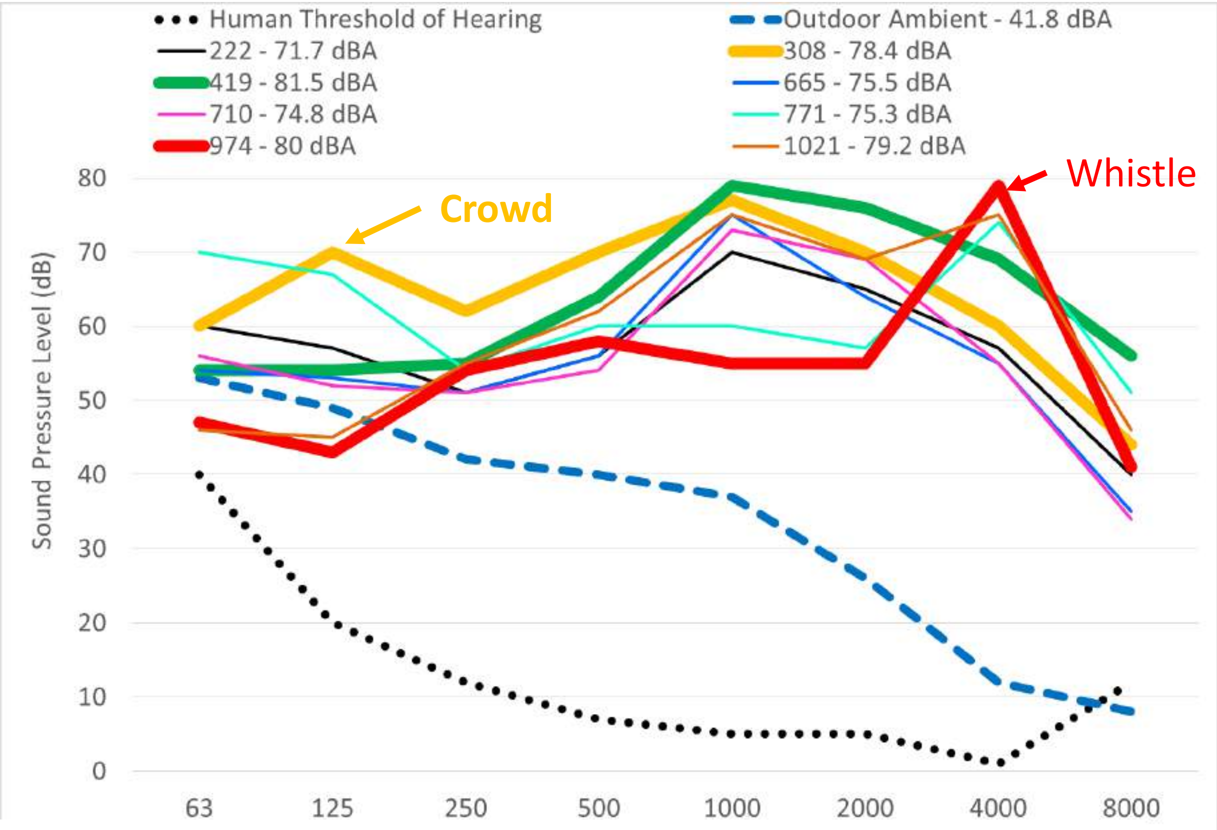
Below right are plots of sound pressure level by octave frequency bands which show the spectral characteristics of various noise events of the overall sound pressure level time record below.   Notice for the dotted-back "human threshold of hearing" curve that there is reduced sensitivity at low frequencies. This is the rationale behind the A-weighting of dBA measurements – the lower frequencies are filtered out of the overall level so as to reflect human response.

The dashed-blue "baseline" curve is the 42 dBA prevailing ambient along Woodrow Street. Notice how the lowest frequency components of football crowd noise are minimally above the ambient compared to the higher frequency components. The various spectral shapes are indicative of whistles (red), crowd noise (orange) and PA (green) among other sources.

There is no question that the impact of the peaks of noise will be substantial and clearly audible on the residential properties, compared to what is typical in the neighborhood.

Note that the attendance was ~350 people; 1000 people could result in peak levels 5 dBA louder just based on the logarithmic increase from a 3x crowd.   But crowd energy feeds on itself, people yell louder to hear there voice above those next to them, etc., and the overall increase can easily be +10 dB above these small crowd readings.





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Excerpts from ***NIGHT NOISE GUIDELINES FOR EUROPE***, The World Health Organization (WHO) indicate how they set "Acceptable" levels at 40 dBA at night, outdoors. (The most widely circulated study of when "annoyance" becomes a health effect has been widely studied.)
http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf

From the Abstract: "Considering the scientific evidence on the thresholds of night noise exposure indicated by Lnight,outside as defined in the Environmental Noise Directive (2002/49/EC), an Lnight, outside of 40 dB should be the target of the night noise guideline (NNG) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly."

Among other things, they list outdoor noise levels and the effects of chronic exposure, as in from Executive Summary, Table 3:

Average night noise level over a year Lnight, outside	Health effects observed in the population
Up to 30 dBA	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects a re observed. Lnight,outside of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
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Above 55 dBA	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

The 184 page WHO guideline goes on to explain the physiological effects of chronic exposure to excessive nighttime noise. For purposes of the Edgewood stadium redevelopment, using the measured noise levels and the limited outdoor-to-indoor typical noise reductions, it is clear that the peak noise will result in at least temporary disturbance from normal in-home evening activities. This could include sleep disturbance for both young and old inhabitants.

Excerpts from ***NIGHT NOISE GUIDELINES FOR EUROPE***, The World Health Organization (WHO) sets "Acceptable" levels at 40 dBA at night, outdoors.
http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf

Also useful in the analysis is this consensus about likelihood of open/closed windows and the typical difference of outdoor-to-indoor noise levels with windows closed (From page 11, Item 1.3.5):

"Passchier-Vermeer et al. (2002) carried out detailed noise measurements inside and outside the bedroom and at the same time measured window position with sensors. The results (Table 1.3) showed that windows are fully closed only in 25% of the nights. (Note: US/Madisson percentages maybe....)

Window position	% nights
Closed	25
Slightly open	43
Hand width	23
Half open	5
Fully open	4

This results in average inside/outside differences of around 21 dB, with there being only a slight difference between single- and double-glazed windows (Table 1.4). The survey did not include dwellings which had been specifically insulated against noise. Nevertheless, there was a large variation in insulation values.

	Single-glazed window	Double-glazed window"
Average difference at night	21.3 dB	22.2 dB

The World Health Organization (WHO) is perhaps the best source of current knowledge regarding health impacts of noise. According to WHO, sleep disturbance can occur when continuous indoor noise levels exceed 30 dBA or when intermittent interior noise levels reach 45 dBA, particularly if background noise is low. With a bedroom window slightly open (a reduction from outside to inside of 15 dB), the WHO criteria would suggest exterior continuous (ambient) nighttime noise levels should be 45 dBA or below, and short-term events should not generate noise in excess of 60 dBA. WHO also notes that maintaining noise levels within the recommended levels during the first part of the night is believed to be effective for the ability to fall asleep.

Other potential health effects of noise identified by WHO include decreased performance on complex cognitive tasks, such as reading, attention, problem solving, and memorization; physiological effects such as hypertension and heart disease (after many years of constant exposure, often by workers, to high noise levels); and hearing impairment (again, generally after long-term occupational exposure, although shorter term exposure to very high noise levels, for example, exposure several times a year to concert noise at 100 dBA). Noise can also disrupt speech intelligibility at relatively low levels; *for example, in a classroom setting, a noise level as low as 35 dBA can disrupt clear understanding.* Finally, noise can cause annoyance, and can trigger emotional reactions like anger, depression, and anxiety.

WHO reports that, during daytime hours, few people are seriously annoyed by activities with ***outdoor*** noise levels below 55 dBA, or moderately annoyed with noise levels below 50 dBA. According to WHO, an adverse effect of noise is defined as:… a change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences … [including] any temporary or long-term lowering of the physical, psychological or social functioning of humans or human organs.

This plot shows, for residential locations along Woodrow Street, how game-time noise levels compare to the historic levels compare to the historic noise levels and other common contributors of increased background noise.

Notice that all of the “natural/customary” sounds are below the 55 dBA WHO threshold.

As can be seen, the level and spectral quality of peak and even average game noise is a very significant disturbance to the environment.

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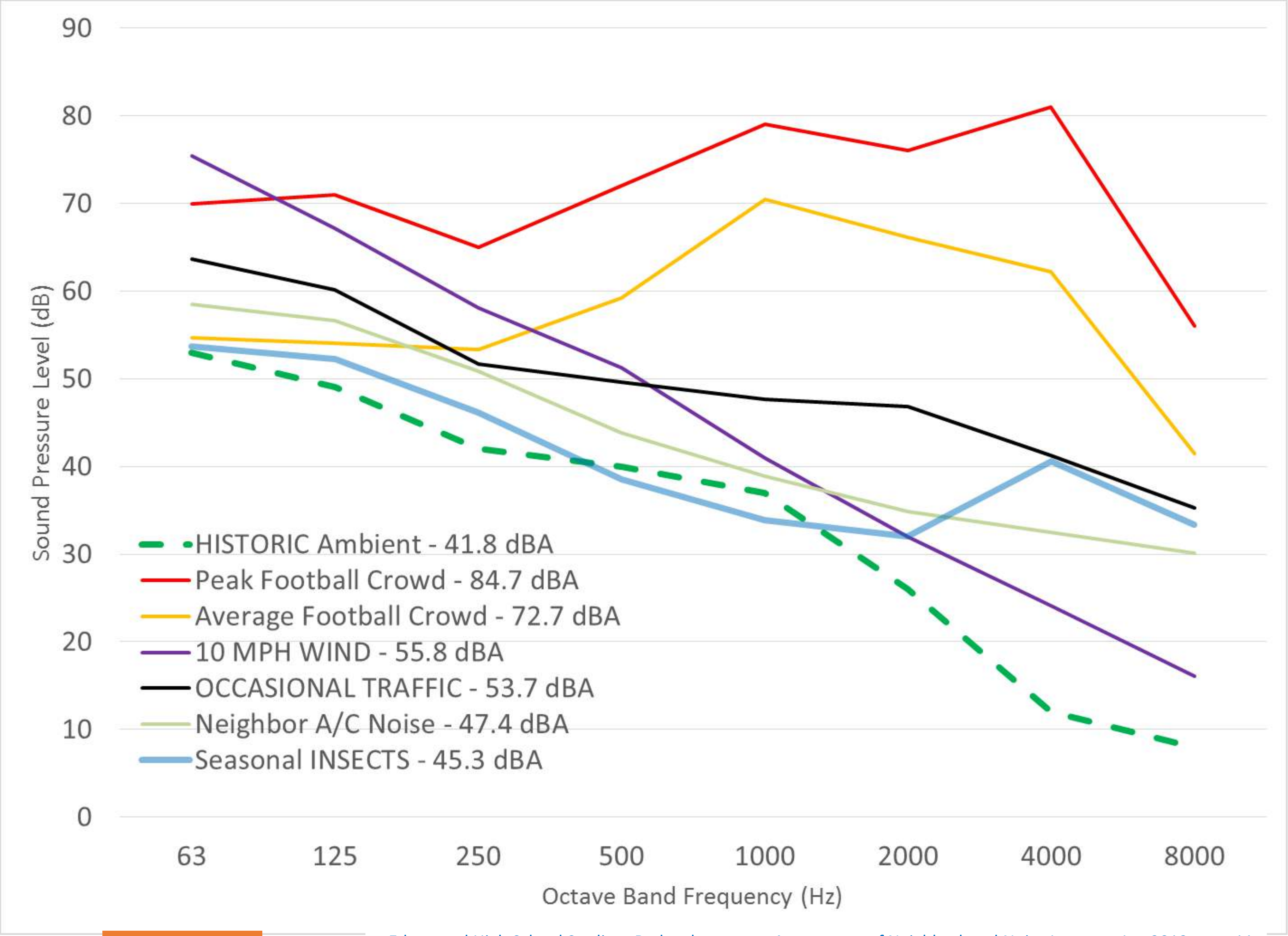

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The best way to understand the nature of the intrusive game time noise is to listen to examples.

Audio can be heard by clicking on the speaker icons below.

This first one can be used to adjust playback amplification to calibration level:

75 dB band-limited calibration

Recording of game noise – ***outside residences at a distance of 500 ft***. (max 80 dB)

Gametime noise from Ethan – OUTSIDE - 500 ft from stands

Recording of game noise – adjusted to reflect audibility ***inside residences***. (Max 58 dB).

(Effect of significant reduction of these mid-frequencies in Woodrow/Monroe area.)

Gametime noise as heard INSIDE

Another reference on the outdoor-to-indoor noise reduction, with and without windows closed, provided the spectral sound attenuation data on which to base an estimate of what stadium sounds outside would sound like inside:

International Journal of *Environmental Research and Public Health*

MDPI

Article

Differences between Outdoor and Indoor Sound Levels for Open, Tilted, and Closed Windows

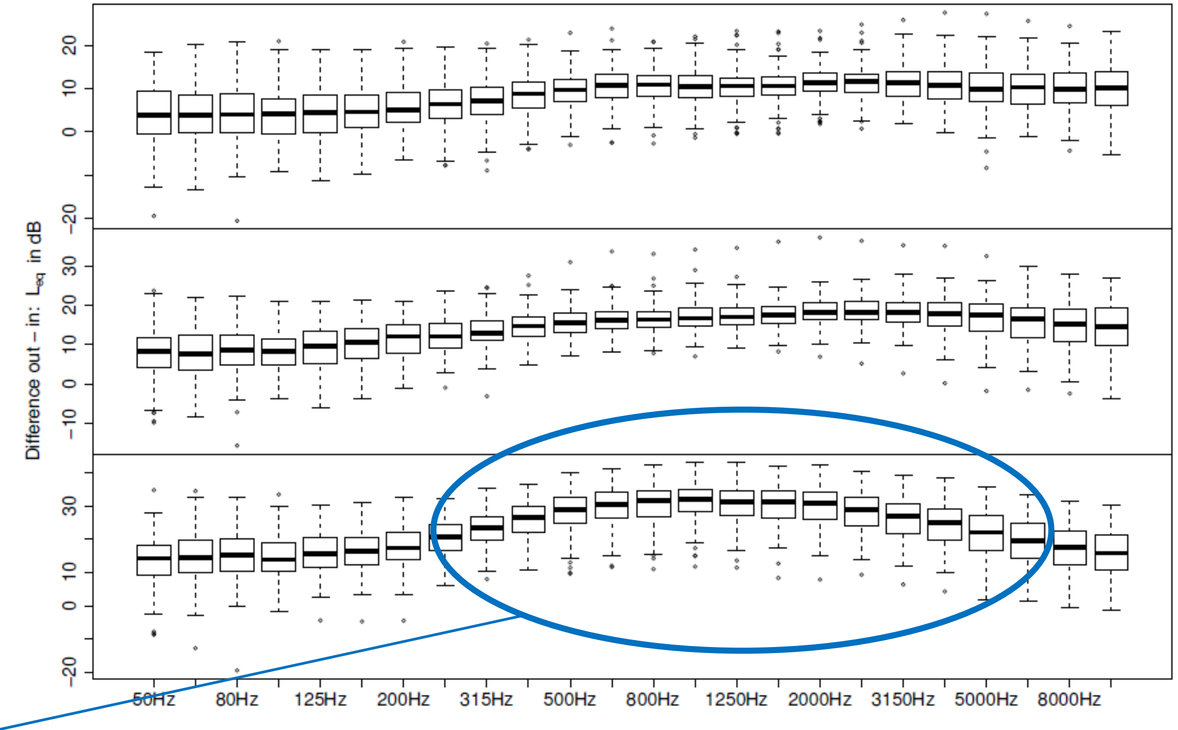

Figure 5. Outdoor–indoor differences for the open (top), tilted (middle), and closed windows (bottom) for all valid measurements. Boxplots show the median (horizontal line in boxes), 25% and 75% quantiles (lower and upper boundaries of boxes), whiskers comprising the data within 1.5 times the interquartile ra

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In this aerial from the football field to Vilas Park Beach, we have picked a reference distance from the stands to a grove of trees along Edgewood Drive.

Sound attenuates over distance, decreasing by about 6 dB for each doubling of distance, so at 1130 feet, the sound pressure will be about 7 dB lower than it is for the residential lots along Woodrow Street. The 80 dB peak levels of game noise at ~500 ft would still be >70 dB and the distance to Lake Wingra.

Atmospheric effects also reduce noise, though mostly at higher frequencies. For distances of 1000-3000 ft, and with peak game frequencies of 2000-4000 Hz, there could be 20 dB of further reduction at very high temperatures and low humidity, but considering a fall evening of 40 degrees and 80% humidity, the excess attenuation may be less than 10 dB, again only at higher frequencies and little at all at low frequencies.

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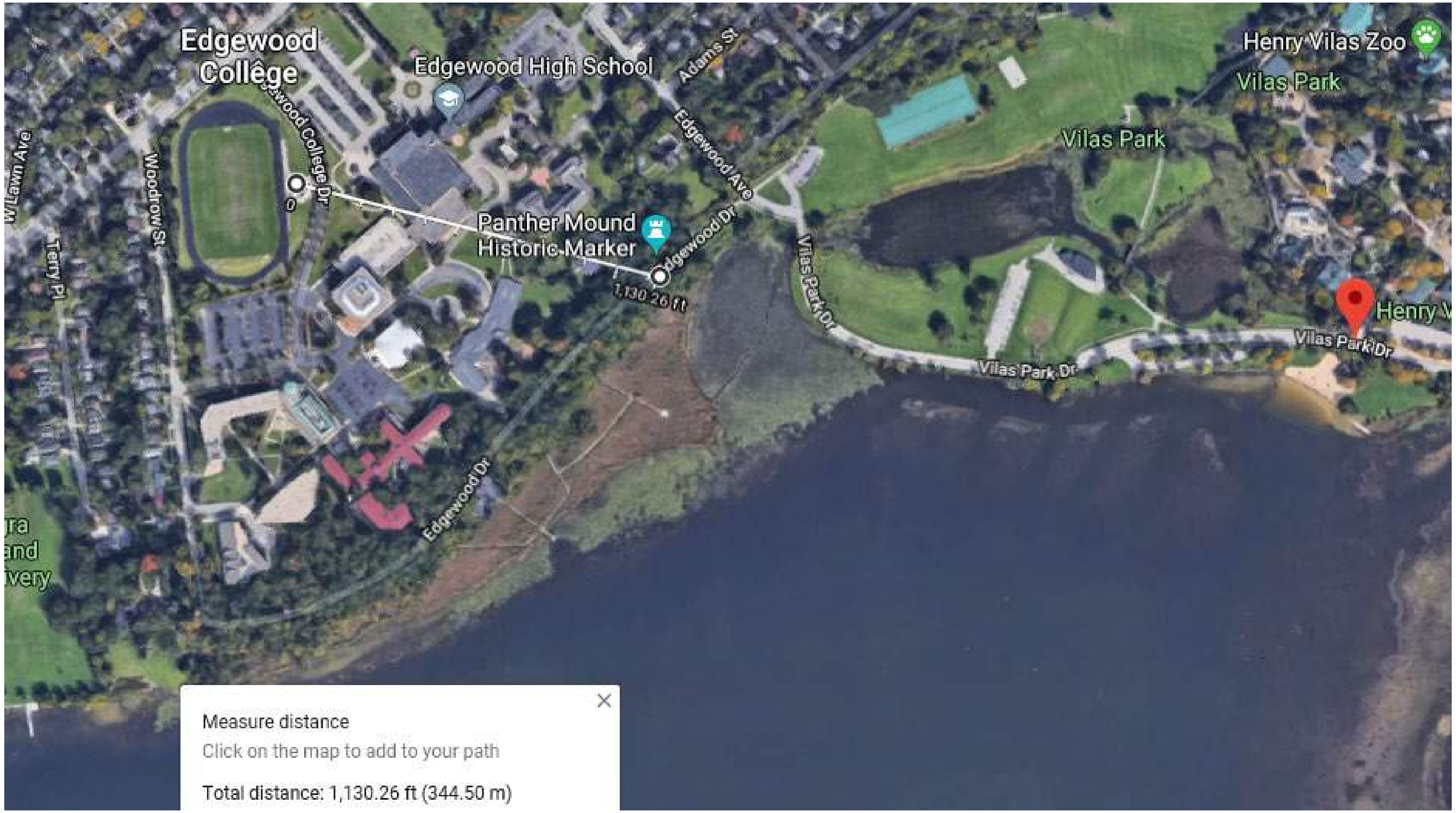


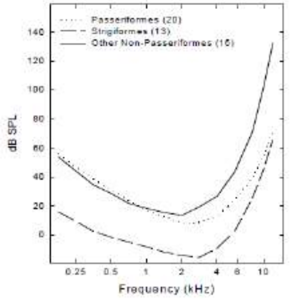
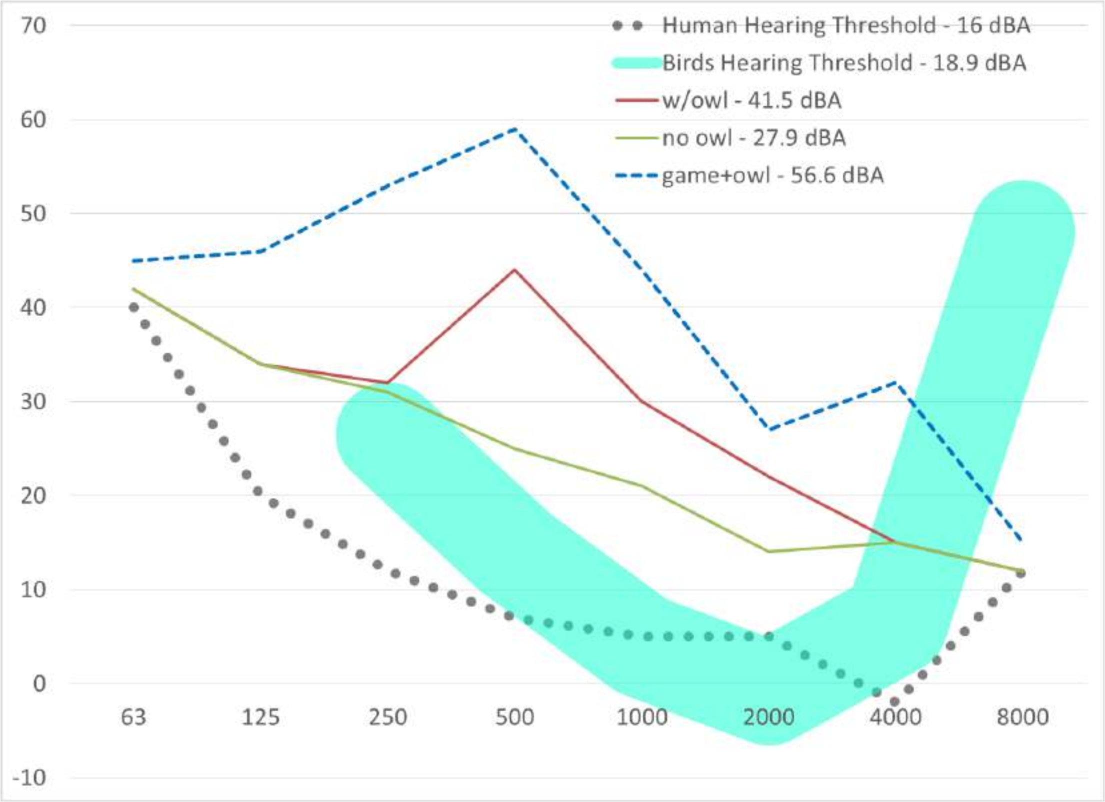


Figure 1. Median audiograms from all birds. See Appendix for references. Passeriformes = 20 species, Strigiformes = 13 species, Other Non-Passeriformes = 15 species.

At left is a plot of frequency vs. sound pressure level of the hearing threshold for birds, with 2 lines indicating the range for various species.

In the plot below, we show that as a thick green shaded curve, as well as the human hearing threshold, along with plots of the Woodrow Street baseline ambient and game time noises as they would register 1000-2000 ft toward the Vilas Park area.

In considering whether the level and characteristics of stadium noise may bother wildlife, we have prepared audios (to the right) that 1) give an indication of the audibility of owl calls in the presence of <40 dBA background noise, and 2) with the same sound mixed with stadium noise at the levels that might be heard in the park area.



Vilas Park evening ambient with owl

(Audibility of owl calls in the presence of <40 dBA background noise)

Vilas Park with owl during gametime

(Same sound as above mixed with stadium noise at the levels that *might* be heard in the park area.)

A NOTE ON "DIRECTIONAL" PA SPEAKERS

The audio recordings heard in this presentation from a game in Waunakee included some PA noise as well as crowd noise and whistles.

In fact, the microphone was located at a 45-degree angle, *behind the PA scoreboard*, and as such recorded much lower levels of PA noise than what was directed toward the spectator stands.

Those recordings thus simulate the potential benefits of the Edgewood PA design which would try to keep the speaker noise from radiated toward residences.

However, most of the high noise peaks from the data records shown on prior pages were from crowd and whistles, not PA; and there is a frequency-dependent limit on achievable directionality.
See from the polar graphs to the right that speakers can be made very directional at 5000 Hz, and to a large extent also at 1250 to 2500 Hz, but at 500 Hz and below, directionality is not well achieved. Bear in mind that voice frequencies typically range from 250-2000 Hz, and music tracks over the full range of 63-8000 Hz.

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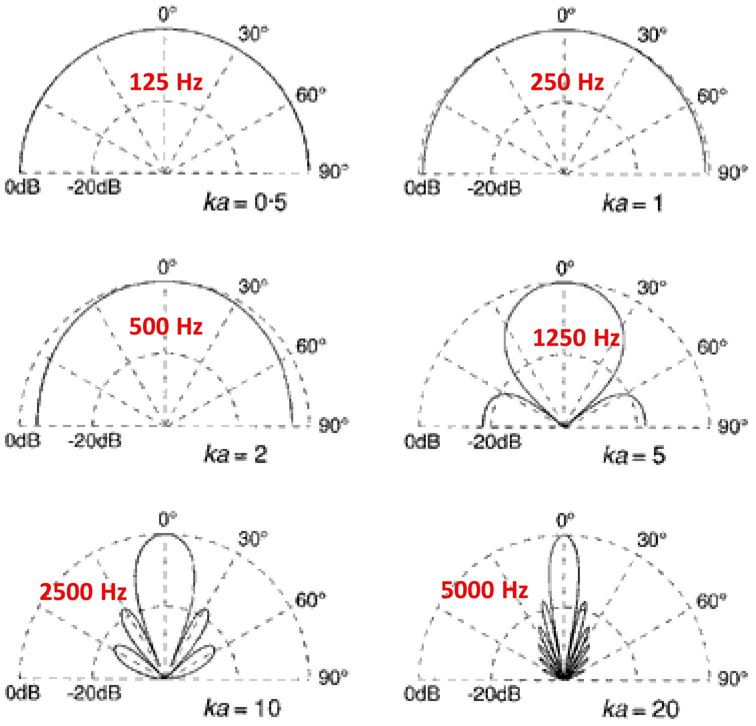
Start of Directional Speaker Pages

Polar plots
Off axis cancellation effects are often illustrated through polar response graphs which show the dB level at various angles from 0 to 90 degrees. In the diagram the dimensionless number *ka* refers to circumference* divided by wavelength. *circumference can be easily calculated as pi or 3.141 multiplied by the diameter.

For example a 15" piston has a circumference of around 4ft, so *ka* is around 250Hz. Above *ka* = 1 the piston starts to become directional. Relatively smooth off axis response is maintained to *ka* = 2 (500Hz for the 15" piston) but by *ka* = 5 (1250Hz for the 15") the piston is beaming with notable response lobing. A 15" single driver speaker would be a narrow directivity speaker whereas a 2" single driver speaker would be considered relatively wide directivity.



Community Annoyance With Sports Crowd Noise – A Case Study of the Facts in a Jury Decision, by Jack Evans, NOISE-CON 90

Northwest Woods Residents vs. The Optimist Club of Town and Country, et al., No 466,613, 167 Judicial District Court, Travis Co., Texas 1990.

Neighbor — Austin American-Statesman — April 11, 1991

Sports complex suit winds down

By Sharon Jayson
American-Statesman Staff

Optimists, neighbors near agreement that would end 4 years of litigation

An agreement to end almost four years of litigation over a 35-acre sports complex that neighbors blame for noise, vandalism and traffic problems is being drafted by lawyers.

The judgment should be final by the end of the month, said Russ Horton, attorney for Town and Country Optimist Club, which offers sports programs for 2,000 youngsters.

The legal battle began when residents of Northwest Woods subdivision sued owners of the 35-acre sports complex, charging negligence and nuisance.

"The jury found that the playing fields did constitute a nuisance to the neighbors, but under court definitions, the club was not negligent as to operation of the fields," said Mike Mullen, an Optimist Club attorney.

The jury verdict came in April 1990 in Travis County District Court before Judge Joe Dibrell. Since then, attorneys have been filing motions, and the plaintiffs last week decided to accept the Optimists' offer to end the case.

Although the agreement has not been signed, the parties have agreed that the Optimists will forgive more than $5,000 in court costs owed by the neighbors in exchange for the neighbors agreeing not to appeal the Travis County jury verdict, Mark Perlmutter, attorney for the plaintiffs, said Tuesday.

"We feel like we got a raw deal," said plaintiff Mary Barbera, who has lived in the neighborhood 15 years and spent the last four complaining about the sports complex.

"Everybody has put their life savings into this and put in thousands and thousands of dollars," Barbera said. "We don't have the money to appeal. It's strictly financial."

She said plaintiffs were divided over the settlement offer but accepted it for financial reasons.

Barbera and her husband Joe are among five couples who joined other neighbors as plaintiffs. They complained of noise, damage to property and traffic congestion created after the sports complex opened in

See Neighbors, Back page

Neighbors, Optimists near agreement on 4-year-old suit

Continued from Page 1

1986 at the end of Meadowheath Drive. Because the tract is outside of Austin city limits, there was no opportunity for neighborhood response to the project before it was built.

"Their only recourse was the reasonableness of the Optimist Club, or failing that, the court system," Perlmutter said. "Because of the case, the Optimist Club has changed things in the way they do business and has made some effort to reduce the noise. But it's still not very liveable out there."

Among the plaintiffs' requests was the installation of a 50-foot wide greenbelt between the back yards and the playing fields, construction of a wooden fence, and regulations regarding the hours of play.

Although the court imposed no such requirements, Town and Country Optimist Club President

Attorneys are drafting papers to end the litigation.

Jason Kartalis said his group continues to work for a peaceful coexistence.

"The Town and Country Optimist Club has continued to make improvements to address neighbor concerns," he said. "We've moved fields and lights, spending tens of thousands of dollars. We've planted over 50 trees along the property line to act as a buffer and have plans in place to add more trees throughout the complex."

The Sports Complex offers programs in baseball, basketball, football, soccer and softball and has several fields for those activities. The site includes a clubhouse with concession stand.

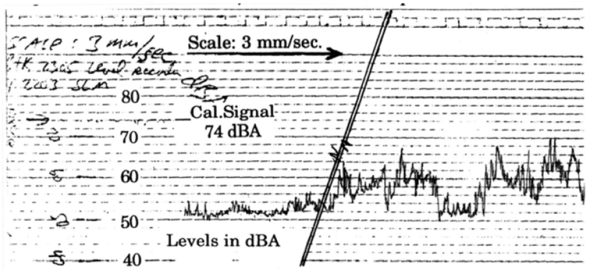


Chart Recording Excerpts: Levels and Variability of Noise

From The Austin American Statesman, "Neighbor: Northwest Austin," Thursday, April 11, 1991, pp. 1, 8.

Testimony Excerpts:

*The sound level was variable, intermittent, transient and tonal in nature and carried identifiable information content. Broadband noise approximately 10 dB over ambient becomes objectionable, but narrow band or tonal noise much closer or even below ambient is perceptible and can be annoying.

*Sound levels between 60 and 70 dBA were measured and exceeded the ambient levels of 38-45 dBA by more than 20 dBA.

*Speech interference and distraction may occur with ambient sound levels between 60 and 70 dBA, when speaker and listener are separated by 15-20 ft, and is common outside and even likely inside the homes.

*Continuous exposure to a varying and intermittent intrusive noise of 60 to 70 dBA, while not endangering health, can be annoying and cause stress.

*Use of music or other background sound to "mask" 60-70 dBA intrusive noise would not be effective, because the masking noise, at a similar level, would be unusual in the suburban environment, and therefore also annoying.

*The soccer field sidelines are with 15 ft of residential property lines. Measured sports activity sound levels on the residential properties already include distance losses from the fields to the yards.

*Assuming up to 5 dBA of noise reduction per doubling of distance between source and receiver, to achieve 20 dBA of distance loss attenuation would require relocation of the soccer fields of over 150 ft from existing locations.

*Interior levels in the houses might be 10-25 dBA lower than outside levels, using attenuation assumptions from HUD (US Housing and Urban Development) guidelines for wood frame construction with open and closed windows, respectively.

*Leq (time averaged) levels were determined inadequate to express the tonal and intermittent qualities of the crowd noise, even though they are good descriptors of actual noise exposures, for these reasons:

*The residents of the homes adjacent to the sports fields showed a sensitivity to the crowd noise that exceeds what would normally be predicted from Leq (time averaged) levels that had previously been correlated with broadband and relatively continuous community noise sources, such as traffic.

***The crowd voice noise, with nearly instantaneous increase and decrease in volume, also has an almost startling effect unlike the gradual rise and fall in volume of intermittent environmental sources such as aircraft flyover or vehicle traffic.**

CONCLUSION

Considering the facts presented, along with the anecdotal testimonies of residents relative to their continuing annoyance and inconvenience due to loss of privacy of their homes, the jury found for the Plaintiffs, thereby extending the case law definition of nuisance to cover extended exposure of annoying intermittent and transient

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