Case Study: Keeping the Sound at a Certain Area

A Tale of Quietness

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While the primary focus of a sound system is to evenly distribute sound, there are instances where sound spills to the surrounding area of coverage and becomes a concern. In this project, we collaborated with JD Sound and Video to design and verify the sound system for a high school football field. Please be aware that the article will mention several product brands. As independent consultants, we are not affiliated with any organization. The product selections and software we use are simply tools to help us achieve our objectives. Due to previous noise complaints, we will not disclose the exact name or location of the project. This article offers insight into our thought process from start to finish, viewed from the perspective of an acoustic and electro-acoustic consultant. Although it is intended for educational and informational purposes, the article does not delve deeply into any specific audio topic.

The Level Limitation and Initial Design Thought

The local noise code prohibits any individual from causing, allowing, or permitting sounds from industrial, commercial, public service, or community service facilities that exceed 65 dB(A) when measured at the property line of any affected residential area. This regulation is enforced from 7 AM to 10 PM. Due to the variation in microphone system calibration, as a consultant, it is safer to assume that the limit is 3 dB lower, at 62 dB(A), with a slow response. Let us observe the area from Google Earth.

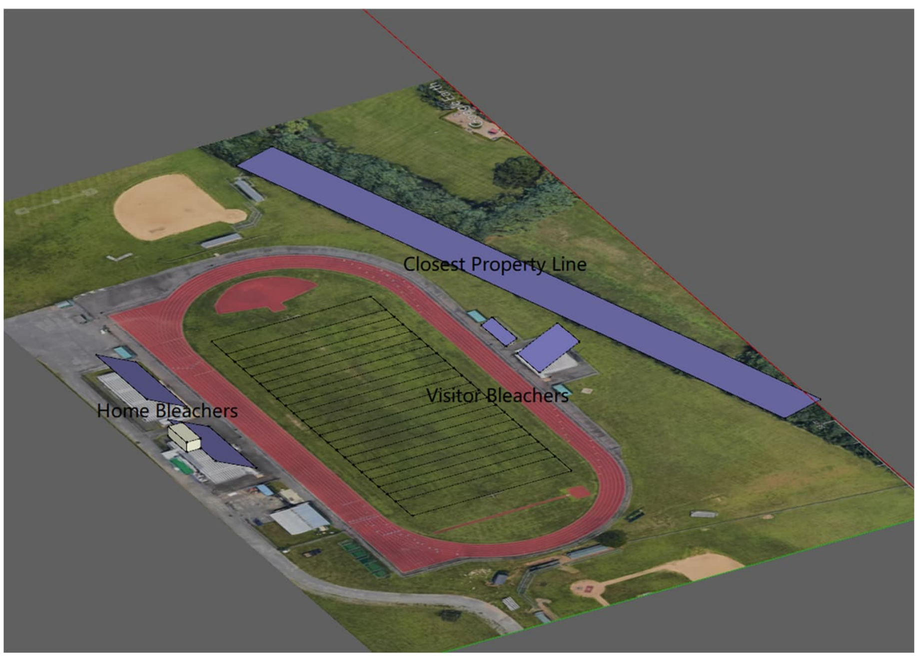

Figure 1 - the aerial bird's eye view of the location

The closest residential property line of the complainant is practically behind the visitor bleachers. This is undoubtedly bad news for the visitor bleachers, as they can only enjoy a maximum sound level of 62 dB(A). The low SPL target level for the sound system design is impractical, as the background noise from the audience is likely to exceed 70 dB(A). In the initial design, we did not suggest adding any loudspeakers anywhere near the visitor bleachers.

Moving on to the home bleachers. To figure out the limit of the loudspeaker's output, a simple direct sound pressure level (SPL) calculation is performed. Initially, we suggested the loudspeaker's location, as indicated by the green circle in Figure 2 below.

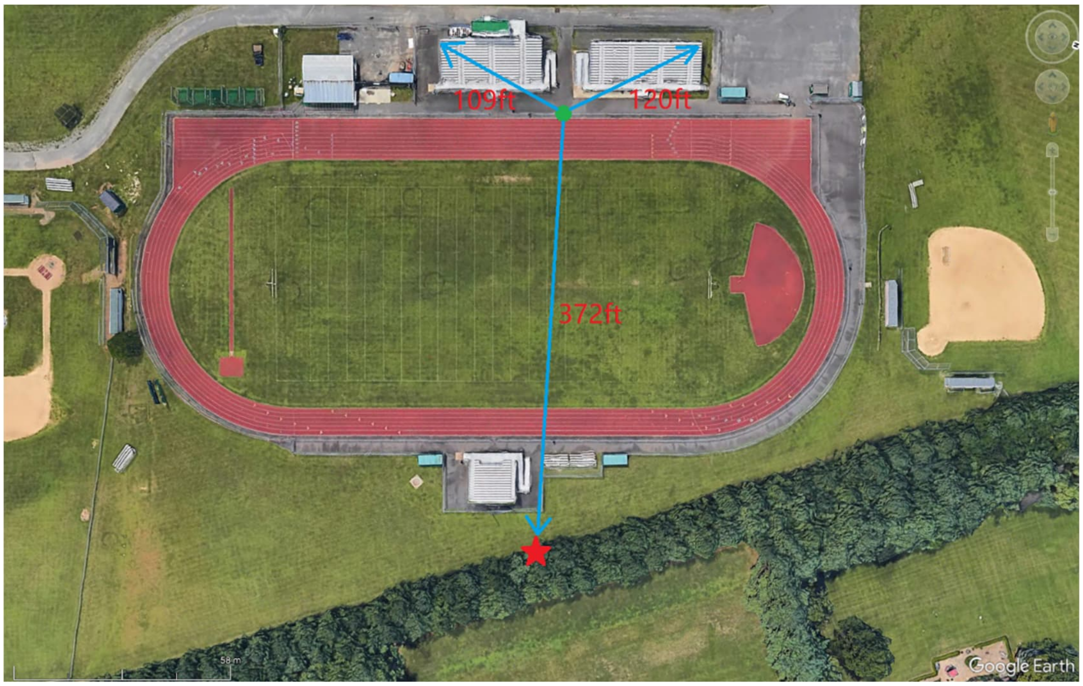

Figure 2 - Loudspeaker location and its throw distance

Two loudspeakers were initially suggested to be located at a pole where the throw distance to the farthest audience is about 109 ft and 120 ft. The back of the loudspeaker will face the problematic property line around 372 feet away. Assuming this is a loudspeaker that spreads sound evenly at all frequencies to all directions, let's calculate the SPL difference between the property line and the farthest reach using the simple inverse square law calculation.

$$SPL\ difference\ 1 = 20\log_{10}\left[\frac{372}{109}\right] = 10\ dB$$

$$SPL\ difference\ 2 = 20\log_{10}\left[\frac{372}{120}\right] = 9\ dB$$

Each result in the above equations is rounded down to the nearest integer. The worst-case scenario will be a 9 dB difference between the home bleachers and the property line. In other words, to reach 62 dB(A) at the property line, the farthest audience from the loudspeaker should not exceed 62 + 9 dB = 71 dB(A). An outdoor sound system that provides a low level of 70 dB(A) to the audience is barely functional because the background noise may reach above 70 dB(A). Once again, this is based on the assumption that the loudspeaker spreads sound equally everywhere. In reality, the loudspeaker will focus sound to its front. The rear radiation will be less, and we may have a chance of getting a low 80 dB (A) at the home bleacher's audience area. For this project, we specified Fulcrum sub-cardioid loudspeakers, the CCX series. It's a unique passive loudspeaker that can be installed outdoors with reduced back radiation. Using AFMG EASE 4.4 software, we can see the total direct SPL A-weighted coverage in the following figure.

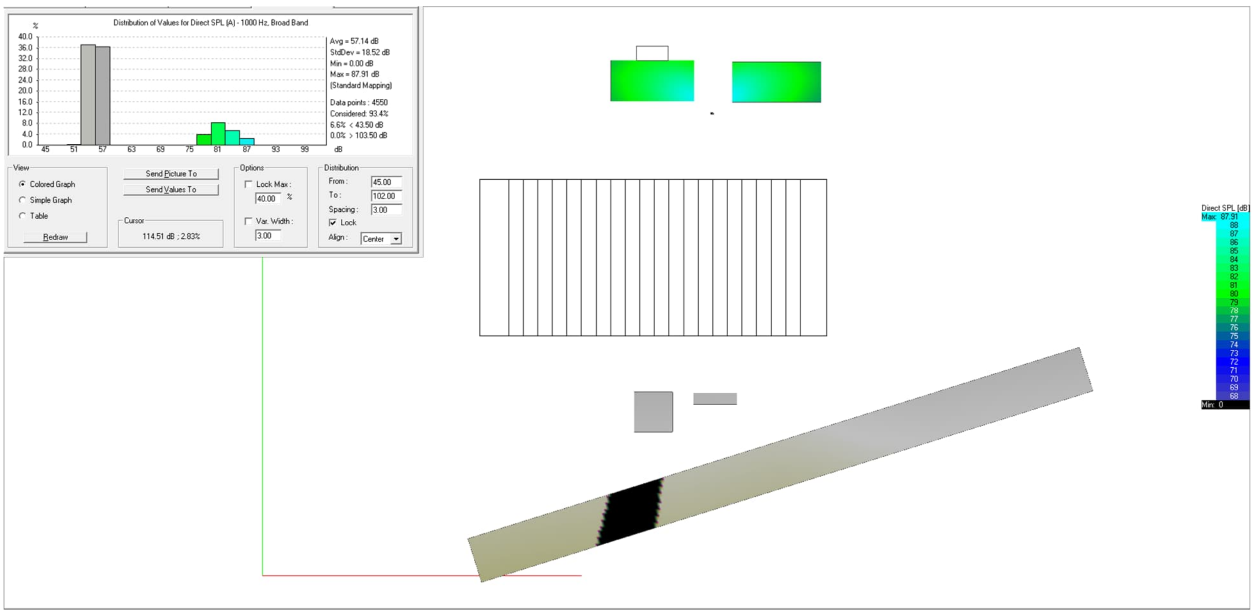

Figure 3 - Initial rendering for Fulcrum CCX series

Two CCX12 were used as if they were installed in the pole at the location denoted by Figure 2's green circle. One loudspeaker is facing toward the left-hand side, and the other toward the right-hand side of the home bleachers. Now, let's see the distribution graph in Figure 3. The grey color represents the property line, which is primarily 54-57 dB(A). In comparison, the farthest back corner of the home bleachers exhibits a darker green, which corresponds to 78 dB (A). That's a 21 dB difference! Setting 62 dB(A) as the maximum permissible level at the property line can result in a maximum of 83 dB(A) at the farthest corner of the home bleachers. A sound system with an output of 80 dB (A) can be acceptable for an outdoor sound system. Is this computer prediction too good to be true?

The Installed System

After several months had passed, we were informed that the system was ready for optimization. The output of the sound system must be appropriately set according to the noise code. The installed system differs from the initial plan due to the different pole locations.

Figure 4 - Newly installed loudspeaker locations

Figure 4 shows two green circles, indicating the locations of the loudspeakers. For each pole, there are two loudspeakers (a total of four Fulcrum CCX loudspeakers). This is undoubtedly a more powerful system than initially planned. However, the distance ratio of the farthest reach vs. the property line isn't very different, so our initial prediction may still have validity for this layout. The loudspeakers were connected so that the top loudspeakers, providing the farthest throw, are connected in parallel to one amplifier channel, and the bottom loudspeakers, providing the shorter throw, are connected in parallel to another amplifier channel. Please also note that the pole where the loudspeakers were installed to cover the left-hand home bleacher (marked as location B) in Figure 4 is farther away than the pole that covers the right-hand side (marked as location C). Hence, we can expect slightly less SPL on the left home bleacher in Figure 4.

Since this article focuses on the noise spill, we will not cover the loudspeaker optimization part. After equalization, delay, and relative gain were determined, a noise survey was conducted by playing a low-crest-factor pink noise and measuring it at three locations.

Referring to Figure 4, location A is behind the visitor bleachers, near the property line. Location B is in the middle of the left-hand side of the home bleachers. Location C is in the middle of the right-hand side of the home bleachers. The weather was sunny and clear with a very low wind speed. Using our in situ-calibrated NTI XL2 system, accurate SPL measurements were easily achieved.

Here is a little snip from the NTI's noise explorer software at location C, middle of the right-hand home bleachers, from Figure 4.

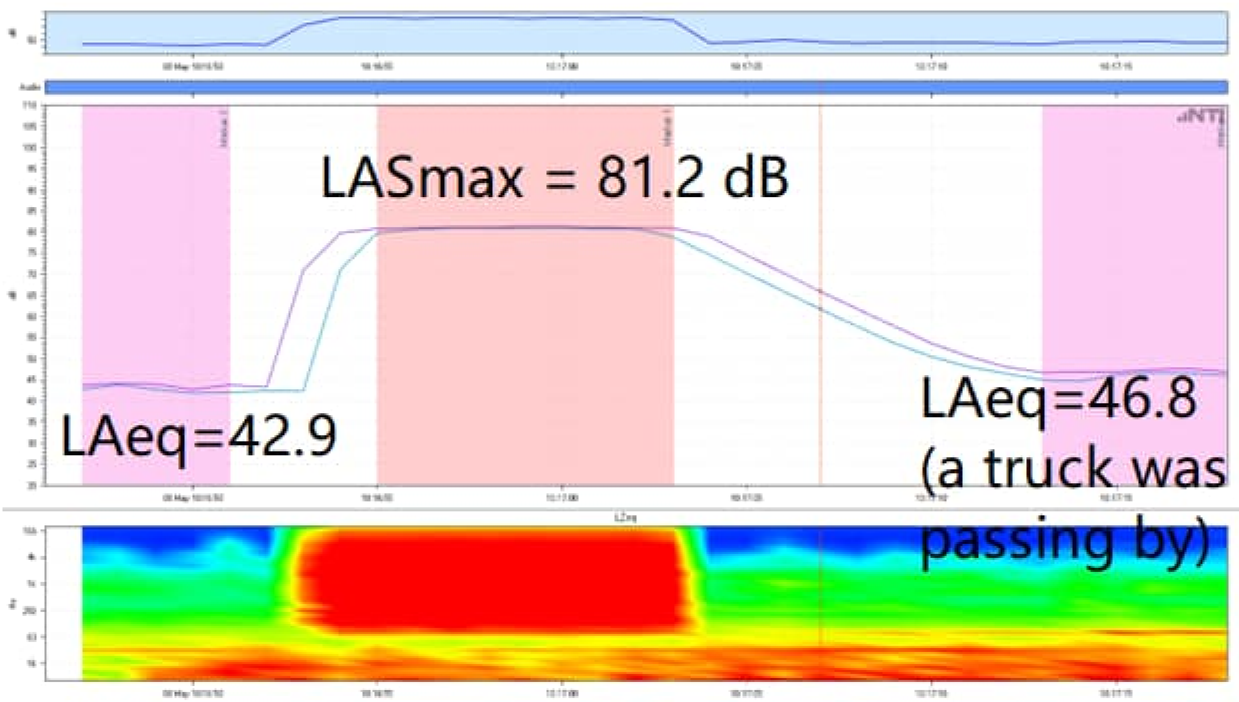

Figure 5 - Location C measurement

Figure 5 shows the measurement at Location C, a couple of seconds before the noise was turned on, with the noise turned on, and a couple of seconds after the noise was turned off. At location C, the background noise level is 42.9 dB(A), with a slow response time before the noise was turned on. As a note, the background noise measured after the noise was turned off was not accurate due to the presence of a passing truck. During the noise playback, the maximum sound pressure level was measured at 81.2 dB(A), with a slow response.

The noise level at Location B was recorded at 76.5 dB(A) with a slow response. A difference of approximately 4 dB is anticipated, attributed to the varying distances of the poles where the loudspeakers were mounted on the home bleachers.

And now, the location A. The background noise level was 42.6 dB(A), slow response. With the noise, the measurement reached a maximum of 55.0 dB(A) with a slow response. Figure 6 summarizes the measurement result.

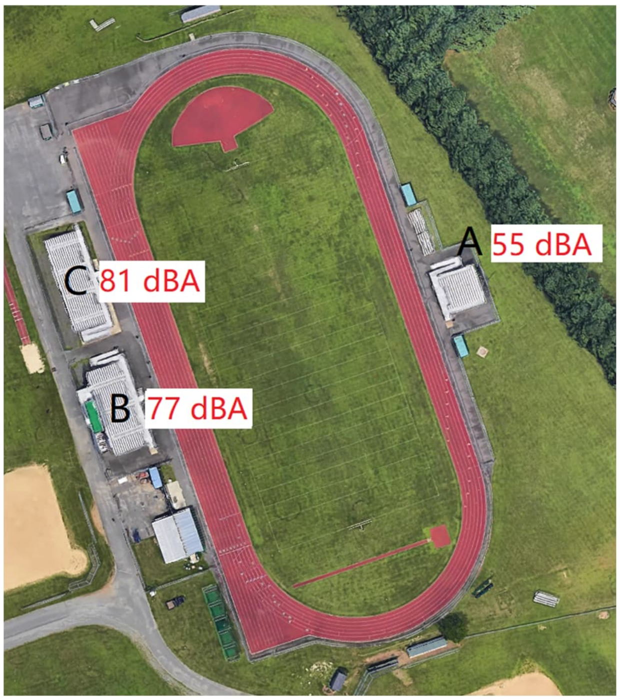

Figure 6 - Maximum level with pink noise turned on, A-weighted and slow response, at three locations

Noting this, a playback level of 77 dB(A) at location B will result in 55 dB(A) at the back of the visitor bleachers. A difference of 22 dB! Remember that the initial prediction was 21 dB using EASE software.

This is good news, as the loudspeaker can theoretically be increased by up to 7 dB more until location A reaches 62 dB(A), yielding approximately 84 dB(A) in location B and 88 dB(A) in location C. However, we want to keep at least 6 dB safety headroom for any signal overshoot, so it is best to keep the output level as is. Fulcrum CCX loudspeakers feature a unique passive sub-cardioid dispersion. It has been proven to be very functional for this project. We’re impressed by the loudspeaker's performance in delivering sub-cardioid dispersion passively.

Noise oh Noise …

Certainly, this is not our first noise-sensitive project. Throughout the years, we have helped several clients with noise control, soundproofing, and/or limiting sound systems to comply with local noise codes. On one occasion, we were called to conduct a noise survey for a resident who couldn't stand the sound of the local football field's sound system. The measurement results suggest that the sound system noise did not even raise the background noise level. Although the noise spill wasn't much, the complainant enjoyed opening windows, and the noise created an annoyance. On another occasion, we were called to survey an outdoor entertainment system that spills noise not to the adjacent building, but to a neighborhood over 1,000 ft away across a river. It was a very nice sound system design, albeit with little consideration for the surroundings.

Basements were many people's favorite places to build a home recording studio. We agree, but it still depends on the specifics. One of our past projects was a basement studio in a major city, located not far from the city's subway. While the building has thick foundations, the sound and vibration can still be heard from the basement.

Noise is indeed a significant factor to consider. In the acoustic world, thorough planning is essential to ensure a successful business. Many disregard this and think that panels, draperies, or minor patches can be added to mitigate or reduce noise problems. Unfortunately, most noise spill reduction efforts involve structural renovations, which can be costly if not planned properly from the beginning.

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