Sound Planning Associates, Inc.
923 W. Liberty Drive, Wheaton, IL 60187

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Wednesday, June 07, 2017

Ronald Kasbohm, Director of Technology and Business Services
Township High School District 113
1040 Park Ave W, Highland Park, IL 60035

RE: Wolters Field Sound System / Acoustic Study

Dear Ronald,

This document was prepared to clarify the recent acoustic measurements and acoustic model predictions. The sound system was tested on March 16th, 2017. These tests verified that the level of spill shown in an acoustic model of the existing loudspeaker system was accurate.

Several loudspeaker types and arrangements were tested in the acoustic model. The best option to consider as the replacement for the current system was utilized highly directional line-array loudspeakers in a westward orientation. The final test added a barrier wall between the visitors' bleachers and neighbors' properties.

The following two scenarios were tested for reducing sound spilling into the neighbors' properties:

1. New Loudspeaker System with West Facing Orientation
2. New Loudspeaker System with West Facing Orientation and a Barrier Wall

Acoustic factors from a barrier wall is not something the acoustic model can accurately test. This is due to sound diffraction and acoustic behaviors of the ground reflections that are not part of the software. The best testing that we have found are from the USDoT (United States Dept. of Transportation) Federal Highway Study. We have included excerpts from the USDOT acoustic study on barriers used for traffic noise. These tests conclude that the walls can only attenuate certain frequencies and are not the panacea for eliminating sound spillage.

If our study and the USDOT information shows anything, it's that a combination of an extremely large barrier wall plus a new loudspeaker system *would be the only way to achieve attenuation of 6-10dB SPL at the neighbors*.

Sincerely,

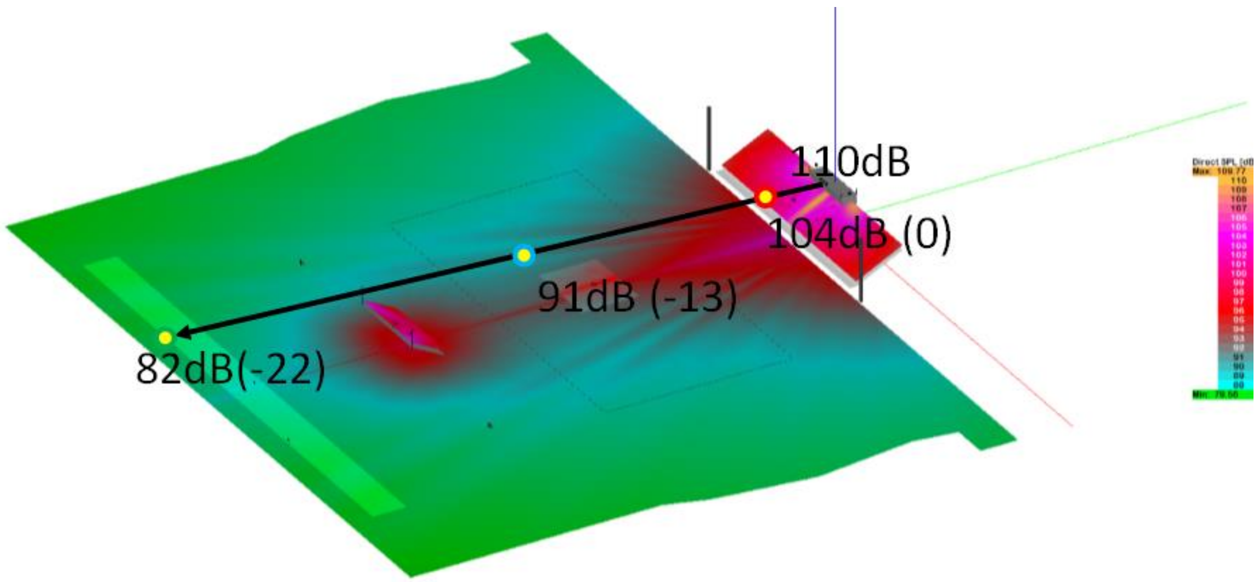
Erik Saari, CTS
Vice President Sales & Systems Design

Document Filename: Wolters Field Study - Presentation

## WOLTERS FIELD ACOUSTIC MEASUREMENTSTEST DATE: THURSDAY, MARCH 16TH 2017

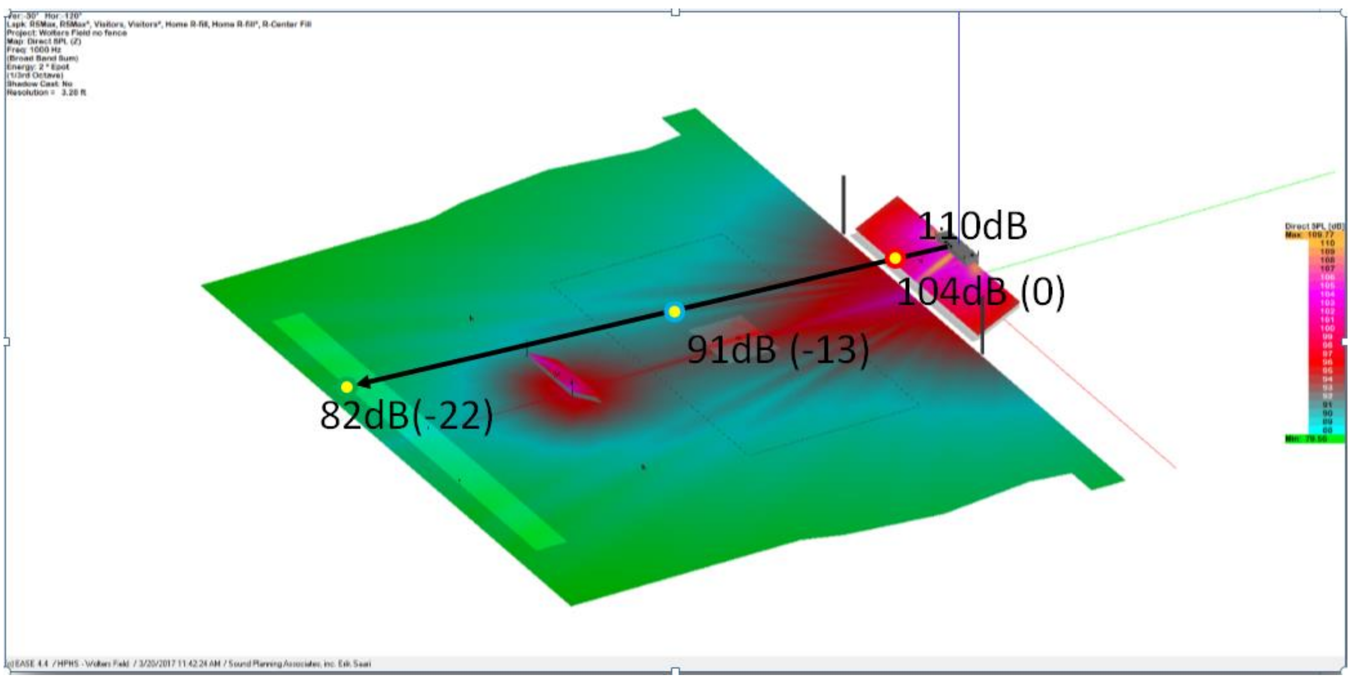
The system was tested and verified for levels in 11 zones. This measured data was compared with the virtual data from an acoustic model. These tests proved accurate and allowed further exploration of loudspeaker types and locations etc. to see what might mitigate sound spilling into the nearby properties.

In summation: to provide adequate coverage to the 9 zones for school athletic events, there was no scenario that reduces the spill to a sufficient level utilizing loudspeakers only. The best case would be to utilize a combination of loudspeakers, westward orientation and a large barrier wall behind the visitor bleachers that spanned the entire field and track areas.

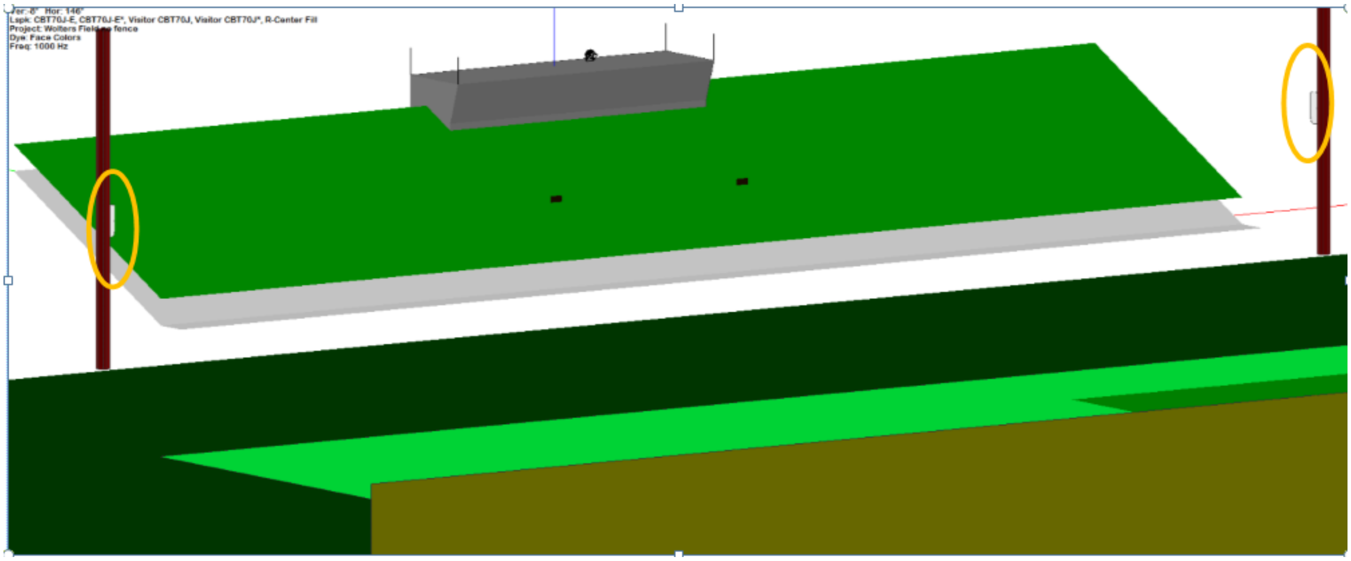



## MEASURED DATA SHOWS NEIGHBORS AT -22DB SPL FROM HOME SIDE


## ACOUSTIC MODEL SHOWS NEIGHBORS AT -22DB SPL FROM HOME SIDE



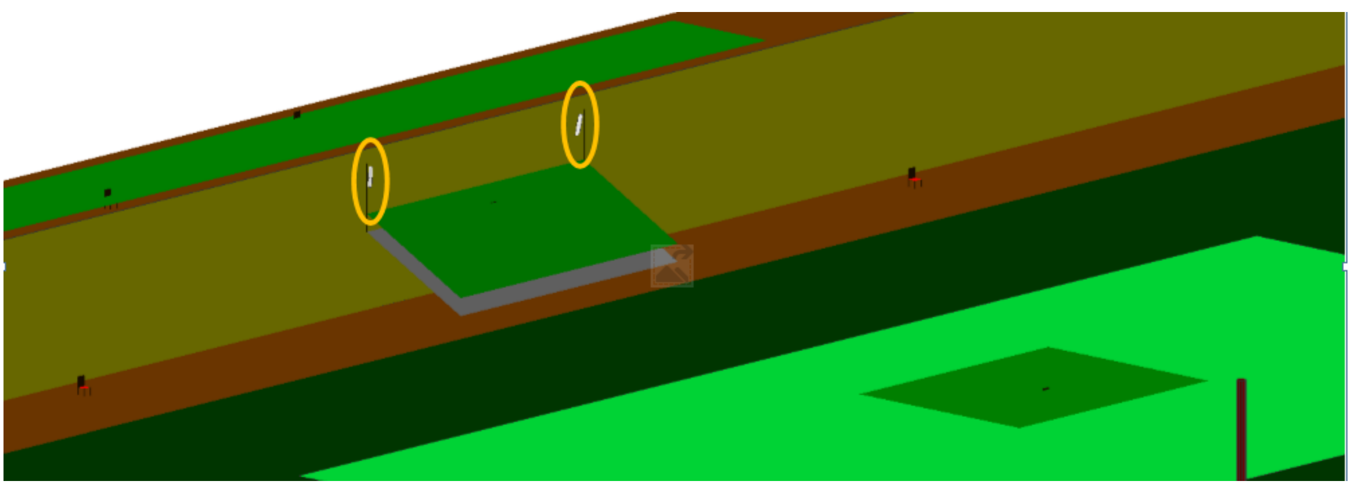
## ALTERNATE LOUDSPEAKERS & BARRIER WALL




We tested line-array loudspeakers mounted to the light poles and aimed westward (towards the home bleachers). We also mounted these to the visitors' side poles aimed to the field. This way all loudspeakers were oriented away from the neighbors.

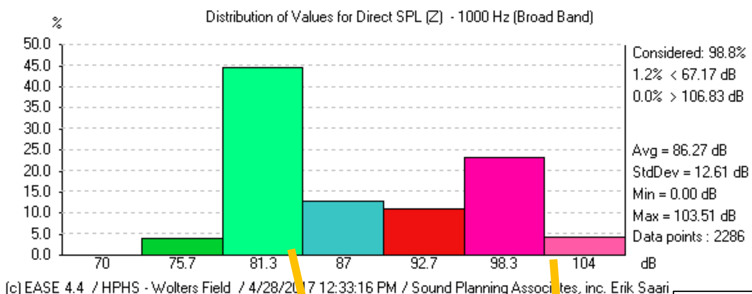
**Even with this orientation, the spill at the neighbors was not significantly reduced.**

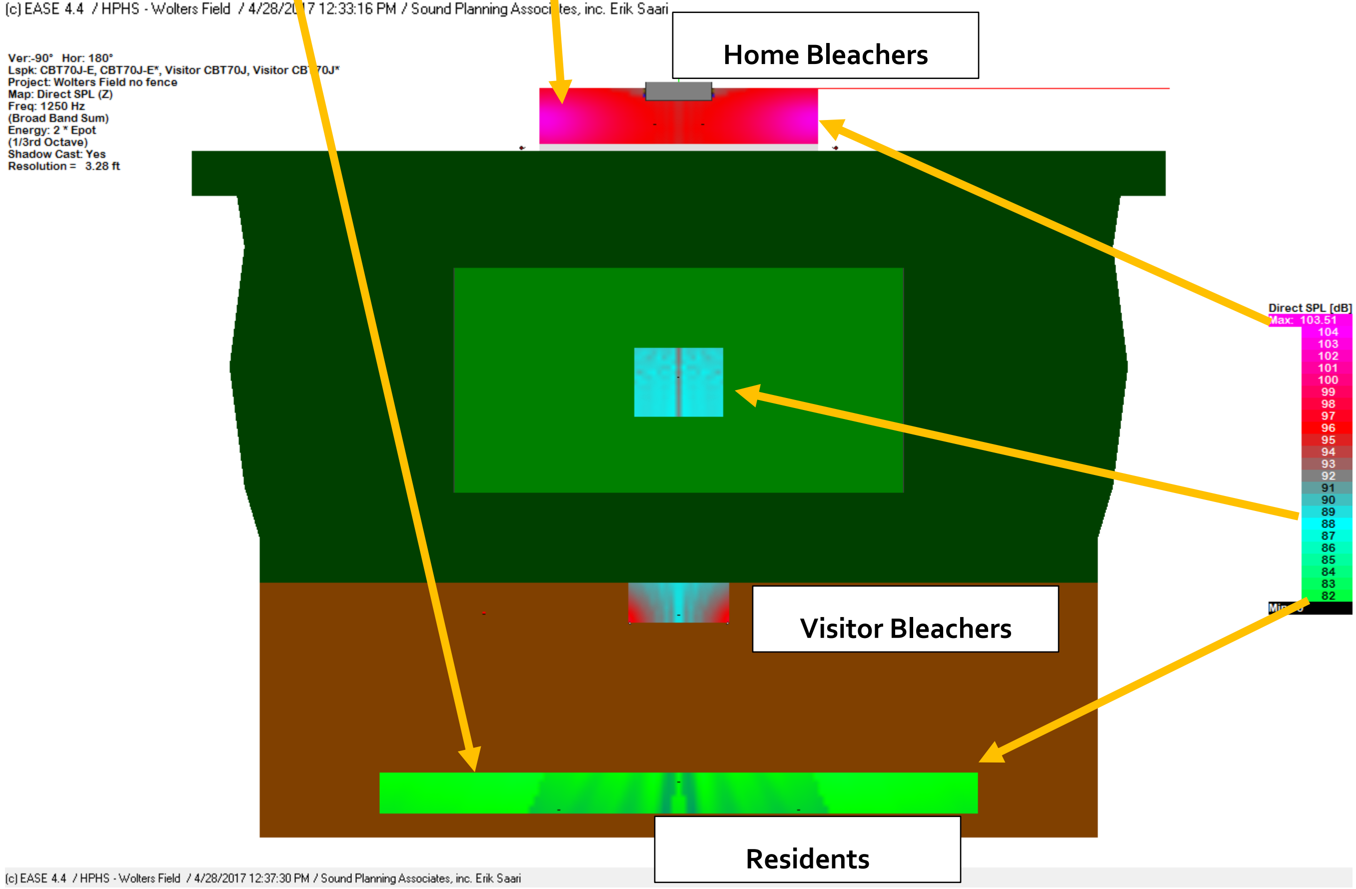
We then added a 35' tall barrier wall of plywood between the neighbors and the rear of the visitors' bleachers. This did reduce the amount of direct sound significantly. I.E. words and clear speech intelligibility would be reduced greatly. But the sound waves would still be diffracted over the barrier in lower frequencies.



## OPTION ONE: ALL LOUDSPEAKERS FACING WEST (AWAY FROM THE NEIGHBORS)

This test utilizes highly directional line-array loudspeakers that are mounted on the visitor side poles facing the field areas and mounted to the light poles aimed to the home side bleachers. This shows that the spill from the rear of the loudspeakers is about -10dB from the visitor side bleachers. Or -20dB lower than the loudest spots in the home side bleachers. This is due to the proximity of the visitor's side to the neighbors properties.



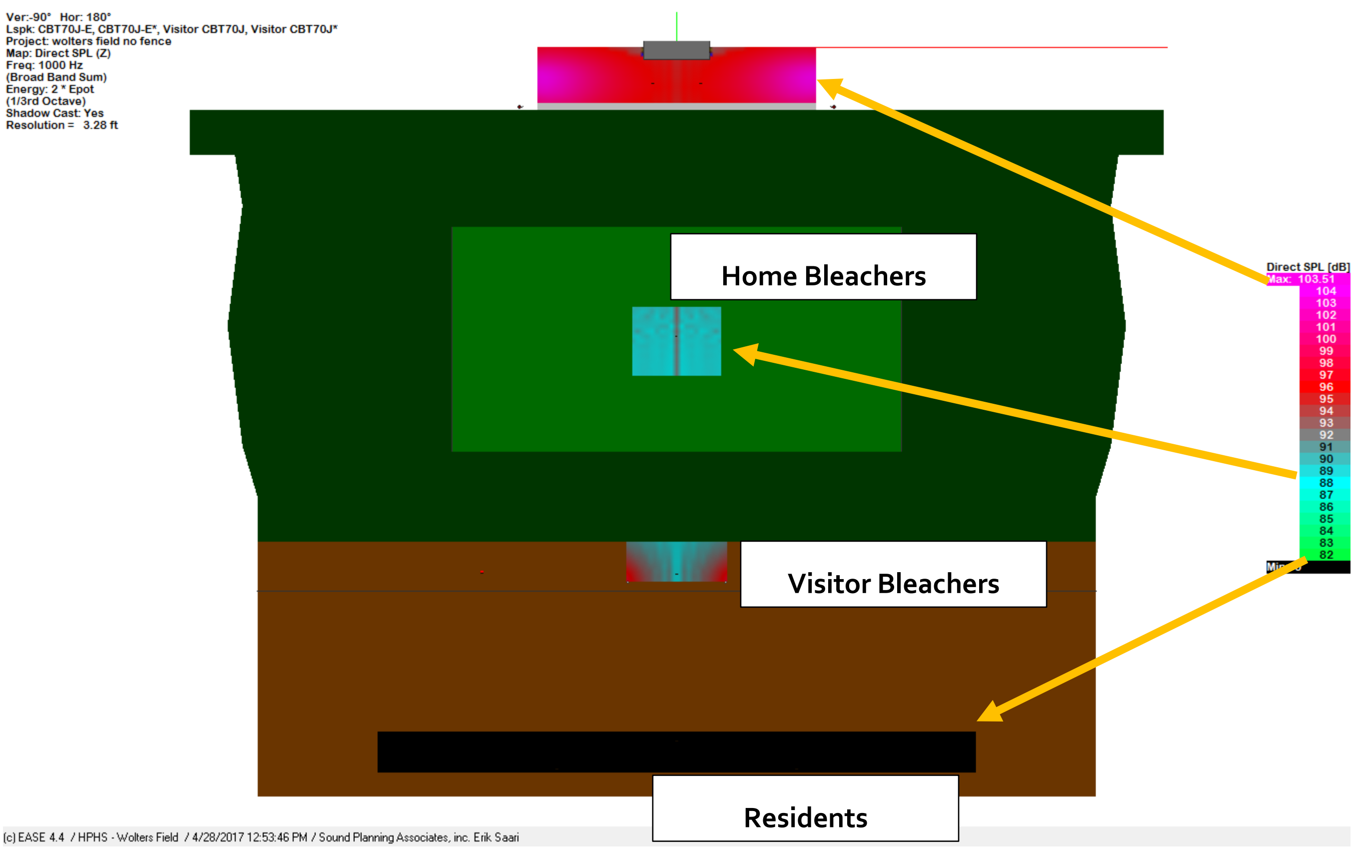



## OPTION TWO: FACING LOUDSPEAKERS AWAY FROM THE NEIGHBORS + BARRIER WALL

This test utilizes highly directional line-array loudspeakers that are mounted on the visitor side poles facing the field areas and mounted to the light poles aimed to the home side bleachers.

This test also includes a 35' tall barrier wall of plywood. As shown, the direct sound is not reaching the neighbors. But what this does not show is the amount of diffracted sound that WILL REACH THE NEIGHBORS over the top of the barrier. The next pages will help explain this reason. But suffice to say, a barrier wall would help a lot. But at what price in dollars and aesthetics?

If a barrier wall or wall + berm was decided upon, I would defer this study and design to the appropriate firm We are a sound and AV contractor and that is not our area of expertise.



## NOISE BARRIER WALLS AND BERMS


If you were to ask any of the houses shown in the image above if the walls around I-294 eliminated the traffic noise, I guarantee that they would say no. Why? Because no amount of wall or berm is sufficiently going to reduce the noise spilling over. It will attenuate it, but never eliminate it.

## THE FOLLOWING VERBIAGE IS TAKEN FROM THE US DEPT. OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION:

https://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design03.cfm

**3.5.1 Barrier Design Goals and Insertion Loss.**

The first step in barrier design is to establish the design goals. Design goals may not be limited simply to noise reduction at receivers, but may also include other considerations of safety and maintenance as well. These other considerations are discussed later in Sections 4 through 13.

In this section, the acoustical design goals of noise reduction will be discussed. Acoustical design goals are usually referred to in terms of barrier Insertion Loss (IL). IL is defined as the sound level at a given receiver before the construction of a barrier minus the sound level at the same receiver after the construction of the barrier. The construction of a noise barrier usually results in a partial loss of soft-ground attenuation. This is due to the barrier forcing the sound to take a higher path relative to the ground plane. Therefore, barrier IL is the net effect of barrier diffraction, combined with this partial loss of soft-ground attenuation.

Typically, a 5-dB(A) IL can be expected for receivers whose line-of-sight to the roadway is just blocked by the barrier. A general rule-of-thumb is that each additional 1 m of barrier height above line-of-sight blockage will provide about 1.5 dB(A) of additional attenuation (see Figure 13).

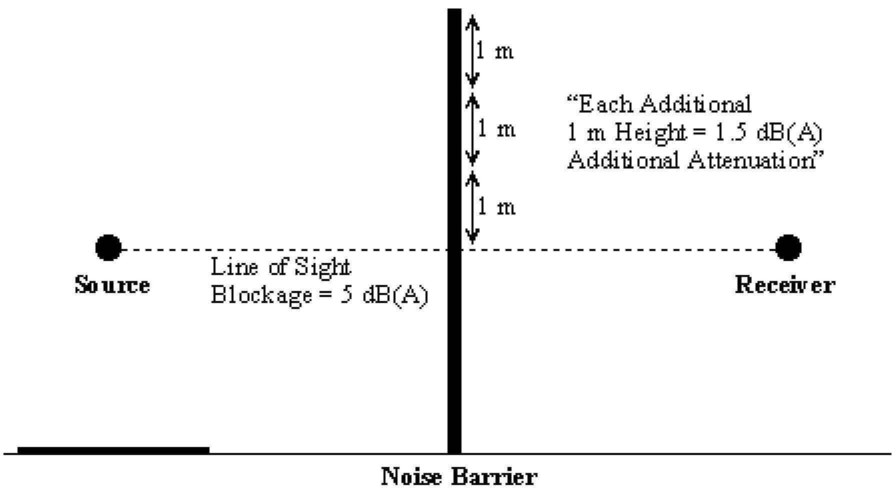



Figure 13. Line-of-sight

*Properly-designed noise barriers should attain an IL approaching 10 dB(A), which is equivalent to a perceived halving in loudness for the first row of homes directly behind the barrier.* For those residents not directly behind the barrier, a noise reduction of 3 to 5 dB(A) can typically be provided, which is just slightly perceptible to the human ear. Table 4 shows the relationship between barrier IL and design feasibility.[ref.1]

**Table 4. Relationship between barrier insertion loss and design feasibility.**

| Barrier Insertion Loss | Design Feasibility | Reduction in Sound Energy | Relative Reduction in Loudness |
|---|---|---|---|
| 5 dB(A) | Simple | 68% | Readily perceptible |
| 10 dB(A) | Attainable | 90% | Half as loud |
| 15 dB(A) | Very difficult | 97% | One-third as loud |
| 20 dB(A) | Nearly impossible | 99% | One-fourth as loud |

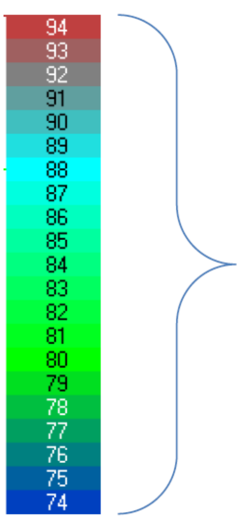
## SUMMARY

In summary for all the data collected and analyzed, the most effective solution would require both a new loudspeaker design and a barrier. Changing the loudspeakers and orientation provides some level attenuation at mid-range and higher frequencies.  The issue becomes what low frequencies will still spill since the proximity of the loudspeakers covering the field will be much closer to the residents.

As the chart below shows, using an A-weighted dB SPL scale, the levels at the residents don't decrease until the barrier wall is added. But again, this is because the low frequencies will spill to the neighbors' due to proximity of them when mounted to the poles behind the visitor's bleachers.

**To simplify the data please refer to the following charts:**

| Location | Existing Level | Predicted Level with New Loudspeakers and Orientation | Predicted Level with New Loudspeakers and Orientation + Barrier Fence |
|---|---|---|---|
| Field Center | 83 dB SPL | 88 dB SPL | 88 dB SPL |
| Home Bleachers | 102 dB SPL | 101 dB SPL | 101 dB SPL |
| Visitor Bleachers | 79 dB SPL | 87 dB SPL | 90 dB SPL |
| **Residents** | **75 dB SPL** | **75 dB SPL** | **69 dB SPL** |



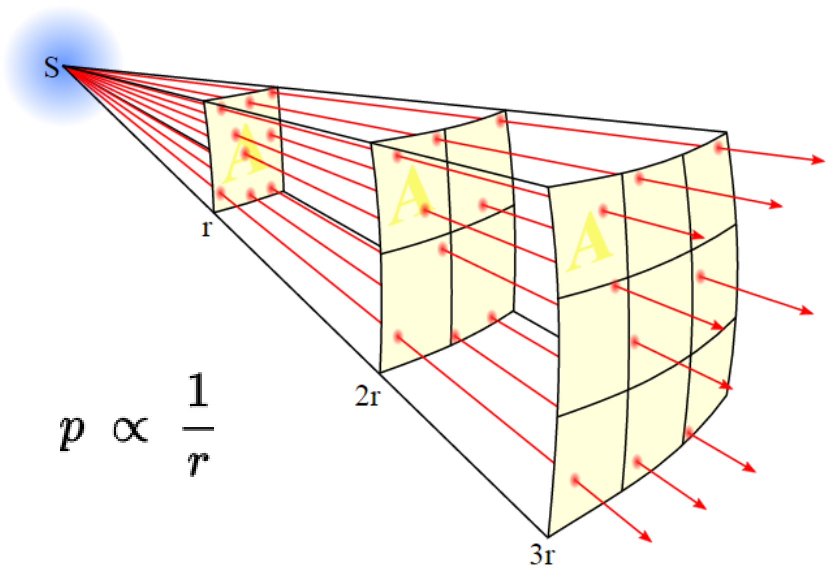

**Understanding decibels (dB) of Sound Pressure Level (SPL)**

| EASE Color | dB SPL | Sound | Perception or Effect |
|---|---|---|---|
| 140 | 140 | Gun Blast | Painful / Acoustic Trauma |
| 130 | 130 | Jet Engine @ 100' | |
| 120+ | 120 | Loud Rock Concert | |
| 110+ | 110 | Car Horn | Very Loud / Damage at long exposure |
| 100+ | 100 | Blow Dryer | Getting Loud |
| 90+ | 90 | Lawn Mower | **Optimal Range for Sound Reinforcement +/- 10dB** |
| 80 | 80 | Noisy Restaurant | |
| 70 | 70 | Alarm Clock | |
| 60 | 60 | Conversation | Background Noises |
| 50 | 50 | Rainfall | Moderate Level |
| 40 | 40 | Refrigerator | Faint |
| 30 | 30 | Whisper | |
| 20 | 20 | Clock Ticking | |
| 10 | 10 | Watch Ticking | Barely Audible |

# APPENDIX

THE FOLLOWING PAGES ARE FOR THE MEASURED DATA COLLECTED AS WELL AS OTHER PERTINENT ITEMS

# Loudspeaker Types: Point Source



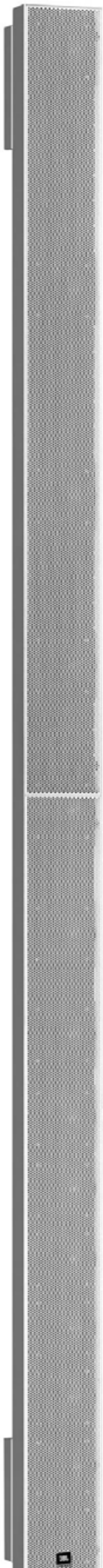

$$p \propto \frac{1}{r}$$

## The Inverse Square Law and Point Source Loudspeakers

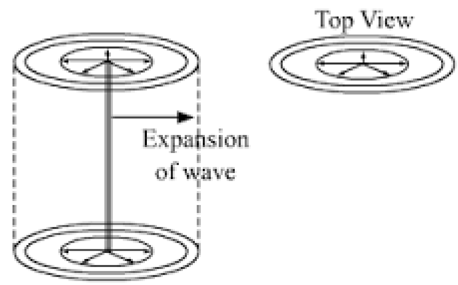
In acoustics, the sound pressure of a spherical wavefront radiating from a point source decreases by 50% as the distance *r* doubled. Measured in dB, the decrease is 6dB.

Or more simply put:

**Every time you double the distance you decrease the level by 6dB SPL or perceived level is half as loud.**



# Loudspeaker Types: Line Source

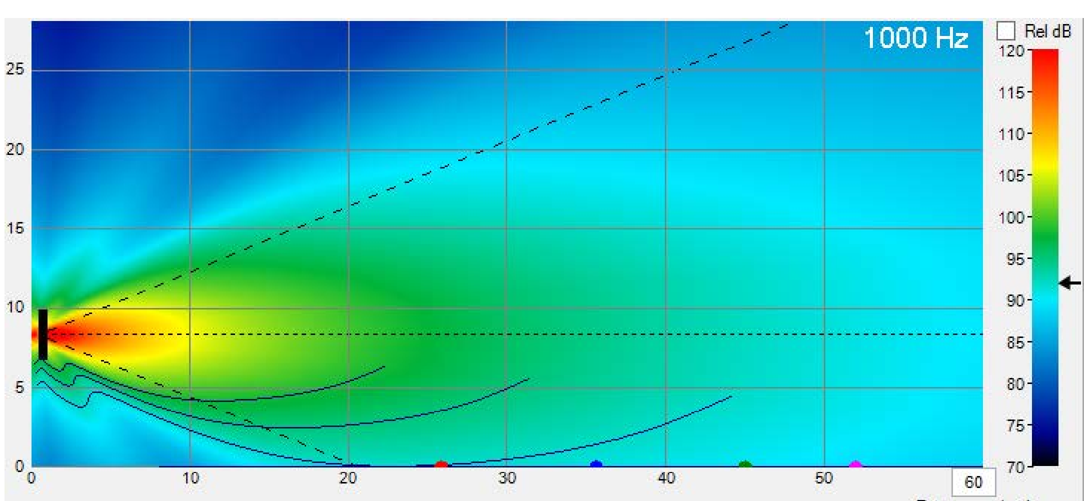



## The Inverse Distance Law and Line Source Loudspeakers

In acoustics, the sound pressure of a cylindrical wavefront radiating from a line source decreases by 25% as the distance *r* doubled. Measured in dB, the decrease is 3dB.

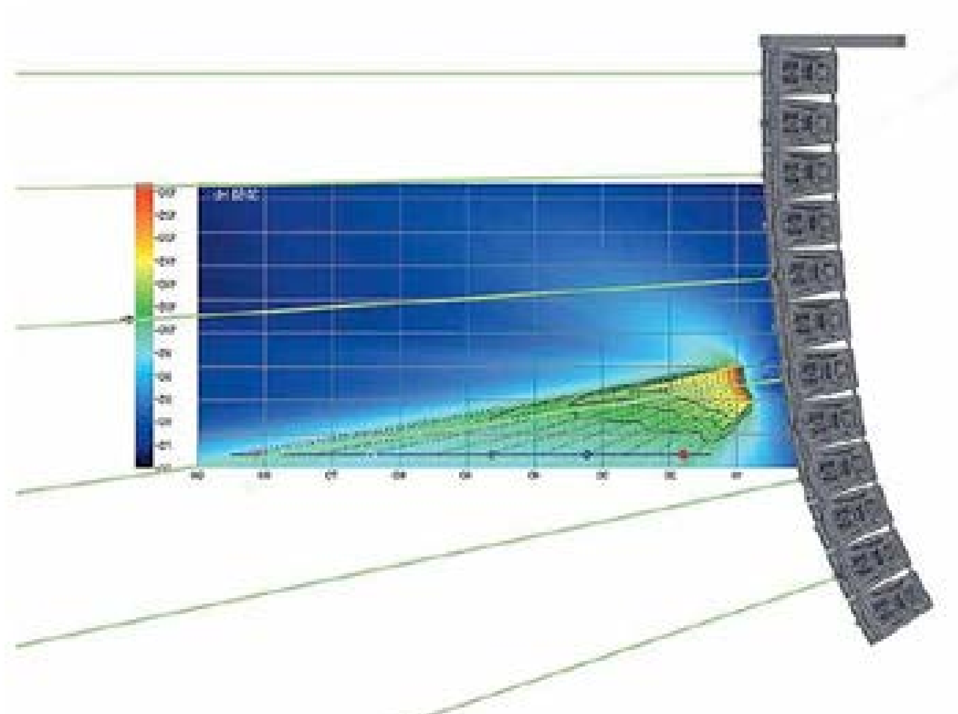
Or more simply put:

**Every time you double the distance you decrease the level by 3dB SPL or perceived level is 3/4 as loud.**



# Loudspeaker Types: Hybrid


Touring Arrays typically utilize stacked point-source loudspeakers in quasi-line source fashion to create a combination of the both type of systems. These are useful for shooting very long distances to the intended audience.

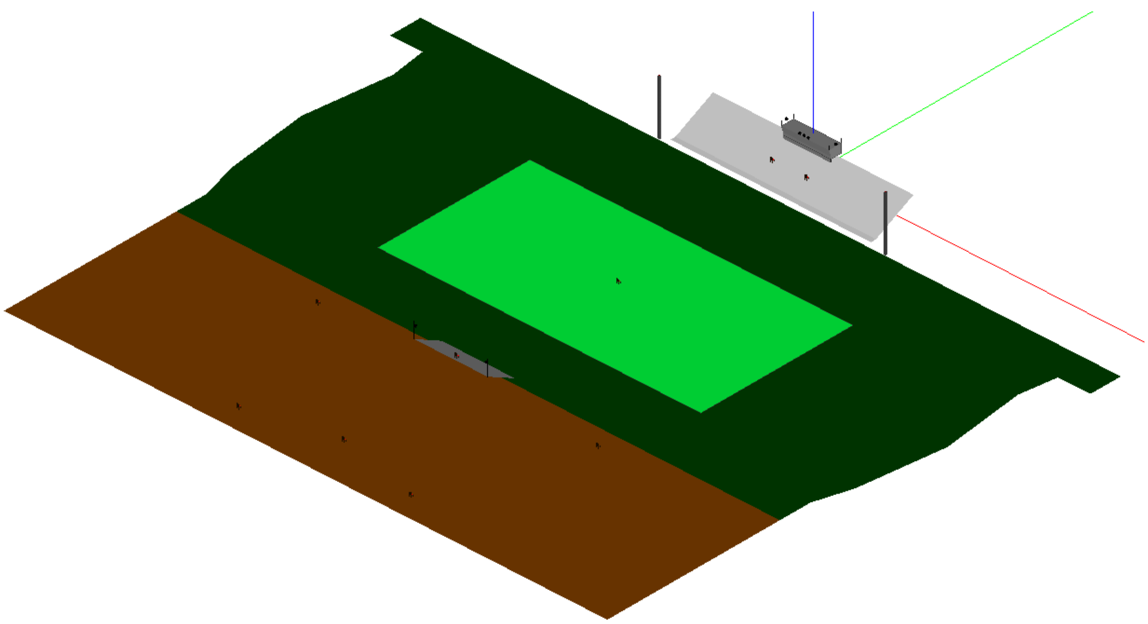


# Wolters Field  Acoustic Measurements

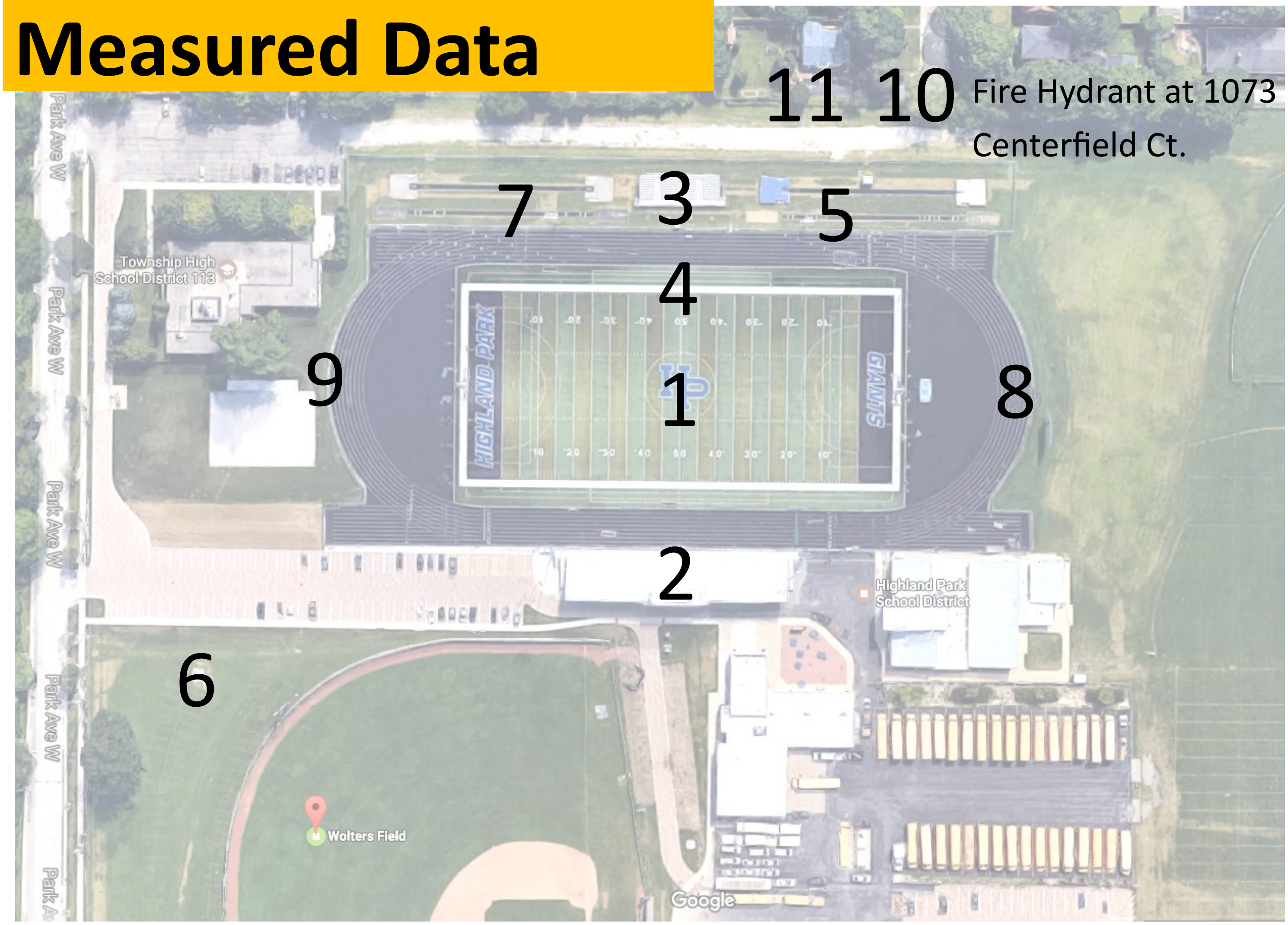
## Test Date: Thursday, March 16th 2017

The system was tested and verified for levels in 11 zones. This measured data was then organized and compared with the virtual data from an acoustic model . These tests proved accurate and allowed further exploration of loudspeaker types and locations etc. to see what might mitigate sound spilling into the nearby properties.

In summation, To provide adequate coverage to the 9 zones for school athletic events, there was no scenario that reduces the spill to a sufficient level utilizing loudspeakers only. The best case would be to utilize a combination of loudspeakers and a large barrier wall behind the visitor bleachers that spanned the entire field and track areas.



# Measured Data




Decibels of sound pressure (dB SPL) of pink noise bursts

1 Field Center: 83dB SPL

2 Home Bleachers: 96dB SPL

3 Visitor Bleachers: 79dB SPL

4 Visitor Sideline: 79dB SPL

5 Pole Vault: 76dB SPL

6 Discus: 76dB SPL

7 Long Jump: 75dB SPL

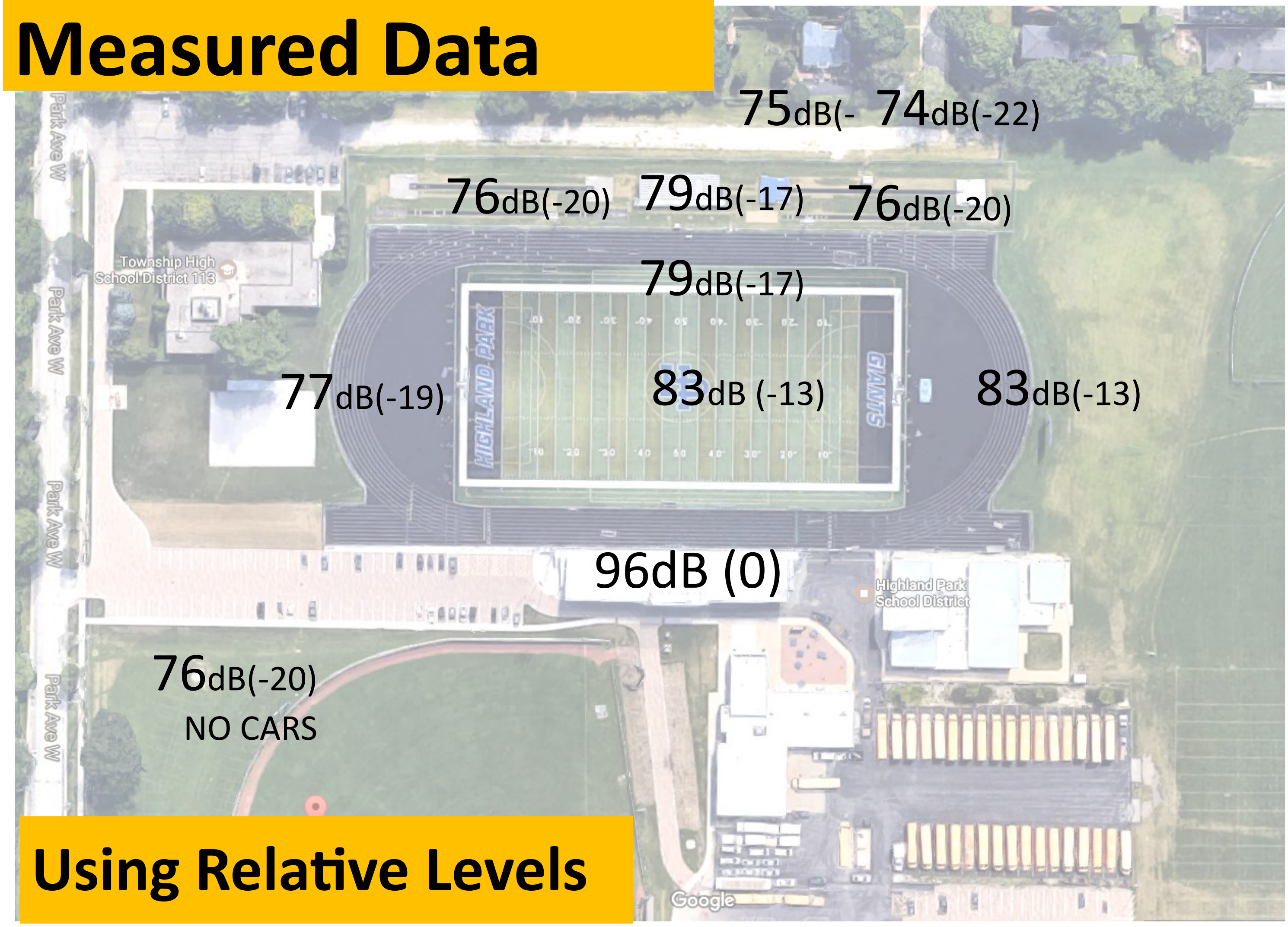
8 High Jump: 83dB SPL

9 Shot Put: 77dB SPL

10 Fire Hydrant: 74dB SPL

11 Yellow House: 75dB SPL

# Measured Data




## Using Relative Levels

Using the loudest level at the home bleachers as the "odB" reference, the level at each location is shown with its relative level from the reference.

**I.E. the Visitors bleachers are –17dB SPL from the reference at the Home side bleachers.**

This level variation is key to understanding the correlation of dB SPL at the source to the distance of the measured audience. As you will see in the virtual model images, these level relationships are shown.

1 Field Center: 83dB SPL

2 Home Bleachers: 96dB SPL

3 Visitor Bleachers: 79dB SPL

4 Visitor Sideline: 79dB SPL

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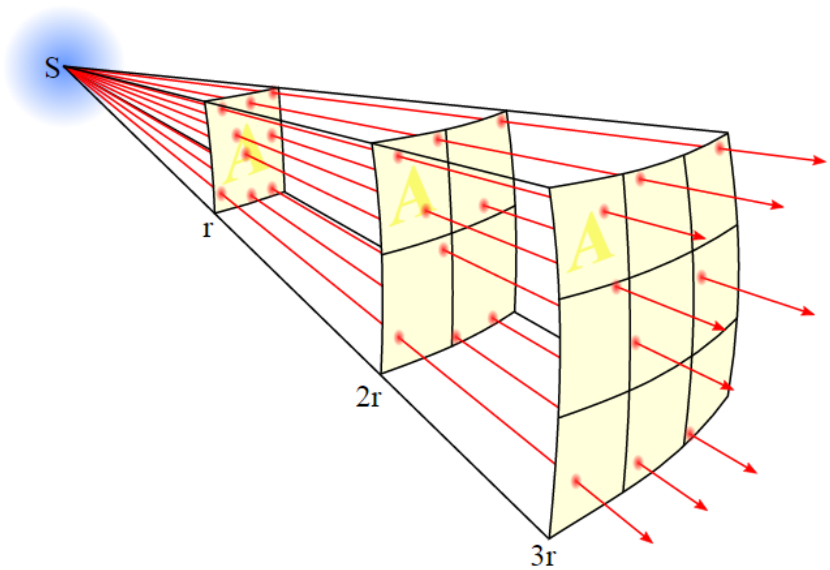


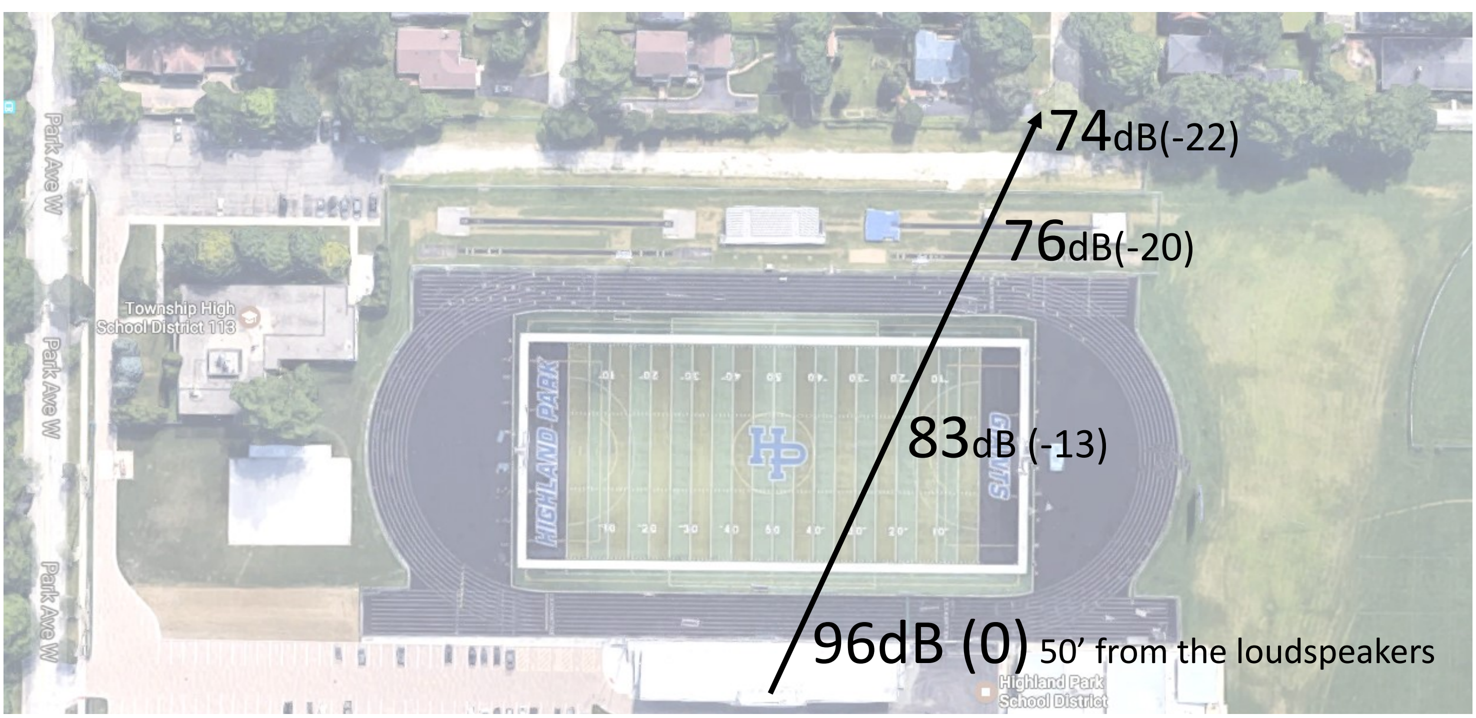

$$p \propto \frac{1}{r}$$

## Sound in air

In acoustics, the sound pressure of a spherical wavefront radiating from a point source decreases by 50% as the distance *r* is doubled; measured in dB, the decrease is still 6.02 dB, since dB represents an intensity ratio. The pressure ratio (as opposed to power ratio) is not inverse-square, but is inverse-proportional (inverse distance law)

Or more simply put:

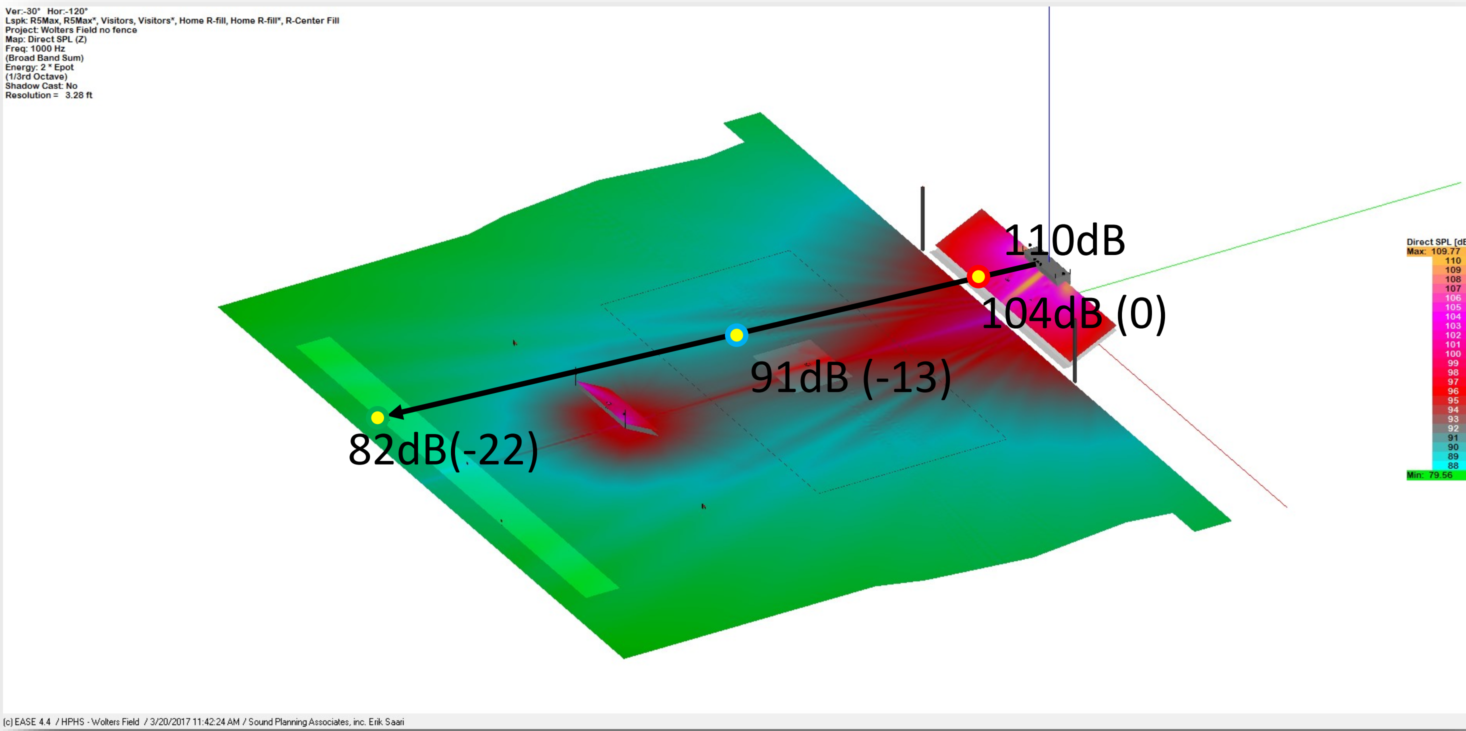
**Every time you double the distance you decrease the level by 6dB SPL or perceived level is half as loud.**



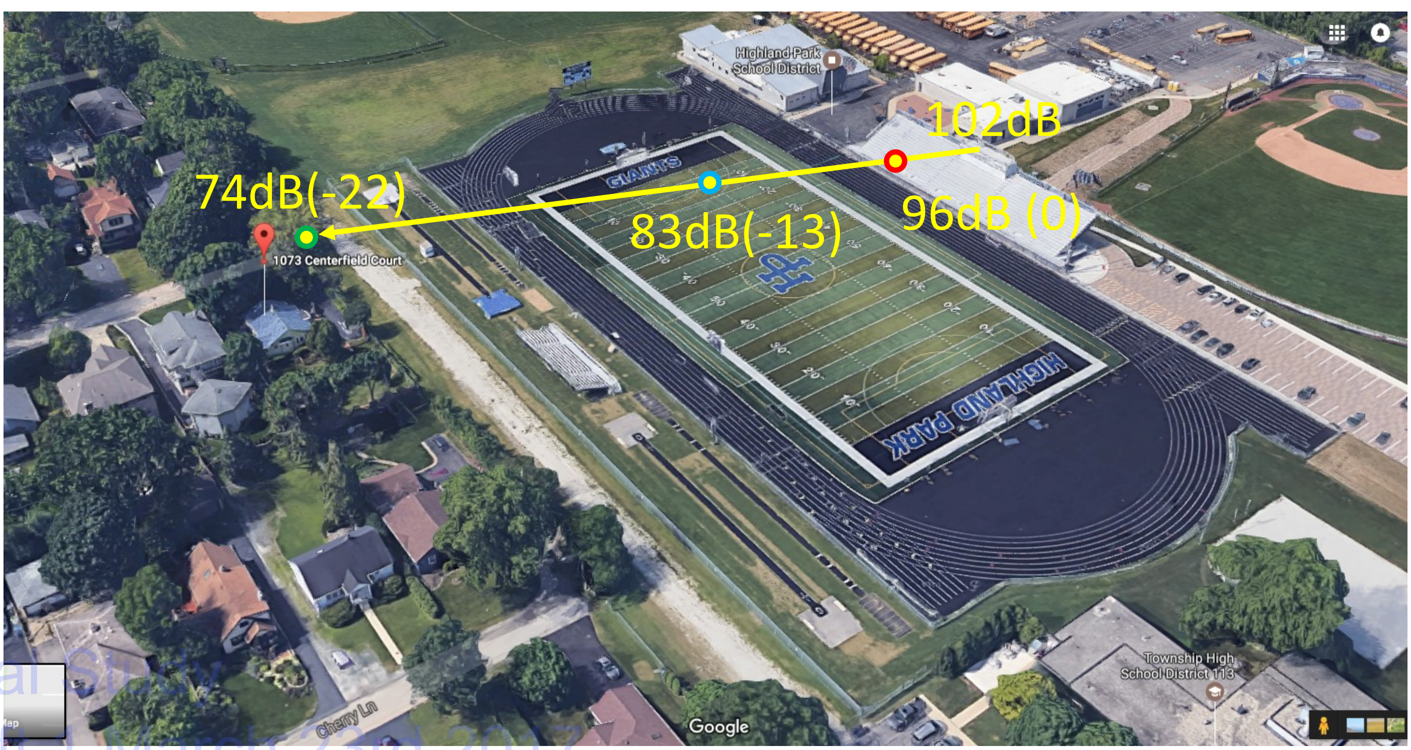

102dB at Loudspeaker

As you see in the acoustic model, the relative level corresponds with the distances from the measured data. If the level measured at the home bleachers is the 0dB reference, the fire hydrant is down –22dB

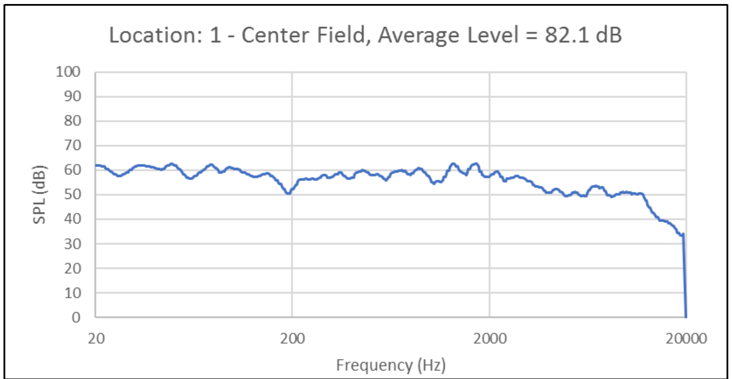
## Acoustic Model

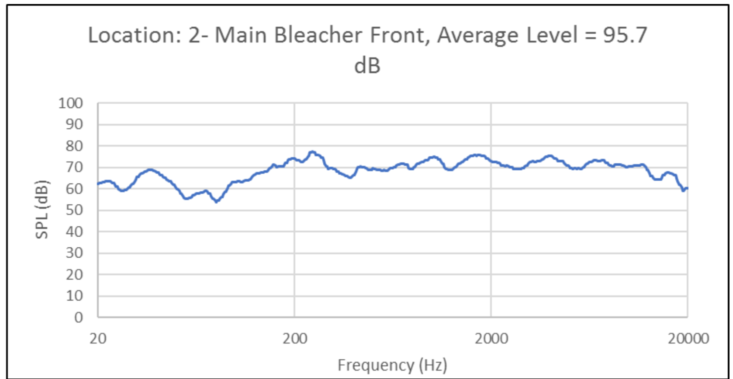


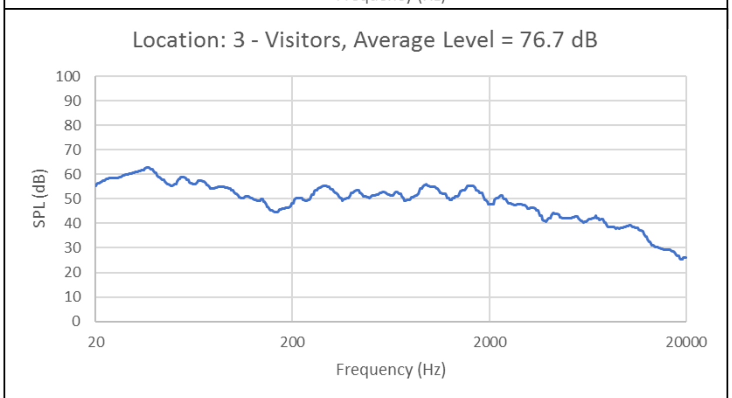

## Measured Data

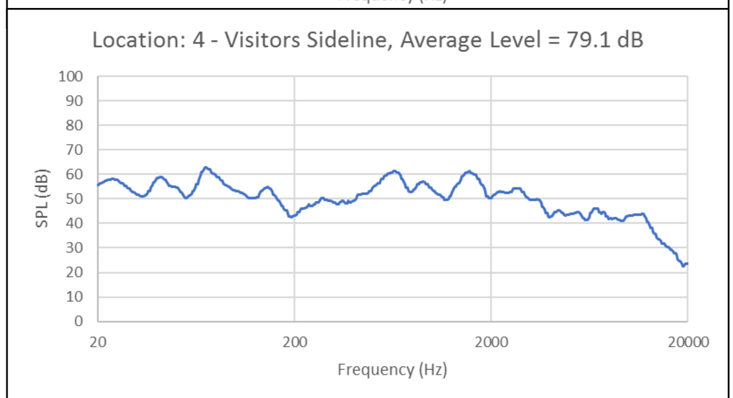


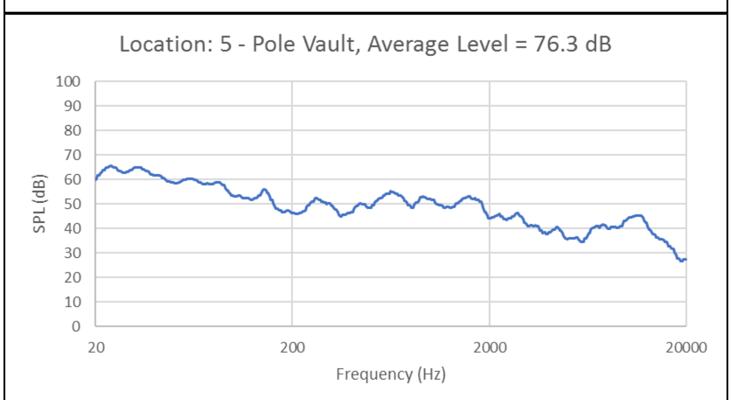
## Decibels of sound pressure (dB SPL) of pink noise bursts

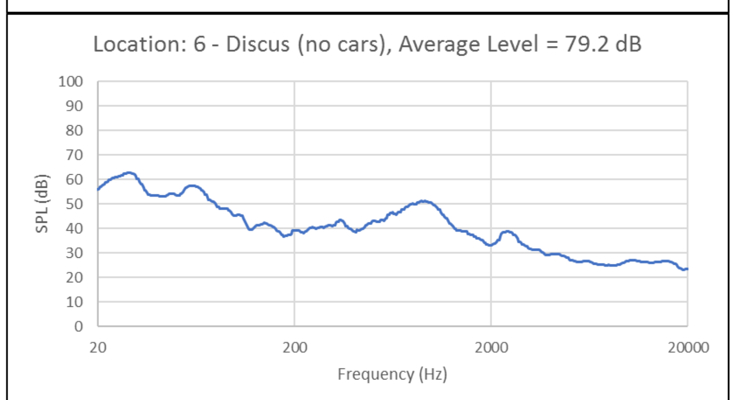


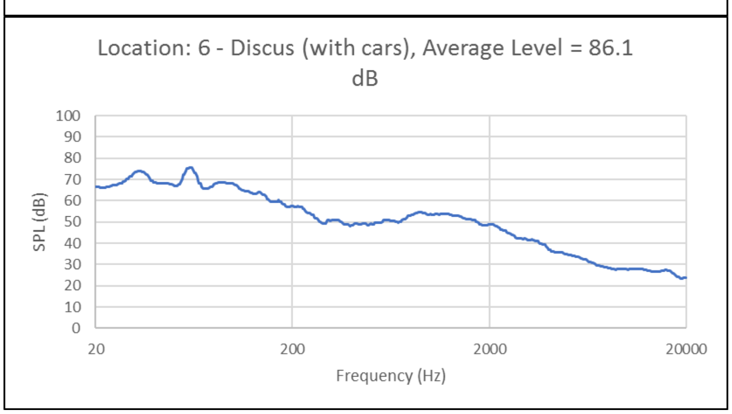



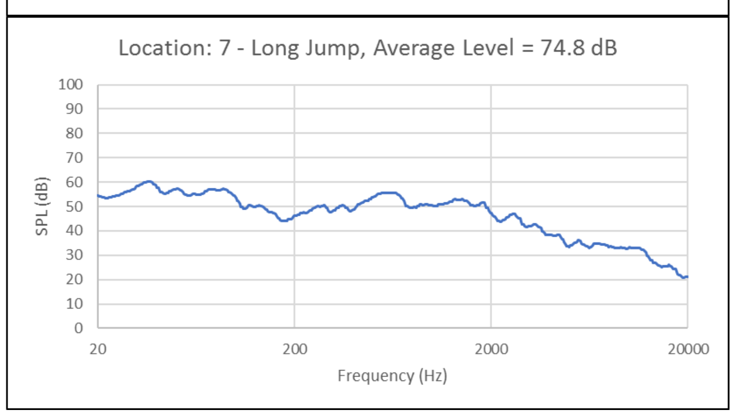



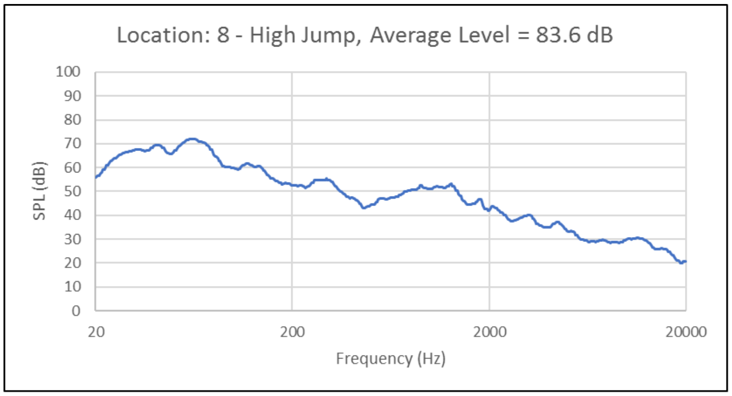



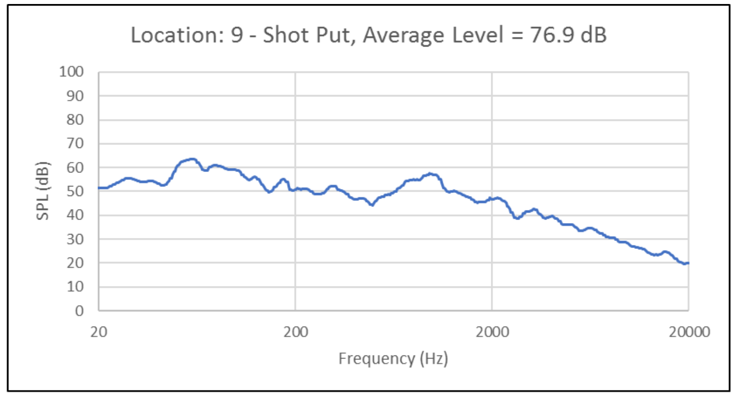



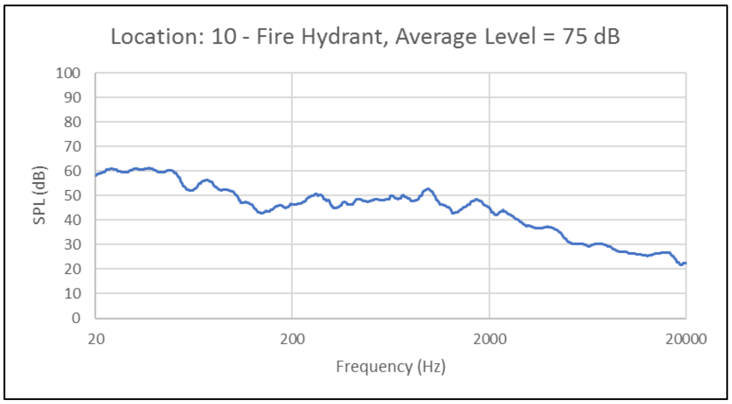



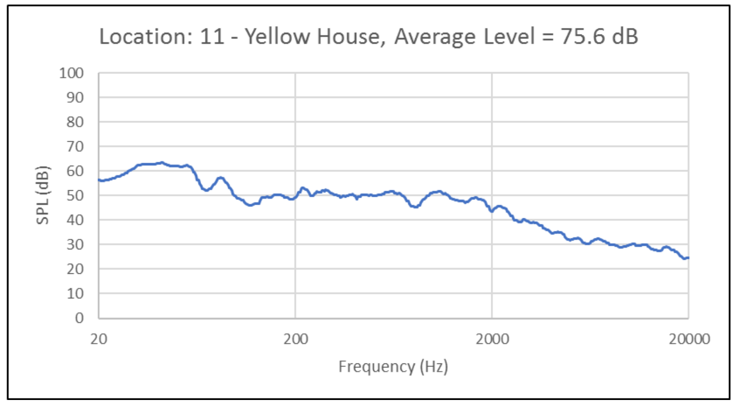



Decibels of sound pressure (dB SPL) of pink noise bursts



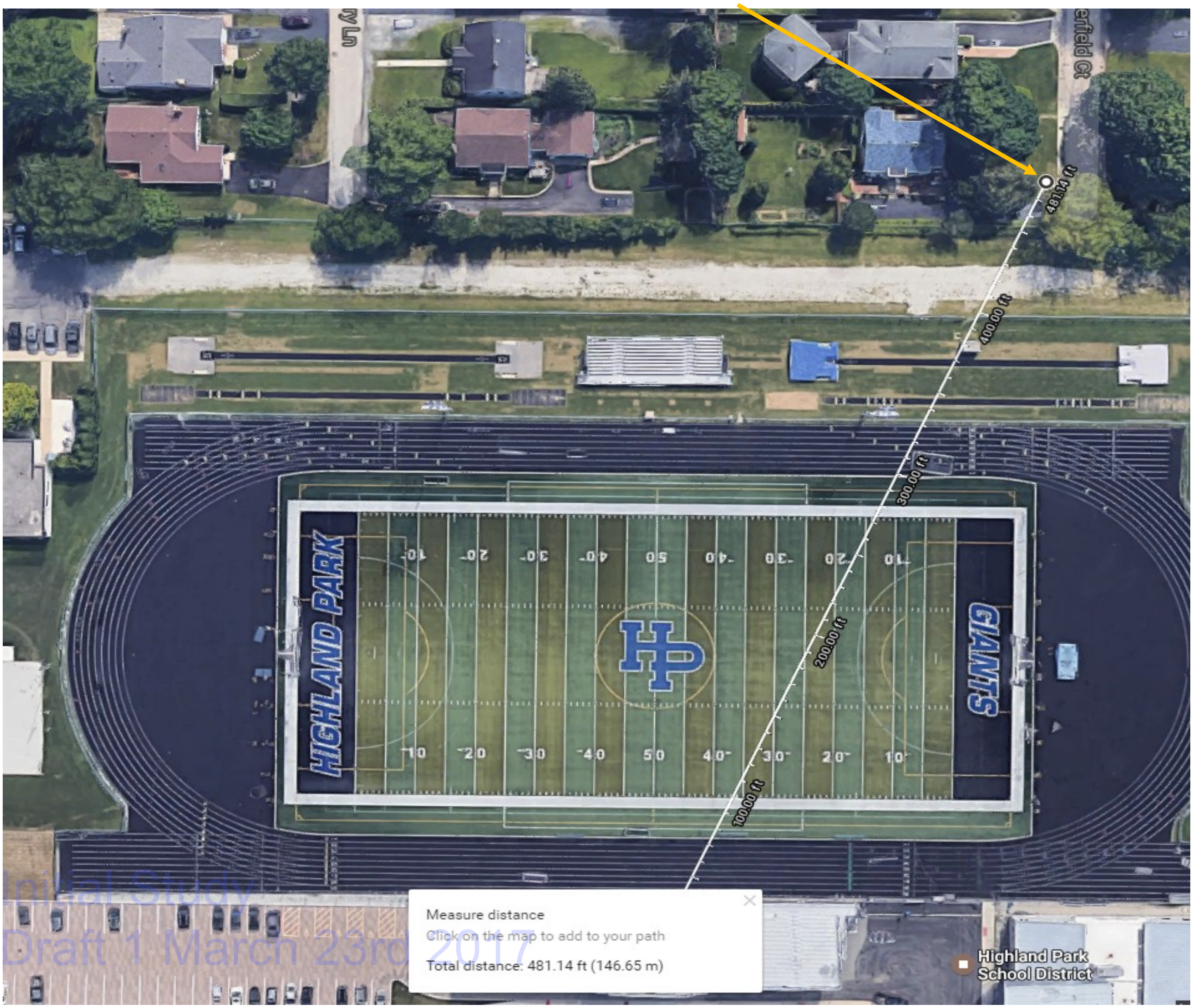



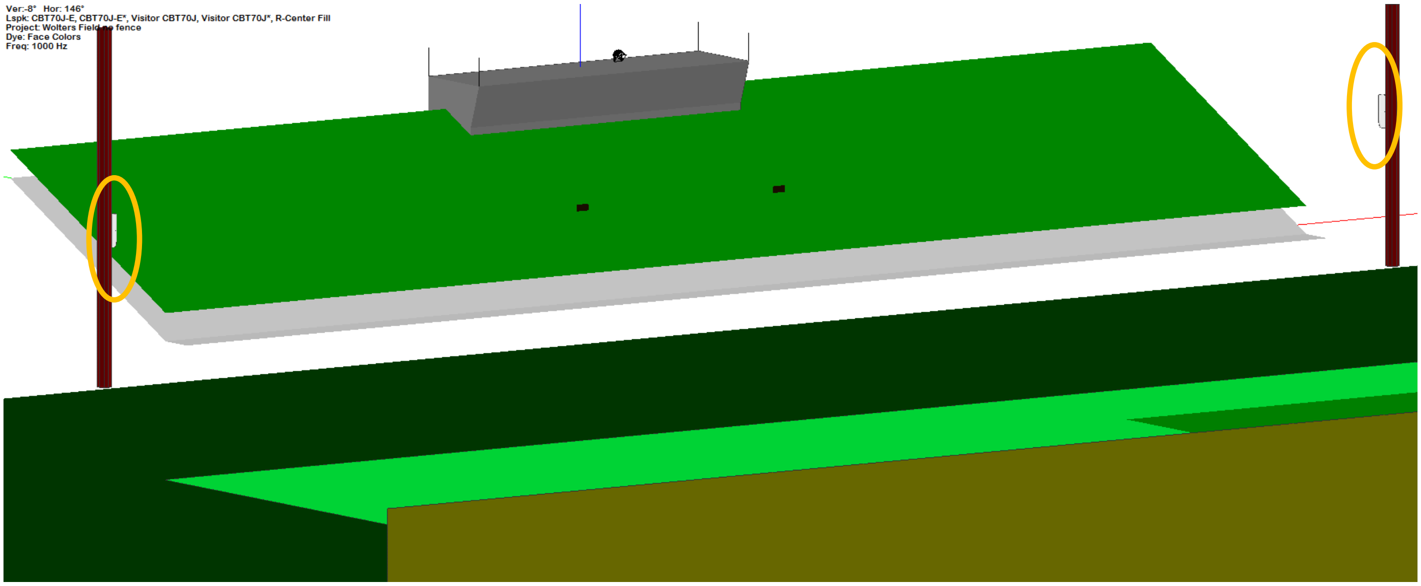


**10 Fire Hydrant**


**10 Fire Hydrant**



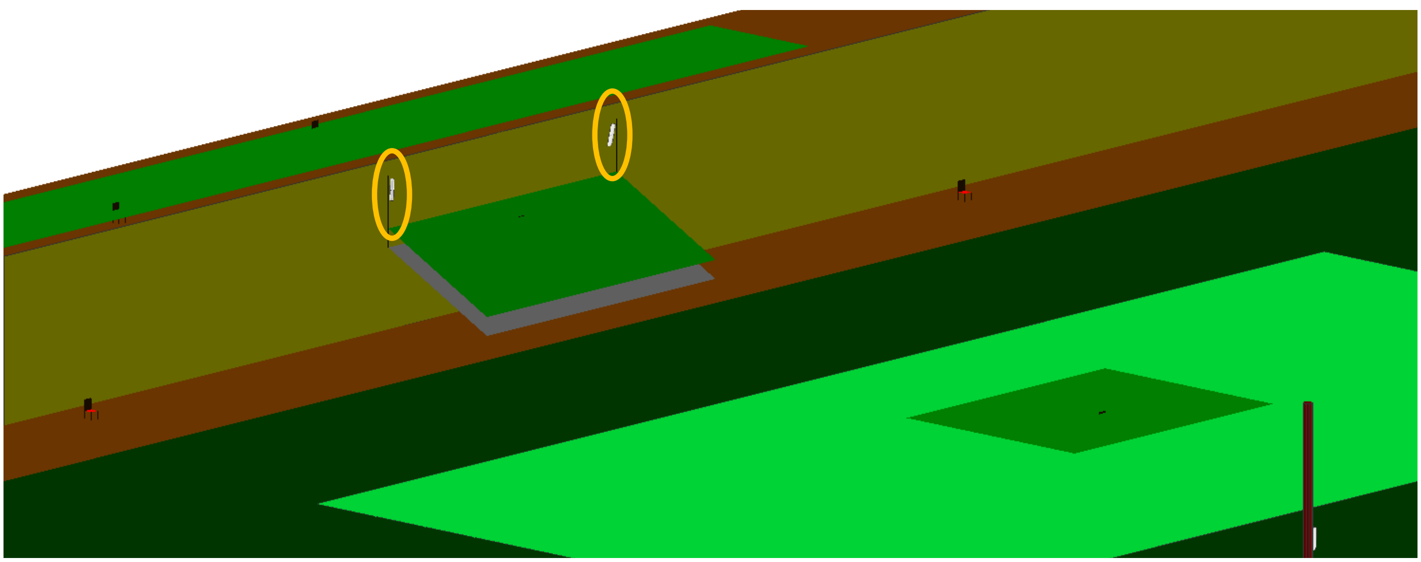
# Alternate Loudspeakers & Barrier Wall



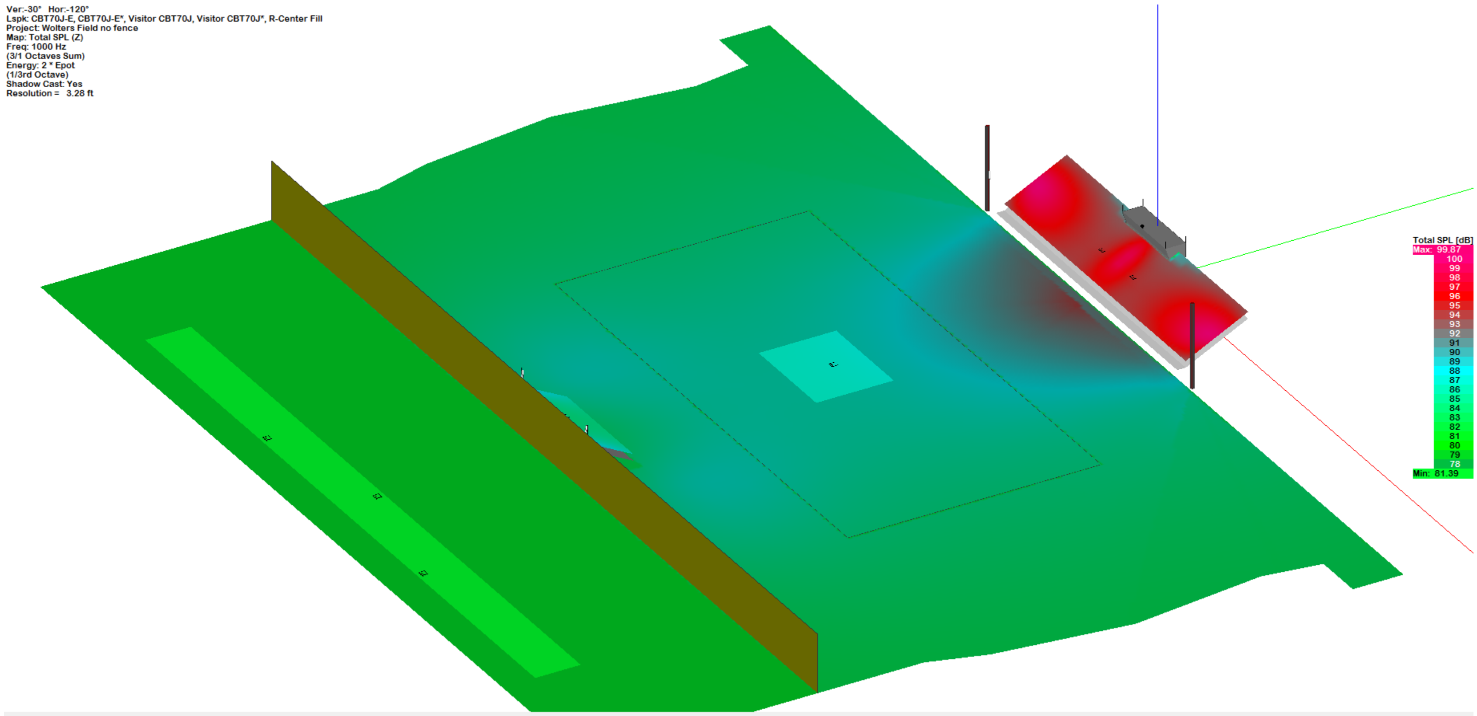

We tested column line-array loudspeakers mounted to the light poles and aimed towards the home bleachers. We also mounted these to the visitors side poles aimed to the field. This way all loudspeakers were oriented away from the neighbors.

Even with this orientation, the spill at the neighbors was not significantly reduced.

We then added a 35’ tall barrier wall of plywood between the neighbors and the rear of the visitors bleachers. This did reduce the amount of direct sound significantly. I.E. words and clear speech intelligibility would be reduced greatly. But the sound waves would still be displaced over the barrier in lower frequencies. Sound is air displacement via pressure, not wind. Barriers will attenuate certain frequencies, but not all sound waves will be stopped. This is why you can hear low frequencies emanating from a car with closed windows.

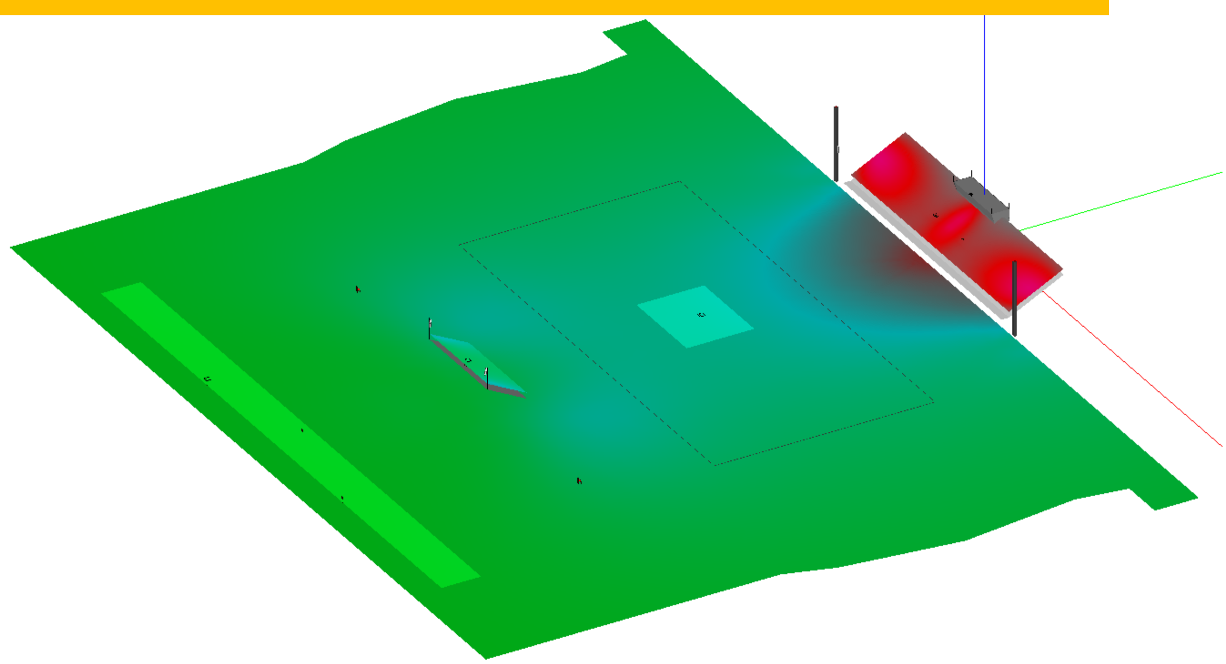


# Alternate Loudspeakers & Barrier Wall



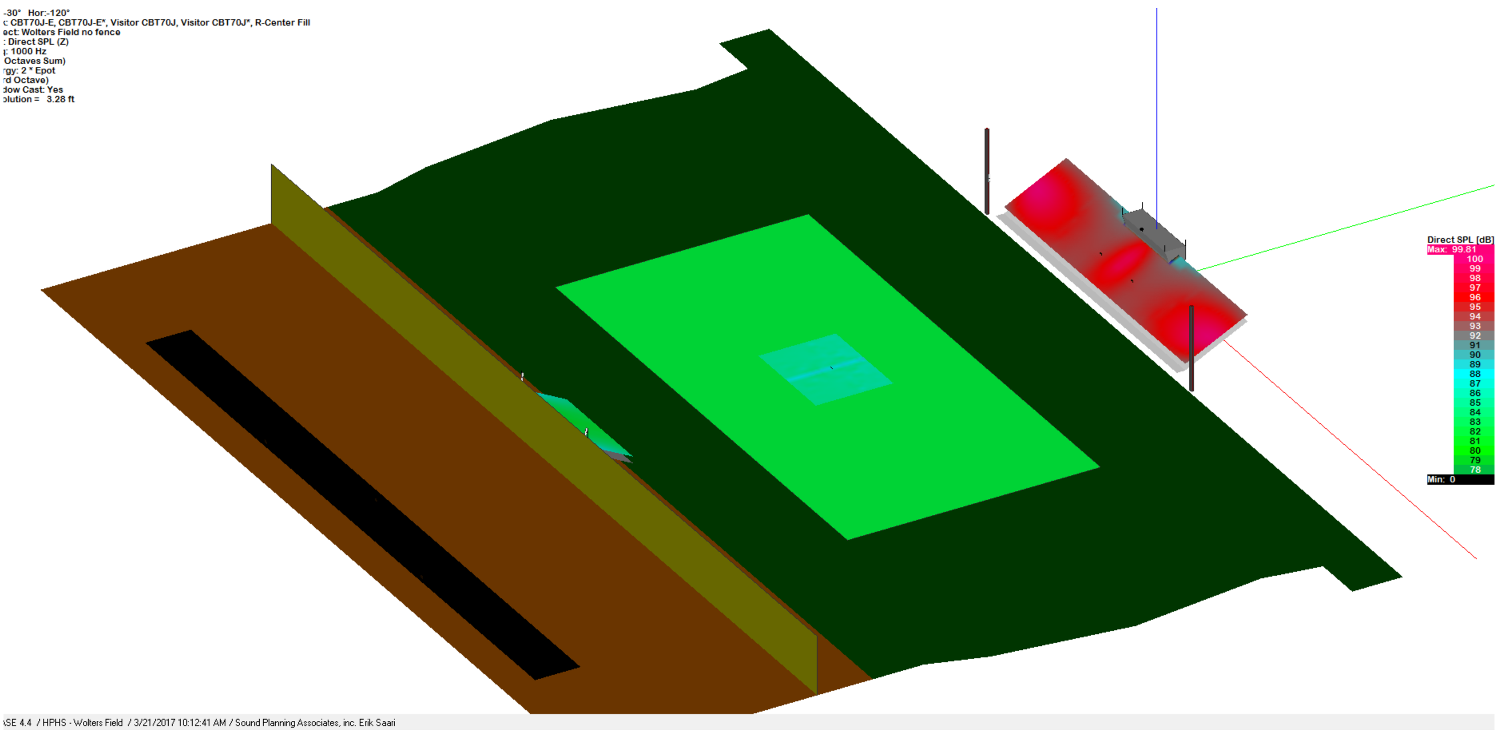

(c) EASE 4.4 / HPHS - Wolters Field / 3/21/2017 9:41:42 AM / Sound Planning Associates, inc. Erik Saari

# Alternate Loudspeakers Only

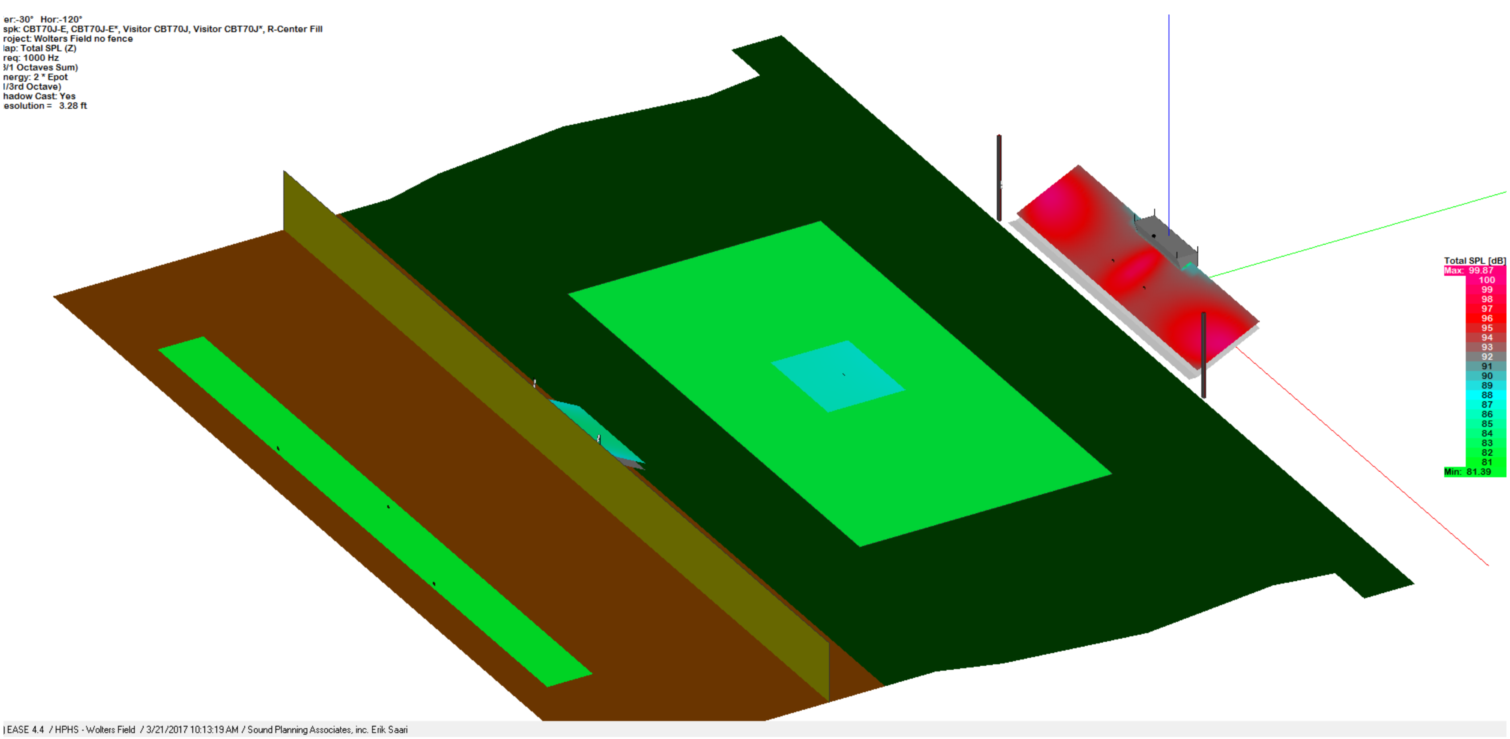


(c) EASE 4.4 / HPHS - Wolters Field / 3/20/2017 12:06:24 PM / Sound Planning Associates, inc. Erik Saari

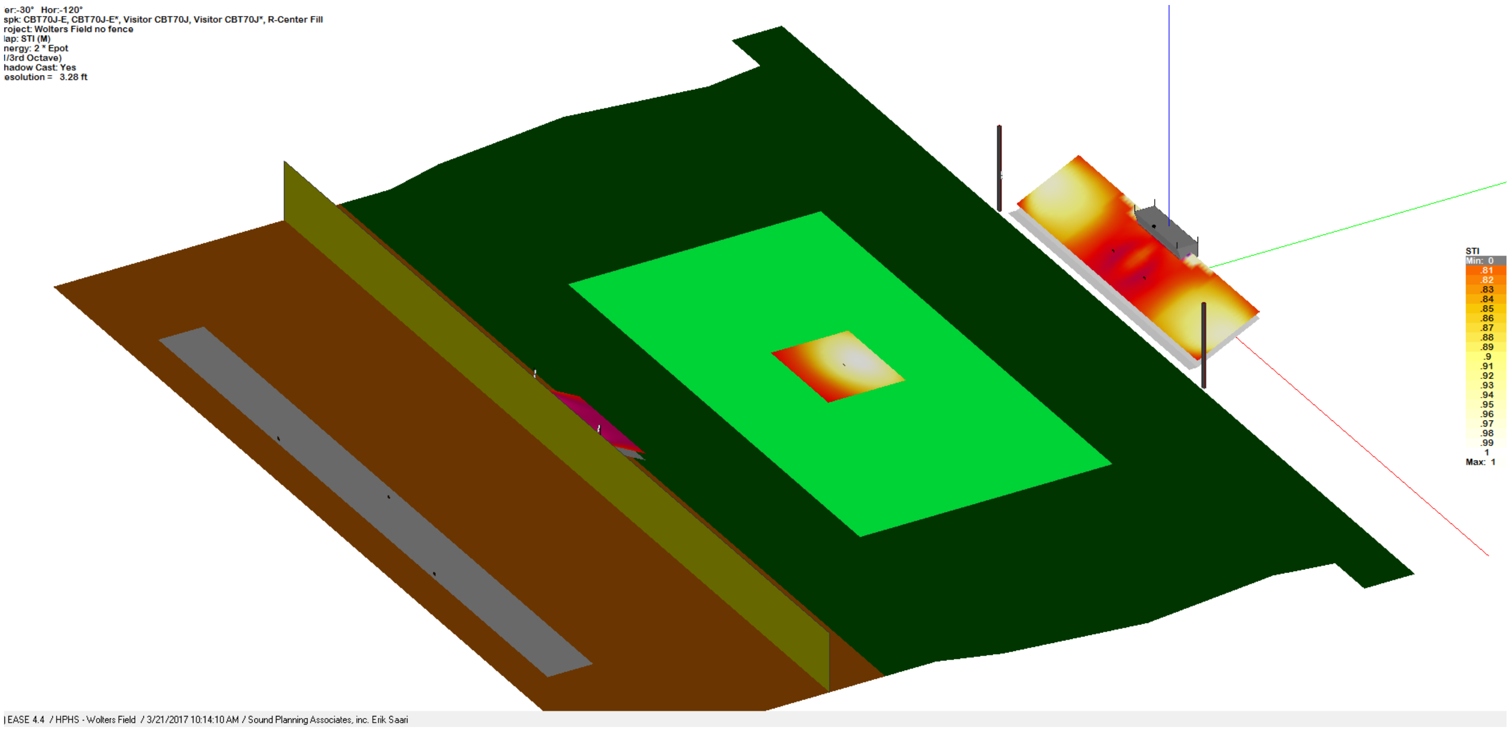
# Alternate Loudspeakers & Barrier Wall Direct SPL




# Alternate Loudspeakers & Barrier Wall Total SPL

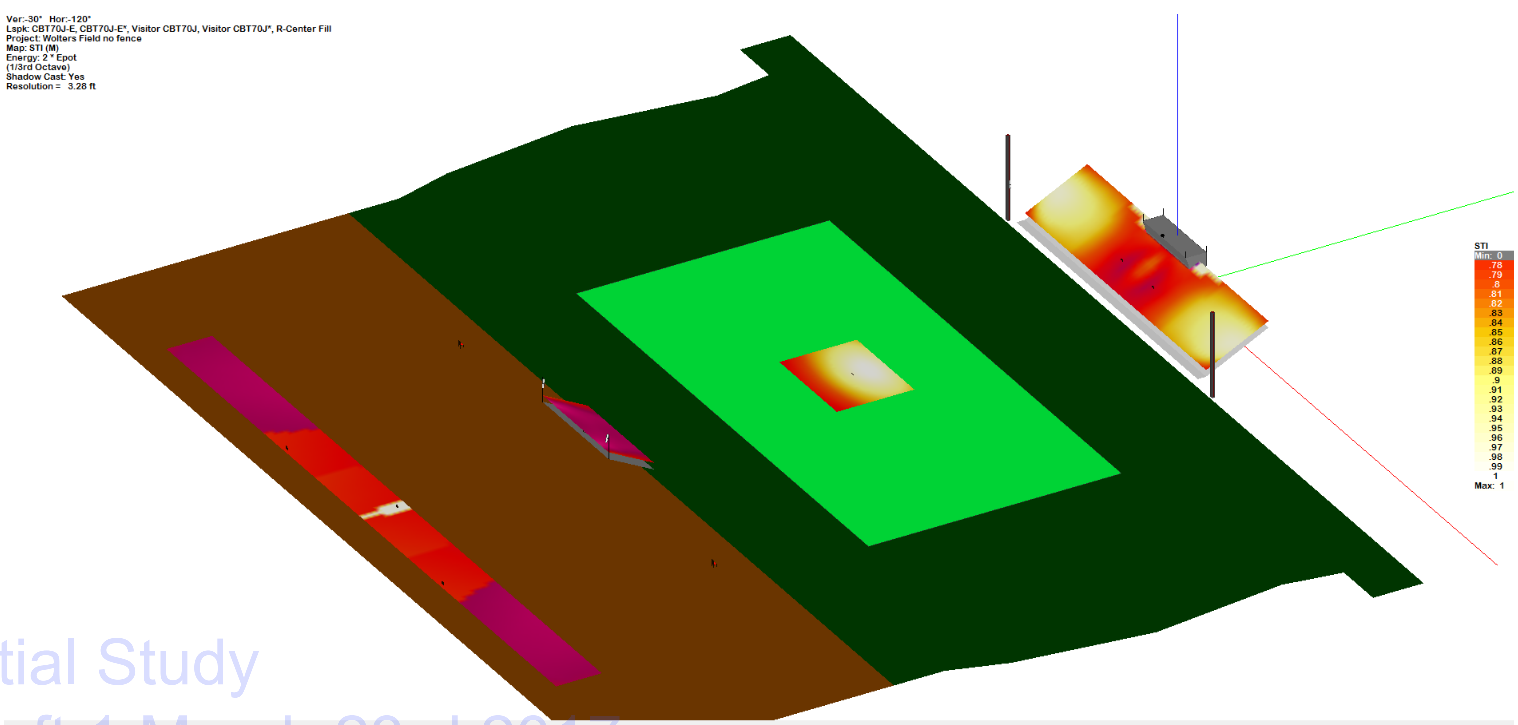


# Alternate Loudspeakers & Barrier Wall STI




This test is for speech transmission index (STI). This tests the intelligibility of the system at the audience. Note that with the barrier wall, that the neighbors are completely out of range for speech. But that does not mean that there is no sound reaching the areas. It's just that this sound will be very low frequency rich and not understandable.

# Alternate Loudspeakers STI (no wall)



# Existing Loudspeakers STI