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LSTN

Robert B. Mudd
President and COO
Notes Live
1830 Jet Stream Dr
Colorado Springs, CO 80921
678-617-4726
bmudd@noteslive.vip

LSTN Consultants LLC
76 Beaver St Fl 2
New York NY 10005
347-788-0810

Subject: Sunset Amphitheater
Environmental Noise Emissions

Dear Bob,

In this document we summarize our current environmental noise assessment for the development of the Sunset Amphitheater in Colorado Springs. We recommend that this progress be submitted and/or reviewed with the Planning and Community Development Department.

Please let us know if you or the municipality have any questions.

Yours Sincerely,

MATT MAHON

Matt Mahon

Partner, LSTN Consultants

CC: Ken Andria, LSTN

1 BACKGROUND

- B Entertainment/Notes Live (Notes) is developing the Sunset Amphitheater at Polaris Point in Colorado Springs.
- Notes and Executive Consulting Engineers are seeking relevant planning approvals and, as part of that effort, has requested LSTN to provide an environmental noise assessment.
- This document summarizes our current environmental noise assessment. We recommend that this document be reviewed with the municipality.

2 NOISE CODE

The noise code for Colorado Springs is captured in the Code of Ordinances, Chapter 9 (Public Offenses), Article 8 (Offenses Affecting the Environment).

Relevant sections of the noise code are reproduced below for reference.

9.8.101: Noise Prohibited:

A. It is unlawful to make, create, or permit an excessive or unusually loud noise, or a noise which endangers public safety, or a noise which is harmful to any person, which can be heard without the use of an electronic measurement device or heard and measured in the manner prescribed in section 9.8.103 of this part; except when made under and in compliance with a permit issued pursuant to section 9.8.109 of this part.

[...]

9.8.103: Classification, Measurement of Noise:

For purposes of determining and classifying any noise as excessive or unusually loud as declared to be unlawful and prohibited by this article, the following test measurements and requirements may be applied. A violation of sections 9.8.101 and 9.8.102 of this part may, however, occur without the following measurements being made:

A. Distance Of Measurement: Noise occurring within the jurisdiction of the City shall be measured at a distance of at least twenty five feet (25') from a noise source located within the public right of way, and if the noise source is located on private property or property other than the public right of way, at least twenty five feet (25') from the property line of the property on which the noise source is located.

B. Measurement:
   1. The noise shall be measured on the A weighing scale on sound level meter of standard design and quality and having characteristics established by the American National Standards Institute.
   2. For purposes of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of the measurement is not more than five (5) miles per hour, or twenty five (25) miles per hour with a windscreen.
   3. In all sound level measurements consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of the sound level measurement. (Ord. 96-41; Ord. 01-42)

9.8.104: Permissible Noise Levels:

A noise measured or registered as provided in section 9.8.103 of this part from any source other than as provided in section 9.8.109 of this part at a level which is equal to or in excess of the db(A) established for the time period and zones listed in this section, is declared to be excessive and unusually loud and is unlawful.

Zone	7:00 A.M. To Next 7:00P.M.	7:00 P.M. To Next 7:00 A.M.
Residential	55 dB(A)	50 dB(A)
Commercial	60 dB(A)	55 dB(A)
Light Industrial	70 dB(A)	65 dB(A)
Industrial	80 dB(A)	75 dB(A)

For purposes of this section only, these zones shall be defined as follows:

A. Residential: An area of single or multi-family dwellings where businesses may or may not be conducted in the dwellings. The zone includes areas where multiple-unit dwellings, high rise apartment districts, and redevelopment districts are located. A residential zone may include areas containing accommodations for transients such as motels and hotels and residential areas with limited office development, but it may not include retail shopping facilities. Residential zone includes educational facilities, hospitals, nursing homes and similar institutions.

B. Commercial:
   1. An area where offices, clinics and the facilities needed to serve them are located;
   2. An area with local shopping and service establishments located within walking distances of the residents served;
   3. A tourist oriented area where hotels, motels and gasoline stations are located;
   4. A large integrated regional shopping center;
   5. A business strip along a main street containing offices, retail businesses and commercial enterprises;
   6. A central business district; or
   7. A commercially dominated area with multiple-unit dwellings.

C. Light Industrial:
   1. An area containing clean and quiet research laboratories;
   2. An area containing light industrial activities which are clean and quiet;
   3. An area containing warehousing; or
   4. An area in which other activities are conducted where the general environment is free from concentrated industrial activity.

D. Industrial: An area in which noise restrictions on industry are necessary to protect the value of adjacent properties for other economic activity, but shall not include agricultural operations.

E. Adjacent Zones: When a noise source can be measured from more than one zone, the permissible sound level of the more restrictive zone shall govern. (Ord. 96-41; Ord. 01-42)

9.8.109: Hardship Permits:

Applications for a permit, for other than vehicular traffic, for relief from the noise level designated in this part on the basis of undue hardship may be made to the Mayor. Any permit granted by the Mayor shall contain all conditions upon which the permit has been granted and shall specify a reasonable time for which the permit shall be effective. The Mayor is authorized to designate a fee which reasonably covers administrative costs incurred for the issuance of the permit. The Mayor may grant the relief as applied for if it is found:

A. That additional time is necessary for the applicant to alter or modify the activity or operation to comply with this part; or
B. The activity, operation or noise source will be of temporary duration, and cannot be done in a manner that would comply with sections 9.8.104, 9.8.105, 9.8.106 and 9.8.107 of this part.
C. That no other reasonable alternative is available to the applicant; and
D. The Mayor may prescribe any conditions or requirements deemed necessary to minimize adverse effects upon the community or the surrounding neighborhood. (Ord. 96-41; Ord. 01-42; Ord. 11-19)

3 PREVIOUS ANALYSIS

Merck & Hill's report 3729-R01 (dated 2022-03-09) documents an initial assessment of potential sound impacts from concerts at the amphitheater. The report assumes a typical sound reinforcement system that can produce noise levels typical for concerts at venues of this size and typology.

Merck and Hill estimates a level difference of ~47dB (broadband) from the venue to nearby residences (e.g. If the venue sound system is operated at 100dB(A) at 60ft from the stage, they expect this to result in a noise spill of 53dB(A) outside the residences located ~3,500ft away).

This analysis is broadly consistent with our analysis and indicates that, without mitigation, the venue may intermittently exceed the limits set in the noise code.

4 VENUE PROGRAMMING AND SOUND SYSTEM CHARACTERIZATION

To refine and advance the design of the amphitheater, we have worked to further characterize its use and the sound systems which would be used.

The noise levels expected to be generated at the amphitheater during events will relate to two primary factors:

- The types of events produced
- The types of sound systems used

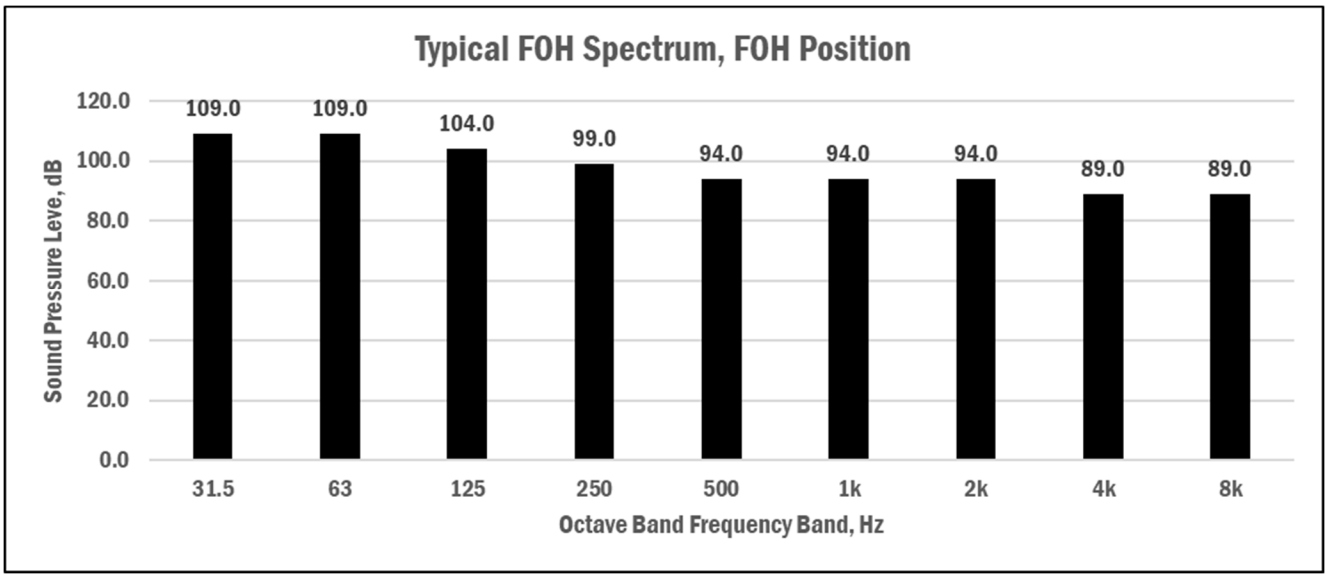
Notes propose to operate an amphitheater that will host live musical performances. The venue may host stand-alone productions and events but will primarily host tours that travel between similar venues to different regions.

For an idea of the programming for such a venue, consider the upcoming performers at the popular Red Rocks Amphitheatre outside of Denver, CO, reproduced here. The performances include a mix of Rock, Pop, Hip Hop, Electronic, and Folk genres.

Such performances rely on sound systems to amplify/reinforce sound produced on stage for the audience. The music performed is typically broad spectrum, i.e. it includes sounds across the audible frequency spectrum.

The level and spectrum of sound varies throughout a performance and will differ broadly between different performance types (e.g. Electronic and Hip Hop performances typically have more low frequency sound than folk music).

Despite significant variation, we can make reasonable assumptions about the typical frequency spectrum and sound level produced for typical events to facilitate estimating environmental noise. The spectrum below corresponds to 100dB(A) of broadband sound, which would be a reasonable level for a performance to reinforce at the front of house (FOH) mix position, ~100ft from the stage. Note, these would be common peak levels to hit periodically during a single song (not average levels).



It is typical for acts touring venues of this type to travel with a main sound system which would be deployed to each side of the stage.

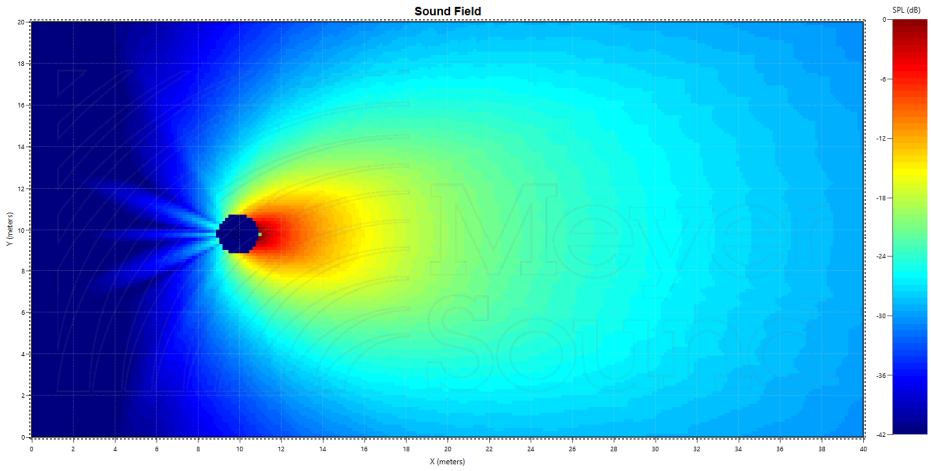
Tours typically deploy line array-type main loudspeakers. Line arrays consist of individual loudspeaker cabinets that are arrayed vertically together, as shown above.

Subwoofers are often hung in vertical arrays as shown in the left two images above. But sometimes they are stage-stacked as shown on the right.

The primary function of a sound system is to provide adequate sound level to the audience. Sound should also be consistent across the audience, i.e. not too loud at the front and too quiet at the back.

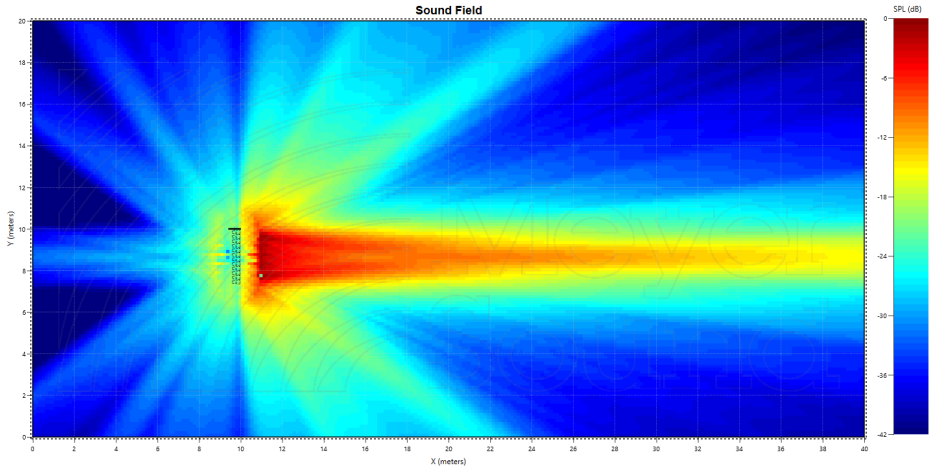
In addition to sound power output, a core characteristic of loudspeakers is directivity—How much sound energy the loudspeaker emits in different directions.

The physical design of line array loudspeakers inherently provides wide, even coverage over typical festival and amphitheater audience areas and limits noise spill in other directions.



Typical Horizontal Line Array Directivity

Note the line array's ability to limit sound emissions in the vertical plane to the axis of the loudspeaker—Little sound is "wasted" off axis. Though tours carry line array loudspeakers with different manufacturers, detailed specifications, and quantities, in practice the variation between typical line arrays is not significant.



Typical Vertical Line Array Directivity

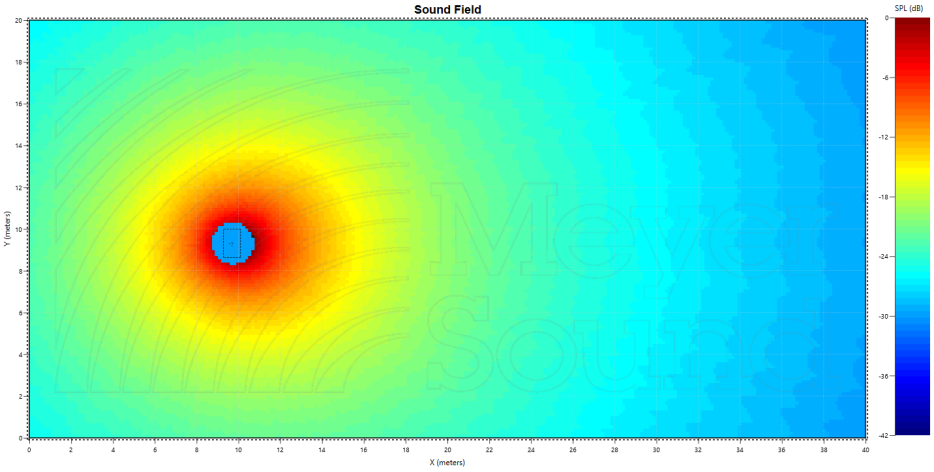
The analysis presented here was based on a Meyer LEO-M loudspeakers and is representative of all common touring line arrays (D&B, L'Acoustics, JBL, EAW, Nexo, Clair, etc)

Subwoofer systems have greater variation in their physical deployment (as shown in the photos above) and in their interior construction that can impact their directivity.

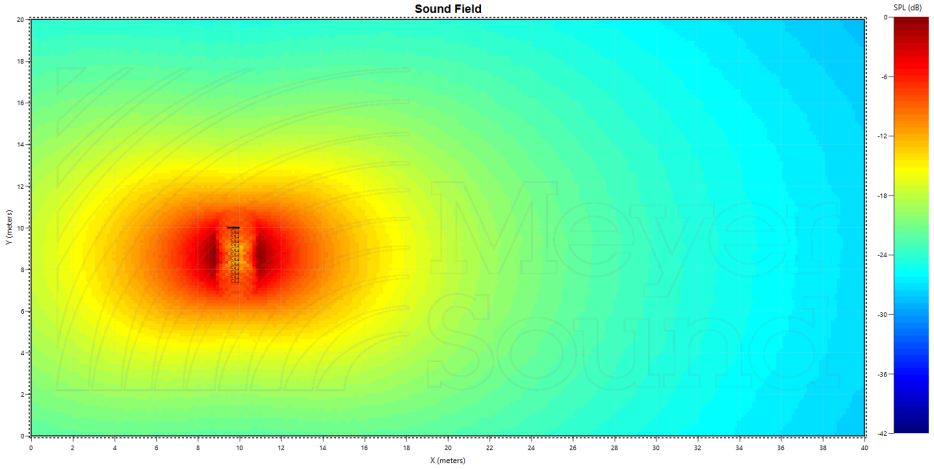
A basic individual subwoofer is effectively omnidirectional (in the vertical and horizontal planes).

When you array basic subwoofers vertically (like the line array loudspeakers), the subwoofer array exhibits pattern control in the vertical direction. In plan, the directivity is effectively unchanged.

Cardioid directivity for subwoofers can be accomplished with either inherently cardioid subwoofer cabinets or by reorienting subwoofer cabinets in array. There is significant variation on the methods to achieve cardioid subwoofer directivity.



Typical Omnidirectional Subwoofer Directivity



Vertical Array Subwoofer Directivity

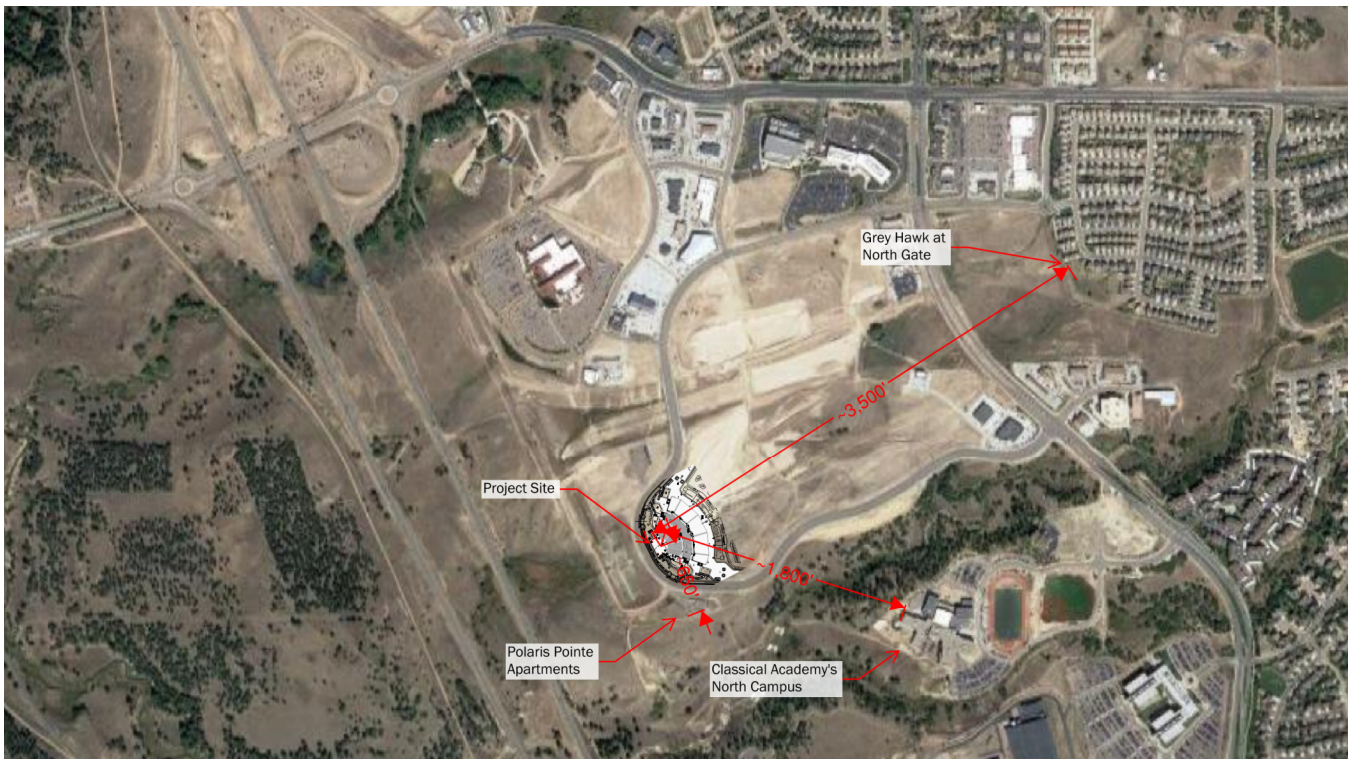
5 ENVIRONMENTAL NOISE MITIGATION

We propose to incorporate mitigation measures that will reduce environmental noise. Noise emissions to the surrounding environment can be mitigated the following factors:

- Physical Mitigation
- Electroacoustic Mitigation
- Operational Mitigation

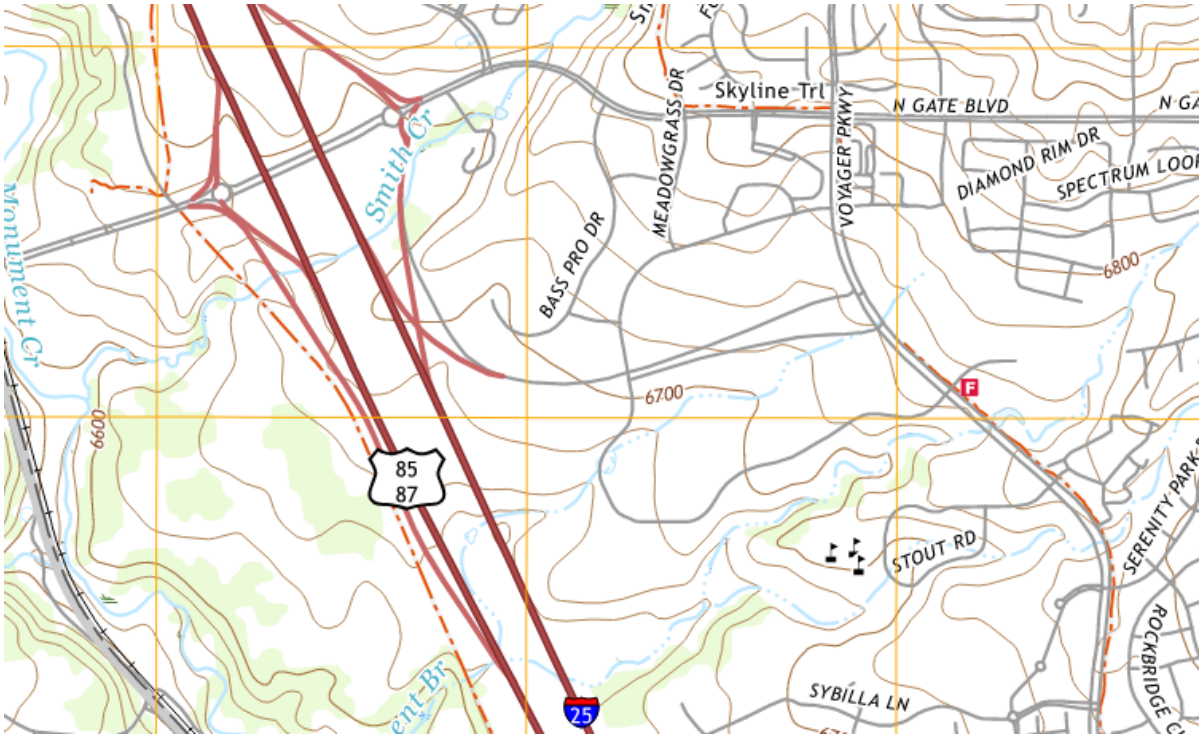
Physical Mitigation

The proposed amphitheater is located in North Gate, Colorado Springs in the Polaris Pointe Development. Much of the immediately surrounding areas are undeveloped, a part of Polaris Pointe. There are single family homes located approximately 3500ft away to the northeast (Grey Hawk at North Gate subdivision). A school (the Classical Academy's North Campus) is located approximately 1,800ft to the east. The Polaris Pointe apartments are under construction approximately 650ft to the south. Interstate 25 runs along the entire west-southwest of the project site. An interstate off-ramp is being constructed to the northeast.



The site's location near the interstate employs good planning practice—the site and nearby environs are already impacted by the interstate noise, reducing the impact of the amphitheater.

The natural terrain generally slopes down towards the proposed amphitheater site from the northeast.

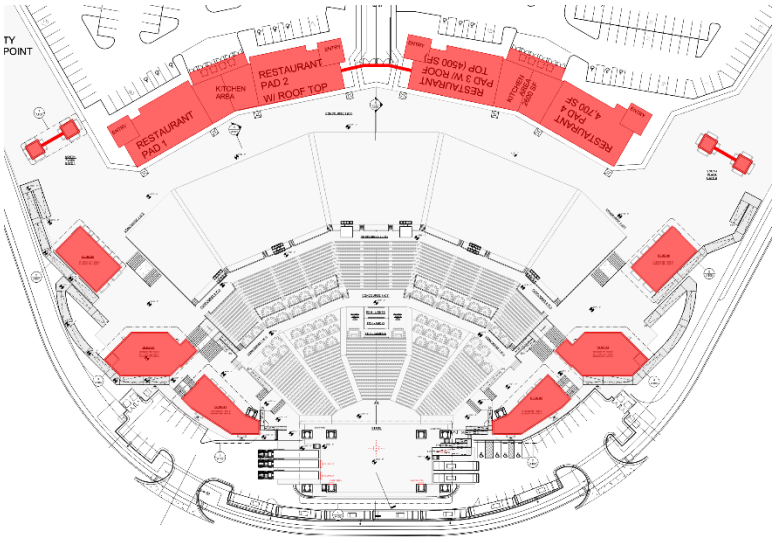


The stage has been located at a low point on the site, 6675'6" elevation.

The layout employs several inherent physical mitigation strategies:

- **By lowering the stage below the surrounding terrain, the amphitheater seating and surrounding earthworks can serve as a barrier/berm to reduce environmental noise emissions.**
- **By locating the stage as far west as practical, we increase the distance sound must travel to nearby noise sensitive areas, reducing noise levels.**

The design further incorporates amphitheater amenity buildings to each side of the seating bowl and a row of restaurant buildings at the rear of the seating bowl. It is intended that the gaps between rear restaurants be infilled with gates and walls that can function as noise barriers. **These buildings will serve as barriers and will provide further reduction of environmental noise emissions, particularly to the northeast and east, the direction of most noise sensitive development.**



Electroacoustic Mitigation

As described in the section on sound system characterization, the types of loudspeakers typically used for performances demonstrate inherent benefits for the control of environmental noise:

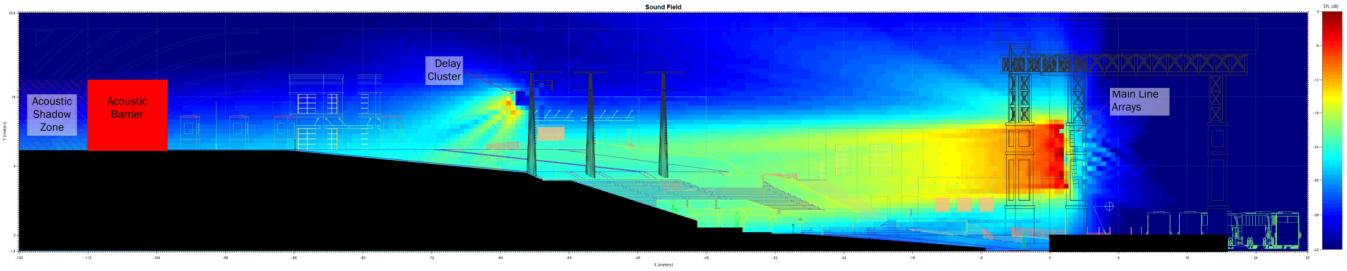
- Sound from line arrays is vertically controlled to allow directing sound to the audience, without sending sound higher vertically. This will reduce noise emissions from the amphitheater to the northeast and east and compounds the effect of the rear buildings/barriers.
- Some subwoofer systems may be deployed in configurations to affect a cardioid directivity. This will avoid noise spill to the rear of the stage. For this project, this effect is not significant due to the siting of the stage area and the non-noise sensitive interstate behind stage.
- Vertical subwoofer arrays, like line arrays, will provide the best vertical control of low frequency sound.

To further reduce sound system noise spill, the design proposes to incorporate house delay loudspeaker clusters that would be located at the front of the rear lawn (as illustrated in the mapping below). By using delay clusters, all loudspeakers (main loudspeakers at stage and delay clusters) may be operated at a lower overall sound power thus reducing overall noise emissions.

Aggregate Effect

The Physical and Electroacoustic mitigation measures described above are expected to significantly reduce environmental noise emissions from the amphitheater, particularly toward the northeast and east (i.e. away from the interstate where most noise sensitive receivers are located). In the table below, we summarize initial analysis of the benefits of the physical and electroacoustic mitigation measures. The residential values represent estimated noise levels 3,500ft distant to the northeast.

	Decibels, dB at Octave Band Center Frequency, Hz								
Estimate	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**Overall**
FOH Mix Position	109	104	99	94	94	94	89	89	100dB(A)
NE Residence, No Mitigation	78	73	67	60	58	54	34	0	64dB(A)
NE Residence, w/ Electroacoustic Mitigation	77	72	64	56	50	43	24	0	61dB(A)
NE Residence, w/ Cumulative Electroacoustic and Physical Mitigation	**66**	**60**	**49**	**39**	**31**	**21**	**0**	**0**	**47dB(A)**



These mitigation measures incorporated in the design significantly reduce environmental noise emissions and reduce disturbance to the surrounding areas:

- Delay clusters lower the overall sound power generated by the amphitheater.
- The inherent line array effects provide a reduction in noise level increasing above 250Hz.
- The siting and barriers provide benefits even at low frequencies, provided the barriers can break the “line of sight” between the sound system and noise sensitive receivers.

These results are typical for outdoor amphitheaters—High frequency sounds are well attenuated by barriers and air absorption at reasonable distances from the amphitheater. Low frequency sounds are the hardest to reduce at distance, but barriers are most effective to attenuate those sounds.

Operational Mitigation

In addition to the physical and electroacoustic mitigation described in the preceding sections, we propose that the amphitheater should adopt additional operational mitigations strategies. These are appropriate both as a good faith effort as a member of the community and to address the limitations of the physical and electroacoustic mitigation strategies:

- Some productions may be inclined to operate sound systems at noise levels in excess of our assumed spectrum.
- Weather events (wind, temperature inversions) may cause noise emissions in excess of those estimated here.

As such, the following specific operational mitigation strategies have been developed with Notes:

Seasonal Use	The venue expects to be used in the months of May to September. No environmental impact would be expected when not in use.
Frequency of Use	The venue is expected to typically host performances Thursday through Saturday during its season. Performances may be hosted on other days of the week, contingent on approvals by parking partners.

Operating Hours	• Saturday
	  • Events would typically occur during the afternoon and evening.
	  • Performances would typically begin between 3-8pm.
	  • Sound check would begin after 12pm.
	  • Performances would end not later than 11:30pm.
	• Friday
	  • Events would typically occur during the evening.
	  • Performances would typically begin between 7-8pm.
	  • Sound check would begin after 3pm.
	  • Performances would end not later than 11:30pm.
	• Thursday (or any other approved day)
	  • Events would typically occur during the evening.
	  • Performances would typically begin between 7-8pm.
	  • Sound check would begin after 3pm.
	  • Performances would end not later than 10:30pm.

Controls on Touring Sound Systems	• The main loudspeakers of touring sound systems are expected to be line-array type. • The main loudspeakers and subwoofers would be rigged no higher than 40ft above stage. • Where practical, subwoofers can be arrayed vertically, rather than stage stacked. • Performances are expected to make use of permanently installed delay cluster loudspeakers. Main loudspeakers would be rigged and aimed only to serve the lower, seated sections.

Noise Monitoring and Performance Controls	**The amphitheater is expected to establish operational maximum sound levels for performances and if performances exceed these levels, active steps would be taken to reduce noise levels.**
	• Noise monitoring would be conducted during performances at the FOH Mix position and at least two key locations at the perimeter of the amphitheater consistent with the noise code. The limits at FOH are expected as follows:
	  • The broadband noise levels measured at the FOH mix position:
	  • A maximum of 110dB(A) more than once during any five-minute period.
	  • An average (Leq) of 105dB(A) during any five-minute period
	  • From 20 – 80Hz, measured noise levels at the FOH mix position in any 1/3 octave band:
	  • A maximum of 125dB more than once during any five-minute period.
	  • An average (Leq) of 115dB during any five-minute period
	• Should noise levels exceed those documented above, the venue operator would promptly inform the event production team and instruct the event production team to reduce noise levels to a level appropriate to maintain the requirements.
	• Event production teams are expected be obligated by their contracts to comply with the venue operator's directions and may be subject to prematurely terminating events if the performance remains out of compliance.

Annual Reporting	• The venue operator is expected to compile an annual document that reports the date and time of past events, a summary of monitored noise levels, and any complaints received from the city or neighbors. The report is expected to discuss any methods further employed to reduce environmental noise emissions.

6 NEXT STEPS

We propose the assessment here be reviewed with the municipality. The design team anticipates environmental noise modeling once the site grading and civil design is complete to optimize mitigation of environmental noise further.