Appendix E. Noise Assessment Report

Noise Assessment Report

10/15/2026

South Fork Solar

South Fork Solar, LLC



Paxwood Acoustics

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1.0 Introduction

South Fork Solar, LLC (“Applicant”) is planning to develop a 45 MW (AC) solar project in Nicholas County, Kentucky (“Project”). Paxwood Acoustics was retained by the Applicant to conduct a noise assessment of the Project.

Based on the information provided in this report, the Project is expected to produce sound levels that are below the commonly-used community noise guidelines which are discussion in Section 3.2.

This report includes:

- A description of the Project,
- A discussion of noise standards and guidelines,
- Sound propagation modeling procedure and results for operational noise,
- A discussion on sound levels from construction activities, and
- Conclusions

In addition, an introduction to acoustics is provided in Appendix A, model input data is in Appendix B, tabular model results are reported in Appendix C, and information about Paxwood Acoustics is provided in Appendix D.

2.0 Project Description

The proposed Project is a 45 MW (AC) photovoltaic solar project that would be located in Nicholas County, Kentucky in an area between Carpenter Pike Road and Miller Station Road, southeast of the Nicholas County industrial park. The area around the Project is composed primarily of agricultural land use with some forested areas. There are some rural residences in the vicinity of the Project.

The primary equipment that has the potential to produce sound includes 13 centralized inverters located on skids throughout the solar arrays, medium voltage transformers that are co-located on each inverter skid, and a medium power transformer at the Project substation. The substation is planned to be located in the north-central section of the Project area on County Road 1215.

The Project is unlikely to use the inverters at night for VAR[1] support, so the only source of sound at night would be the transformers which remain energized. Additional information on the inverters and transformers is provided in Section 4.2.

A map of the proposed Project showing the solar arrays, inverters, substation, modeled receptors and the surrounding area is provided in Figure 1.

[1] Volt-ampere reactive. Inverters can be used for VAR support which helps to manage reactive power on the grid.



Figure 1: Map of the Project and the Surrounding Area

3.0 Noise Standards

3.1 Local Standards & State Regulations

There are no local or state sound level limits that apply to the Project.

3.2 Community Noise Guidelines

EPA Guidelines

In 1974, the EPA's Office of Noise Abatement and Control published the guidance document, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." The guidance identifies a day-night level (L_{dn}) of 55 dBA as being protective of public health and welfare with a margin of safety for outdoor residential areas and other outdoor areas where people spend time and for which quiet is a basis for use. The L_{DN} is the average sound level over the course of 24 hours with a 10 dB penalty applied to nighttime (10 PM to 7 AM) sound levels. An L_{dn} of 55 dBA equates approximately to a continuous equivalent level (L_{eq}) of 48 to 49 dBA. The day-night level and other acoustical metrics are discussed further in Appendix A.

World Health Organization Guidelines

The World Health Organization ("WHO") has published community noise guidelines[2] that provide guideline sound levels for specific environments to protect against specified effects. The guidelines are based on scientific knowledge of health impacts due to community noise. The most relevant guidelines from the WHO document for these Projects are:

- 55 dBA $L_{eq(16\text{-}hr)}$ to protect against serious annoyance during the day and evening in an outdoor living environment.
- 50 dBA $L_{eq(16\text{-}hr)}$ to protect against moderate annoyance during the day and evening in an outdoor living environment.
- 45 dBA $L_{eq(8\text{-}hr)}$ and 60 dBA L_{fmax} to protect against sleep disturbance outside a bedroom window.
- 70 dBA $L_{eq(24\text{-}hr)}$ and 110 L_{fmax} outdoors or indoors to protect against hearing impairment.

This noise assessment provides a comparison of the projected sound levels from the Project with these community noise guidelines.

[2] WHO, "Guidelines for Community Noise", 1999.

4.0 Sound Propagation Modeling

4.1 Modeling Procedure & Settings

Sound propagation modeling was completed using the modeling software CadnaA made by DataKustik GmbH. CadnaA implements the international sound propagation standards, ISO 9613-2 "Acoustics - Attenuation of sound during propagation outdoors - Part 2: Engineering method for the prediction of sound pressure levels outdoors." Both CadnaA and the ISO 9613-2 standard are used by noise control professionals across the United States and are regularly relied upon by local and state jurisdictions including the Kentucky Public Service Commission. The model takes into account source sound emissions, topography, receptor locations, and several other factors. It calculates sound levels for meteorological conditions that are favorable for sound propagation, assuming that all receptors are downwind of the sound sources.

For this assessment, USGS terrain data was used for the Project to create the three-dimensional topography throughout the surrounding area. Other site features, including the proposed locations of equipment, the receptor locations, and Project boundaries were provided by the Applicant. Model setting and input data are provided in Appendix B.

4.2 Modeled Sound Sources

Inverter Skids

The model included sound emissions from 13 centralized inverter skids (Sungrow SG4400UD-MV-US). The sound emissions from the inverters were based on a test report provided by the manufacturer which indicates an average sound power level of 97 dBA. Each inverter skid also includes a medium voltage transformer (MVT). At night when only the MVT would be operational, the 4.4 MVA transformer would have a sound power level of 78 dBA. Modeled sound power levels for the inverters are provided in Appendix B.

Substation Transformer

One medium power transformer (MPT) (42/56/70 MVA, 350 kV BIL) was modeled at the Project substation. The rated sound pressure level of the MPT based on the physical size and the NEMA TP80050 standard[3] is 68 dBA ONAF[4] and 65 dBA ONAN[5]. Modeled sound power levels for the MPT is provided in Appendix B.

[3] NEMA TP-80050 (formerly TR-1), Transformers, Regulators, and Reactors.
[4] ONAF: Oil Natural Air Forced
[5] ONAN: Oil Natural Air Natural

4.3 Model Results of Project Operations

Sound levels were calculated throughout the area at a grid of receptors that were spaced every 10 feet (3.05 meters). Each receptor was placed 5 feet (1.5 meters) above the ground level representing the approximate height of a listener's ear. Based on the grid of receptors, sound level iso-lines are generated throughout the area so that the projected sound levels can be shown all along the Project property line and the surrounding area. In addition, sound levels were calculated at 21 discrete receptors around the Project area at a height of 5 feet (1.5 meters) above ground level, representing area residences.

The inverters and transformers may produce sound during the day, but only the transformers would produce sound at night. Given this, two model scenarios are included in this assessment:

- Daytime Scenario: Includes all inverters and the transformer (ONAF mode) operating simultaneously.
- Nighttime Scenario: Only includes the transformers (ONAN for the medium voltage transformers at each inverter skid, and ONAF for the MPT at the substation)

The model results for the daytime scenario are presented in Figure 2, and the results for the nighttime scenario are presented in Figure 3. Sound levels are represented by sound level isolines in 1 dB intervals with grey dashed lines while the 5 dB intervals are represented by solid color lines. The highest projected sound level at a residence and at the Project site boundary is called out on each map for ease of reading. Projected sound levels at each receptor are provided in tabular format in Appendix C.

As shown in Figure 2 and Figure 3, the highest projected sound level at a residence is 33 dBA during the day and 22 dBA at night. The highest projected sound level at the Project boundary occurs on the western side of the project near an inverter, where the projected sound level is 50 dBA during the day and 28 dBA at night. These projected sound levels are less than the community noise guidelines discussed in Section 3.2.

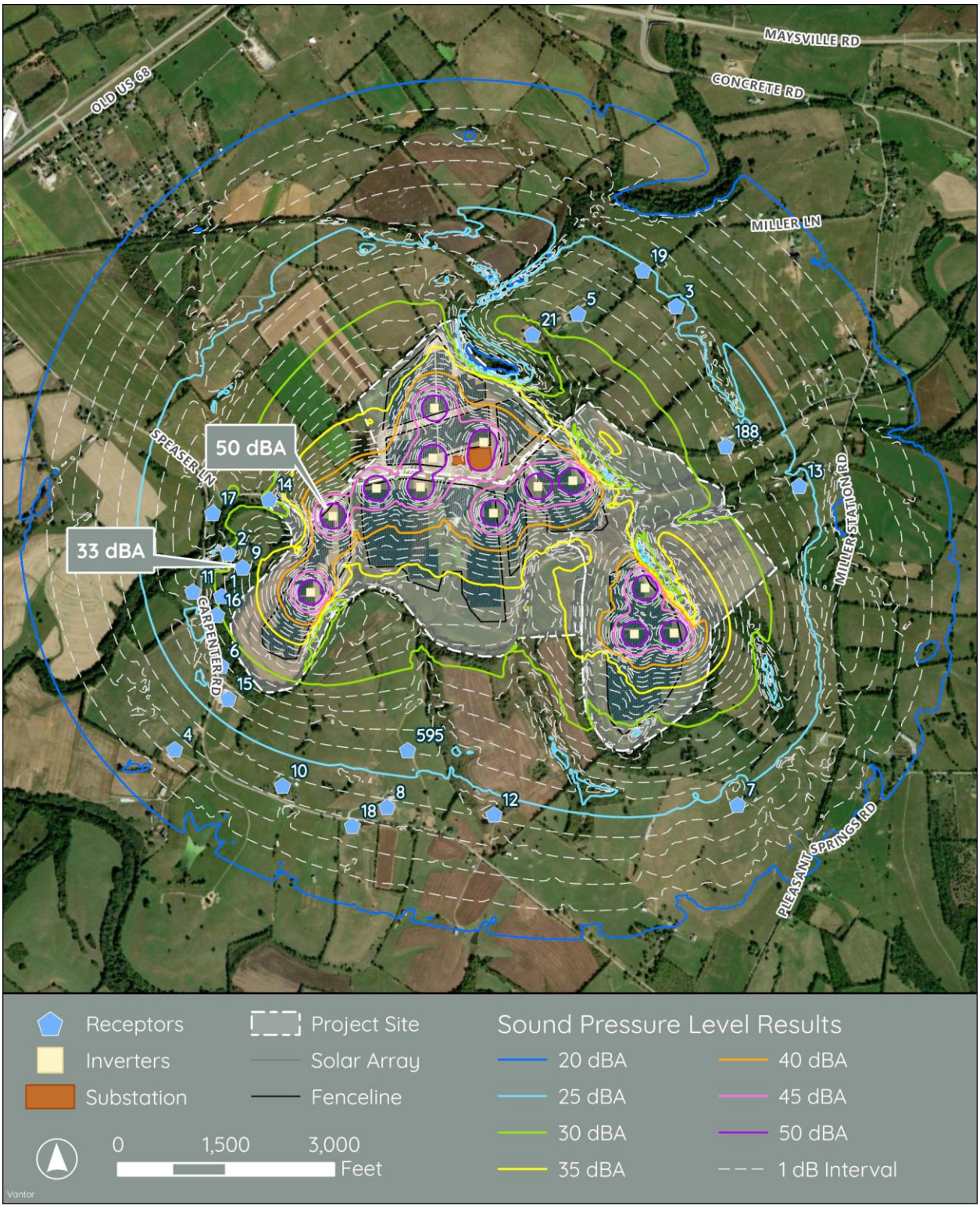


Figure 2: Map of Modeled Sound Pressure Levels, Daytime Scenario

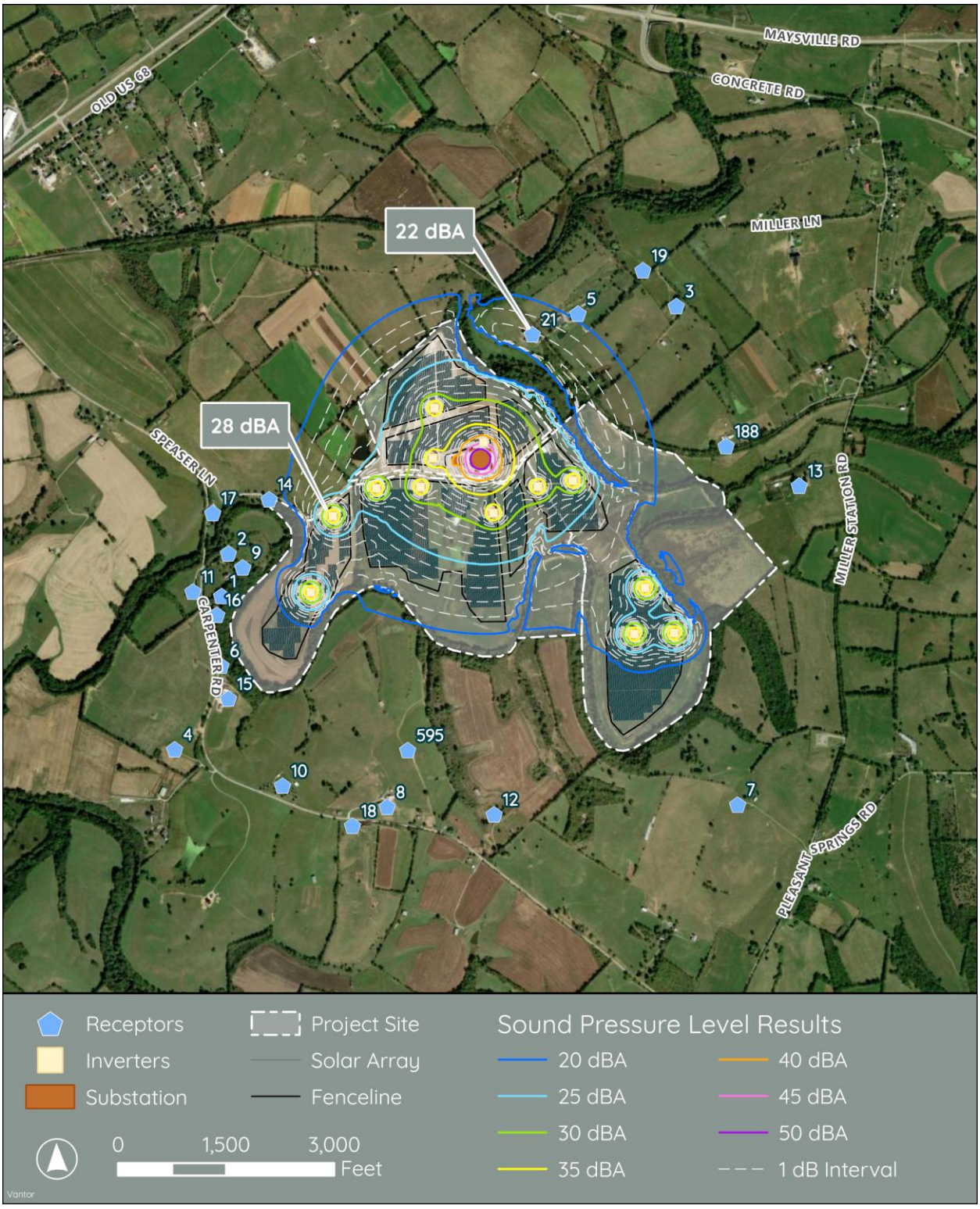


Figure 3: Map of Modeled Sound Pressure Levels, Nighttime Scenario

4.4 Sound Levels from Construction Activities

Construction Activities & Scheduling

Construction of a solar power project involves several different phases or activities that do not occur all at once but may have some degree of overlap in terms of their scheduling. The primary categories of activities include:

- Groundwork or site preparation which includes clearing, grading, and access construction;
- Array preparation which typically includes pile driving or drilling to prepare the base supports for the arrays;
- Racking and solar panel installation;
- Electrical work including trenching or horizontal drilling (HDD) for cables;
- Substation construction; and
- Equipment installation including inverters and transformers.

While construction of the entire Project is expected to last approximately 12 to 18 months, all of these activities are intermittent, and for a given area occur over a relatively short period of time.

Construction Equipment & Sound Levels

While some construction activities produce little noise such as assembly and wiring, some involve the use of heavy machinery. Sound levels from some of the louder machinery that may be used during construction are provided in Table 1. Sound levels from construction will vary by location and distance to the equipment, but those provided in Table 1 are representative of some of the closest sensitive receptor distances. Receptors at further distances would result in lower sound levels than those shown in Table 1.

The primary source of the reference sound pressure levels that was used to generate the projected levels in Table 1 is the source emission data from NCHRP 25-49[6] which was used in the development of the Federal Highway Administration's (FHWA) Roadway Construction Noise Model 2.0 (RCNM 2.0). Sound levels from the construction equipment were calculated using ISO 9613-2, the same standard used for calculating the operational sound levels, with hard ground (G=0), flat terrain, and no attenuation due to forests, all conservative assumptions.

[6] National Cooperative Highway Research Program 25-49, Development of a Highway Construction Noise Prediction Model, 2018.

Lastly, both the maximum (L_{max}) and equivalent continuous sound level (L_{eq}) are reported in Table 1 for most equipment. One or more sound level parameters may be well suited to describe the amplitude of the sound experienced by a listener depending on the nature of the equipment. For example, the bucket on an excavator may hit a rock which can cause a louder short-term sound, while at other times, the primary sound from the excavator is the engine which is relatively consistent during the operation. The area in which a source operates also helps determine the best parameter to use. For example, a grader is best described by the maximum sound level because it only briefly passes by a listener location. It is for these reasons that both the L_{max} and L_{eq} values are provided for some equipment, but only L_{max} is provided for other equipment. For equipment where only the L_{max} is provided, the L_{eq} is listed as not applicable ("NA").

Table 1: Projected Sound Levels (dBA) from Construction Equipment[7]

Equipment	Reference Point (50 ft)		Closest Panel to Residence (605 ft)		Closest Inverter to Residence (875 ft)	
	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}
Rock Drill	95	91	73	69	69	66
Solar Post Pile Driver	100	94	79	73	76	70
Forklift	88	NA	68	NA	65	NA
HDD	88	74	66	53	63	50
Concrete Pump Truck	87	83	67	63	64	60
Excavator	87	76	66	55	63	52
Dozer	86	80	65	59	62	56
Roller	82	NA	62	NA	59	NA
Concrete Mixer Truck	82	81	61	60	58	57
Grader	78	NA	58	NA	55	NA
Crane	76	74	55	53	52	50
Plate Compactor	75	NA	54	NA	51	NA
Flat Bed Truck Passby	74	NA	53	NA	50	NA
Man Lift	73	72	52	51	49	48
Dump Truck Passby	73	NA	52	NA	49	NA
Generator	68	67	47	47	44	44

[7] Most of the source emission data comes from NCHRP 25-49[6]. The sound emission data for the Solar Post Pile Driver is published in the Vermeer PD10 Operator Manual (Deutz engine option).

5.0 Conclusions

Paxwood Acoustics conducted a noise assessment of the proposed South Fork Solar Project located in Nicholas County, Kentucky. The Project will have a total capacity of 45 MW (AC). This noise assessment included identification of the primary and secondary Project equipment that can create sound, a discussion of noise standards and community noise guidelines, sound propagation modeling to project operational sound levels throughout the surrounding area, and information on construction noise.

As discussed in Section 4.3, the highest projected sound level a residential receptor is 33 dBA during the day and 22 dBA at night. The highest projected sound level at the Project boundary is 50 dBA during the day and 28 dBA at night. These sound levels are below the community noise guidelines discussed in Section 3.2.

Sound levels caused by construction activities were discussed in Section 4.4. Construction-related noise will vary depending on the phase of construction, equipment being used, and the distances between the construction activities and the receptors. However, construction in any given area will occur over a relatively brief period limiting potential impacts.

Appendix A: Introduction to Acoustics

Sound, Sources, and Perception

Sound in air is caused by fluctuations in air pressure which can be due to a variety of sources. Those sources fall into three broad categories: anthropogenic, biogenic, and geophonic. Anthropogenic sounds are human-caused, such as voices, instruments, vehicles, and mechanical and electrical equipment. Biogenic sounds are produced by organisms, such as animal calls or animals interacting with the environment. Geophonic sounds are produced by the environment itself, such as waves hitting a shoreline or wind interacting with plants or other objects.

There are three primary characteristics of sound that affect how people perceive it: frequency, which may also be described as pitch or tone; amplitude, which relates to perceived loudness or volume; and temporal fluctuation, meaning the way a sound changes over time.

Frequency

Humans can hear sound over a range of frequencies typically from 20 Hz to 20,000 Hz. While not strictly defined, this range can be divided into three subranges which are described as low frequency (20 Hz to around 250 Hz), mid frequency (around 250 Hz to around 4,000 Hz), and high frequency (around 4,000 Hz to 20,000 Hz). Most human speech occurs in the mid frequency range. For analysis, the range is divided into octave bands (31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz), or even further into 1/3 octave bands, which divide each octave band into three narrower bands. Sound below 20 Hz is referred to as infrasound and sound above 20,000 Hz is referred to as ultrasound; neither is typically audible to the human ear.

Most sounds are broadband in nature, meaning they contain energy across a range of frequencies. If, however, a sound contains notably more energy at one frequency compared to the adjacent frequencies, it may be perceived as a tone, such as a note in music.

Humans hear sound over a wide range of pressures, from approximately 20 micropascals to over 20 million micropascals. Sound can occur outside of this range, but pressures below 20 micropascals are typically inaudible and pressures above 20 million micropascals are typically perceived as painful. Because the range of audible sound pressures is so wide, acoustics compresses it onto a logarithmic scale, expressed in terms of decibels (dB), that acousticians and environmental regulations use to quantify the amplitude of sound.

Temporal Changes

Both frequency and amplitude can change with time. A sound may be constant in both frequency and level, but this is uncommon. Considering how the sound of people in conversation, birds chirping, or vehicles passing by varies from one moment to the next makes clear how much sound can change. For this reason, acousticians use a variety of metrics to define and describe sound. These metrics are discussed further below.

Weighting Networks, Sound Pressure Level, and Metrics

Weighting Networks

Humans are most sensitive to sound between 500 Hz and 5 kHz, and sensitivity decreases both below and above that range. The A-weighting network, or filter, was developed to approximate this variation in sensitivity and the way people perceive loudness. A-weighting discounts sound in varying degrees by frequency below 500 Hz and above 5,000 Hz. Between 1,000 Hz and 4,000 Hz, the A-weighting network amplifies sound slightly to account for the increased sensitivity of the human ear in that range. Since the A-weighting network accounts for human sensitivity at different frequencies, it is widely used in environmental acoustics and most environmental noise regulations. When a sound level is A-weighted, an “A” is typically added to the end of the abbreviation for decibel: dBA.

Other weighting networks exist for other purposes including C-, G-0 and Z- weighting, but A-weighting is the one mostly commonly used in environmental acoustics. If a sound is not weighted or sometimes referred to as unweighted, it is considered Z-weighted and is expressed as dBZ.

Sound Pressure Level

As noted above, the amplitude of sound is commonly expressed as sound pressure level. Representative sound pressure levels of some common sound sources and environments are shown in Figure 4. The sound levels presented in Figure 4 are illustrative, so any specific source or environment may be similar to, or fall outside of, the ranges shown in the graphic.

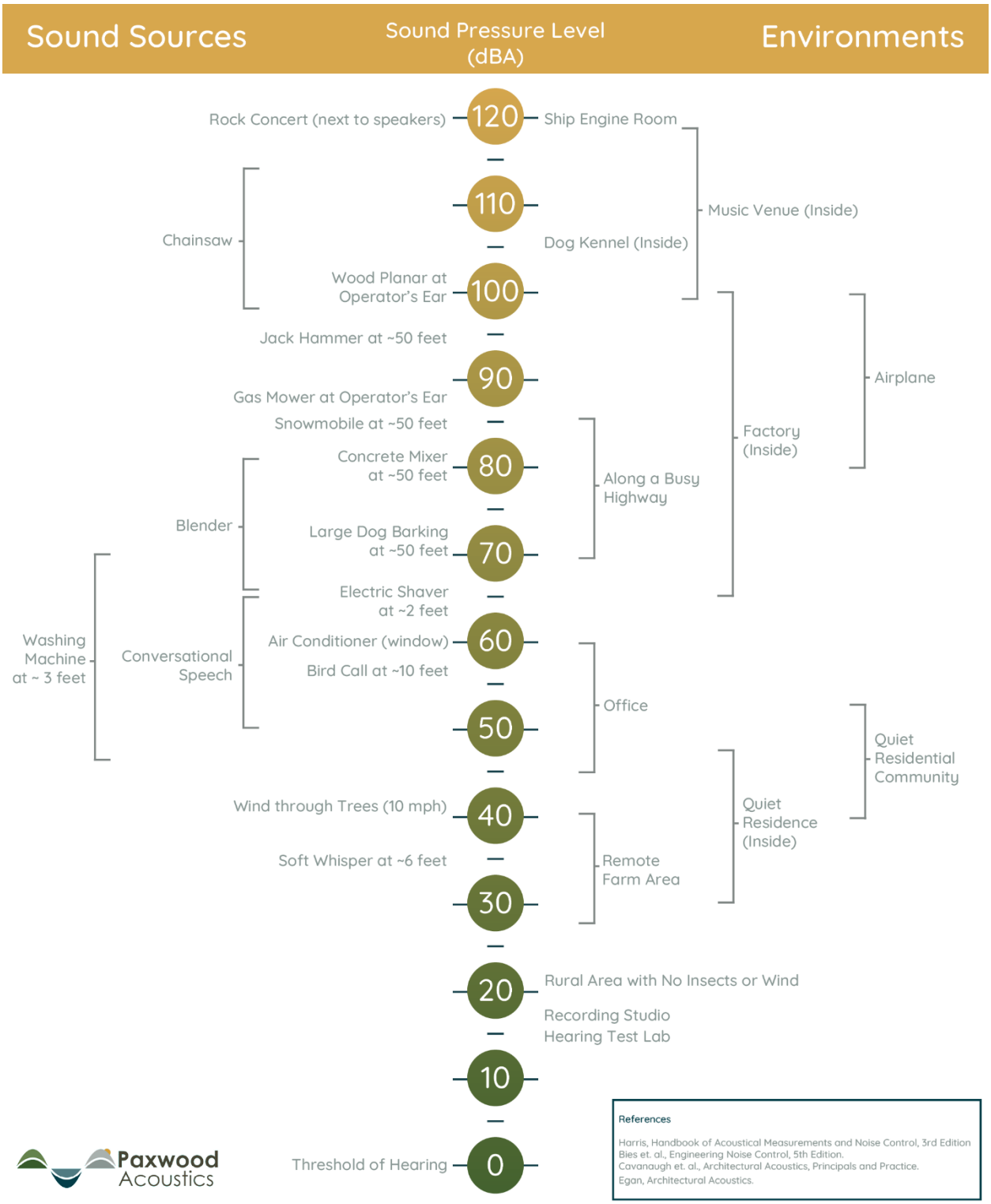


Figure 4: Representative Sound Pressure Levels (dBA) of Common Sound Sources & Environments

Since sound levels are expressed on a logarithmic scale, they cannot be added or subtracted using ordinary arithmetic. Conversational speech, for example, typically occurs at a level between 55 dBA and 65 dBA. If one person speaks at 60 dBA and a second person also speaks at 60 dBA, the combined level is not 120 dBA. (And a good thing too, otherwise, two people talking at the same time would quickly approach the threshold of pain, 120 dBA.) Instead, two voices at the same level only causes an increase of 3 dB, so 60 dBA plus 60 dBA equals 63 dBA. To illustrate this further, Table 2 provides a general guide on how two sound levels sum together.

Table 2: Guide to Sound Level Summation

If the difference between two sound levels is:	Add the following value to the greater of the two sound levels:
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0 dB
Note: For the precise calculation - $\boldsymbol{Lp_{total} = 10 \times \log_{10}\left(10^{Lp1/10} + 10^{Lp2/10}\right)}$	

Two rules of thumb are useful when interpreting changes in sound level. First, a change in broadband sound level of 10 dB is generally perceived as a doubling or halving of loudness, depending on whether the sound level increased or decreased. Second, changes in broadband sound level of less than 3 dB are generally not perceptible.

Sound Level Metrics

With sound levels in an environment continuously changing, different sound level metrics are used to describe how sound level varies with time. Several common metrics are described briefly below:

- Equivalent Continuous Sound Level (L_{eq}): The L_{eq} is the level of the average sound pressure over a specified period of time. It takes into account quieter, long-term sound levels along with louder, short-duration sound levels to provide an overall sound level for a given time period. The louder sound levels, even with a short duration, can have a strong influence on the L_{eq}. The L_{eq} is often used in environmental acoustics to convey an average representation of the acoustical environment, even though it is influenced more strongly by higher sound levels that occur over the specified interval. An L_{eq} may be as short as 1-second or up to an hour or more depending on the purpose of the quantification.
- Statistical Sound Levels (L_n): Statistical sound levels or percentile sound levels describe the level that is exceeded for a specified percentage of time. The L_{10}, for example, is the level that is exceeded 10% of the time. The L_{50}, is the median sound

level: half the time the sound level is above the L_{50} and half the time the sound level is below the L_{50}. And the L_{90} is the sound level that is exceeded 90% of the time.

- Maximum Sound Level (L_{max}): The phrase “maximum sound level” may be used to describe the highest L_{eq} or L_n over a given time period, but it can also be used to describe the sound level over a very short-duration typically using either a 1-second time constant which is referred to as slow-response, or a 125-millisecond time constant which is referred to as a fast-response. If the L_{max} metric is being used, it is good practice to note which time constant is being applied by adding the notation S or F to the abbreviation: L_{Smax} or L_{Fmax}. The most appropriate time constant to use depends on the specific context of the quantification.
- Day-Night Level (L_{dn}): The L_{dn} is similar to the L_{eq} except that it is specifically applied over an entire day or 24-hour period with a 10 dB penalty applied to sound levels between 10 PM and 7 AM to account for greater sensitivity at night.

Appendix B: Model Settings & Input

Table 3: Sound Propagation Model Settings

Model Parameter	Setting
Ground Attenuation	ISO 9613-2 spectral ground attenuation with a ground factor of 0.5 in gravel areas and 1.0 elsewhere.
Topography	USGS terrain.
Foliage Attenuation	No attenuation due to forest was taken into account in the model.
Atmospheric Attenuation	Based on 70% relative humidity and 10° C.
Search Radius	3.1 miles (5,000 meters).
Receptor Grid	10 feet by 10 feet (3.05 meters by 3.05 meters) over the entire Project area at a height of 5 feet (1.5 meters).

Table 4: Modeled Point Source

Source	Sound Power Level (dBA)		Relative Height (m)	Coordinates (NAD83 Z16N)		Elevation (m)
	Daytime	Nighttime		X (m)	Y (m)	
Medium Power Transformer	93	93	4.75	753579	4244001	269
Inverter 01	97	78	2.2	753385	4244218	265
Inverter 02	97	78	2.2	753378	4244006	257
Inverter 03	97	78	2.2	753593	4244073	270
Inverter 04	97	78	2.2	752861	4243438	256
Inverter 05	97	78	2.2	752955	4243760	259
Inverter 06	97	78	2.2	753326	4243884	258
Inverter 07	97	78	2.2	753139	4243878	255
Inverter 08	97	78	2.2	753634	4243773	258
Inverter 09	97	78	2.2	753823	4243886	252
Inverter 10	97	78	2.2	753971	4243910	261
Inverter 11	97	78	2.2	754276	4243456	259
Inverter 12	97	78	2.2	754231	4243261	249
Inverter 13	97	78	2.2	754399	4243266	253

Table 5: Modeled Sound Power Level (dBZ) by Octave Band Frequency[8]

Source	Full Octave Band Center Frequency (Hz)									Overall Sound Power Level	
	31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBZ
Medium Power Transformer (ONAF)	83	77	93	94	95	84	75	68	63	93	99
Sungrow SG4400 Inverter	90	87	92	92	95	88	88	93	79	97	100
Medium Voltage Transformer (4.4 MVA)	53	53	76	78	80	65	55	43	37	78	83

[8] Spectral levels for the transformers were derived from the *Handbook of Acoustical Measurements and Noise Control, Third Edition*, Cyril M. Harris (ed.), 1998. Spectral levels for the inverters were based on data from the manufacturer.

Appendix C: Tabular Model Results

Tabular results for each modeled receptor are provided below in Table 6. The receptor IDs are included on each map in the body of the report showing the corresponding location.

Table 6: Tabular Model Results with Receptor IDs, Addresses, and Coordinates

Receptor ID	Relative Height (m)	Coordinates (NAD83 Z16N)		Elevation (m)	Projected Sound Pressure Level (dBA)	
		X (m)	Y (m)		Daytime	Nighttime
R01 - 3400 CARPENTER RD	1.5	752484	4243424	255	31	16
R02 - 3452 CARPENTER RD	1.5	752513	4243605	244	30	16
R03 - 501 MILLER LN	1.5	754408	4244652	267	26	16
R04 - 2903 CARPENTER RD	1.5	752286	4242776	269	22	11
R05 - 428 MILLER LN	1.5	753993	4244620	254	29	20
R06 - 3052 CARPENTER RD	1.5	752482	4243130	258	28	14
R07 - 2897 PLEASANT SPRINGS RD	1.5	754668	4242542	275	24	11
R08 - 2550 CARPENTER RD	1.5	753185	4242532	273	24	12
R09 - 3450,CARPENTER RD	1.5	752574	4243546	253	33	17
R10 - 2512 CARPENTER RD	1.5	752742	4242622	271	24	12
R11 - 3449 CARPENTER RD	1.5	752363	4243443	242	27	14
R12 - 2202 CARPENTER RD	1.5	753637	4242500	265	24	12
R13 - 886 MILLER STATION RD	1.5	754928	4243891	252	26	14
R14 - 3722 CARPENTER RD	1.5	752685	4243834	240	30	16
R15 - 3010 CARPENTER RD	1.5	752513	4242990	262	26	13
R16 - 3252 CARPENTER RD	1.5	752464	4243345	254	30	15
R17 - 3552 CARPENTER RD	1.5	752447	4243776	239	29	16
R18 - 2453 CARPENTER RD	1.5	753038	4242452	272	23	11
R19 - 500 MILLER LN	1.5	754267	4244803	275	25	16
R21 - 410 MILLER LN	1.5	753799	4244532	252	31	22
R188 - 800 MILLER STATION RD	1.5	754618	4244061	251	28	16
R595 - 2290 CARPENTER RD	1.5	753271	4242772	269	26	14

Appendix D: Qualifications

Paxwood Acoustics provides professional consulting services in acoustics and noise control engineering with a focus on environmental permitting and compliance. Eddie Duncan, Principal Consultant, is a Board-Certified Noise Control Engineer (#09002) through the Institute of Noise Control Engineering and is a member of the Acoustical Society of America. Mr. Duncan has been practicing acoustic consulting for over 20 years. In that time, he has managed over 450 acoustics projects and has worked on 125+ wind power projects, 85+ solar projects, and 70+ transmission projects. He has also managed noise assessments for a growing portfolio of BESS projects which have often been a component of other renewable energy projects. Mr. Duncan's resume is available upon request.