Appendix B17

Noise Study

1-Q24-063-Study

Canyon Peak Power Arapahoe County 1041/USR Application Q24-063

Power Acoustics, Inc.
CONSULTANTS IN ACOUSTICS AND NOISE CONTROL

Community Noise Impact and Acoustical Analysis of the Kindle Energy LLC Canyon Peak Power Project Report Number 24-1250-00

Date: December 19, 2024

Prepared at the request of:
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Contents

1.0 INTRODUCTION

Kindle Energy LLC has proposed to build a new simple cycle gas turbine based power generation facility in Arapahoe County, Colorado. The proposed facility, the "Canyon Peak Power Project," will include six (6) GE LM2500Xpress gas turbine packages and associated equipment. Power Acoustics, Inc. was contracted to measure existing sound in the area and assess the acoustical impacts of the new gas turbine equipment to nearby community properties.

The acoustical study consisted of:

1.) Measuring the ambient sound levels at representative critical locations in the vicinity of the proposed facility,
2.) Setting noise goals for the new facility based on Colorado Revised Statutes 2023 TITLE 25, ARTICLE 12, Section 103 "Maximum Permissible Noise Levels" [1], and other USEPA/American noise standards[6,7,8],
3.) estimating the sound levels generated by the proposed facility, and
4.) assessing conceptual noise abatement strategies and determining the feasibility of the facility achieving lower sound levels.

Power Acoustics obtained ambient sound data over a period of three (3) calendar days from November 20th through 22nd 2024. The data include sound measured near critical residential locations and reference sound level measurements made on the proposed facility property.

2.0 EXECUTIVE SUMMARY

Each of the LM2500Xpress simple cycle gas turbines (GT) packages (without exhaust noise contributions) are estimated to achieve approximately 59 dB(A) at 400 feet. The GT units' exhaust systems will include and SCR and exhaust stack silencer. The SCR provides a substantial amount of low and mid-frequency noise reduction, thus minimizing the chances of low-frequency (infrasound) related noise issues. A gas turbine exhaust silencer was designed such that the overall plant community sound levels are a minor audible noise source that does not appreciably contribute to the overall gas turbine package noise. (i.e. the total sound of the gas turbine package plus exhaust stack is approximately equivalent to that produced by the gas turbine packages alone.) Additional facility noise abatement includes insulation and lagging to the fuel gas conditioning and metering piping and valves.

The maximum A-weighted sound level at the Canyon Peak Power Project property boundary is estimated to be approximately 72 dB(A) or less. The closest critical noise receptors are both located approximately a quarter mile from the centerlines of the gas turbine units. Each sound sensitive receiver is either located directly east or, or west of the proposed Canyon Peak Power Project facility. The estimated Canyon Peak Power Project sound level at these locations is approximately 53 dB(A). Other sensitive locations, located approximately a mile from the proposed facility are estimated to be 40 dB(A) or less.

The existing community sound was observed to be low, mostly in the mid-20's dB(A) range. Since the area is rural with low sound levels occurring throughout the daytime and nighttime, the facility will be audible within the community.

3.0 SIMPLE CYCLE GAS TURBINE ADDITION

Kindle Energy LLC has proposed to add six (6) aeroderivative LM2500Xpress simple cycle gas turbines to the property adjacent to an existing substation located east of County Road 129 and north of Belleview Avenue in Arapahoe County, Colorado. A representative conceptual view of the Canyon Peak Power Project can be seen in Figure F3-1. The LM2500XPRESS gas turbines are 95% factory assembled modules to expedite site installation. Although not shown in the aerial, a solar power farm exists adjacent to the proposed facility.

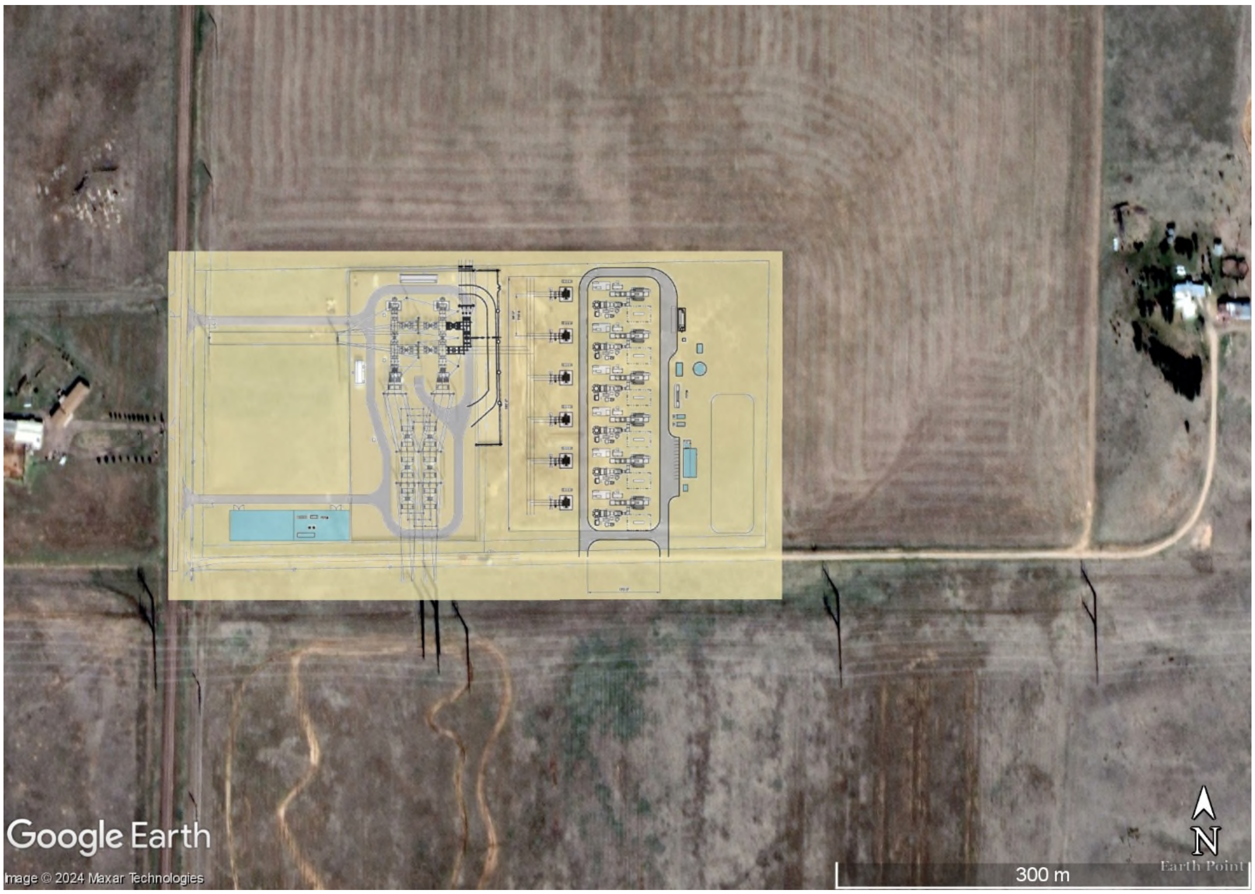


Figure F3-1. Proposed Conceptual Layout of the Canyon Peak Power Project
(showing main noise sources only)

4.0 MEASUREMENT METHODOLOGY, INSTRUMENTATION AND CONDITIONS

4.1 Sound Measurements and Methodology

The existing ambient sound levels were measured over a three-calendar day period November 20th through 22nd 2024. The ambient sound levels were measured at representative locations near the proposed site with emphasis given to residential locations. The sound survey principles were based on the on Colorado Statutes, Arapahoe County Noise Code, ANSI, ASME and ASTM standards such as ASTM E 1503 "*Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Sound Analysis System*" [1,2,3,4,5].

The metrics used* for evaluating the sound include:

LA_{eq}, - equivalent (average) sound level during the measurement period
LA_{10}, - the loudest 10% of the measurement period
LA_{50} - the median sound level of the measurement period
LA_{90} – the residual sound level, or quietest 10% of the measurement period.

* See Appendix A for all definitions of acoustical terminology.

4.2 Sound Measurement Instrumentation

The community sound level measurements were made using RION NL-52ex Precision Sound Level Meters and Frequency Analyzers. Sound analyzers were equipped with a half-inch microphones and windscreens. The instrumentation meets ANSI Sl.4 [2] Type 1 (precision) requirements for acoustical measuring devices. Specific equipment used in the measurements is shown in Table 4.1.

Table 4.1. Sound Measurement Equipment Model and Serial Numbers

Equipment	Model	Serial Number	Last Laboratory Calibration	Location Used
Norsonic Field Calibration Source	1251	32841	05/08/2024	All
RION Type 1 Logging SLM	NL-52ex	00610182	11/29/2023	M-1
RION Type 1 Logging SLM	NL-52ex	00610181	11/29/2023	M-2
RION Type 1 Logging SLM	NL-52ex	00610180	11/30/2023	M-3
RION Type 1 Logging SLM	NL-52ex	00610179	11/30/2023	M-4

The sound measurement equipment was field calibrated immediately before and after each survey. The post calibration check indicated the measurement equipment had no significant drift in sensitivity (≤0.5 dB). All sound measurement equipment conforms to manufacturer's recommended intervals and standard practices for laboratory calibration. Copies of laboratory certificates of calibration are on file and available for review upon request.

4.3 Personnel Performing the Sound Survey

All Sound Survey measurements were made by David Parzych, INCE.Bd.Cert., Principal Consultant, Power Acoustics, Inc. Qualifications and résumé are provided in Appendix B.

4.4 Weather Conditions

Time histories of the weather conditions (temperature, humidity and wind) are provided in Figure F4-1. There was no precipitation during testing. Temperatures were mild, winds were light to moderate and primarily out of the south.

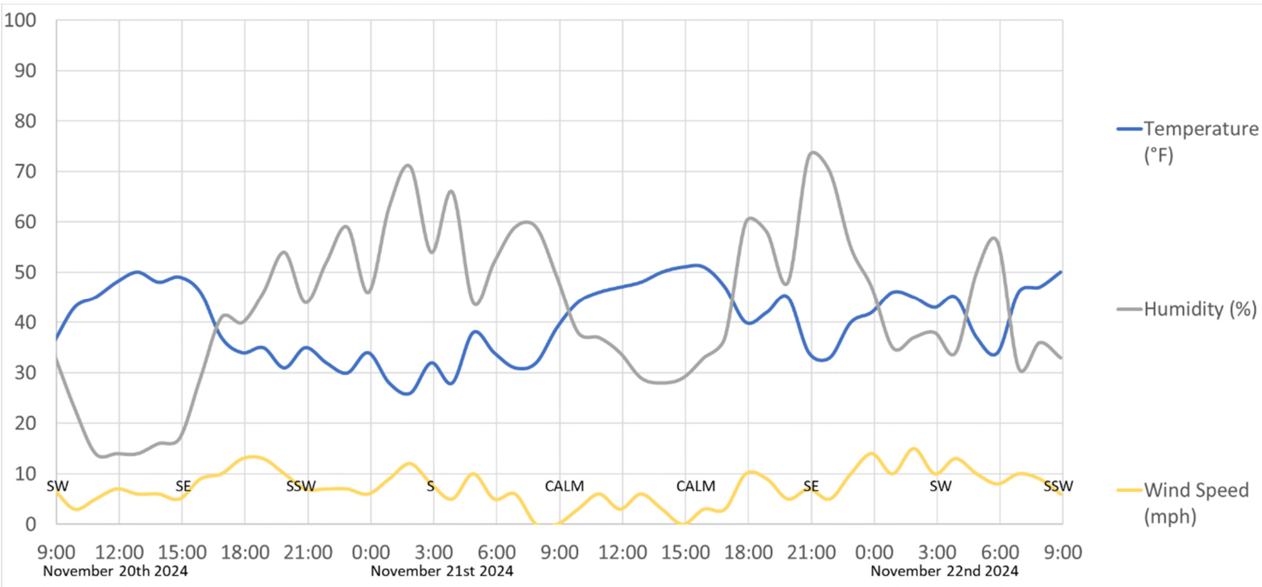


Figure F4-1. Weather Conditions

5.0 SOUND MEASUREMENT RESULTS

5.1 Measurement Locations

Community sound level measurements were made at four (4) locations, M-1, M-2, M-3, and M-4. M-3 is a reference sound monitor located toward the southern portion of the proposed Canyon Peak Power property.

The approximate UTM coordinates are shown in Table 5.1. The corresponding locations are presented in Figure F5-1

Table 5.1. Location of Noise Measurement

Measurement Location	UTM Coordinates, Zone 13S	
M-1	547452 N	4386060 E
M-2	546834 N	4386098 E
M-3	547066 N	4385949 E
M-4	546801 N	4384719 E

The community noise monitors' microphones were located on tripods approximately 5 feet above the ground.

Figure F5-1. Ambient Sound Measurement Locations

5.2 Sound Level Data

Ten (10) minute time samples of the A-weighted LA_{eq}, LA_{10}, LA_{50} and LA_{90} sound level time histories are shown in Figure F5-2 through F5-6 for locations M-1, M-2, M-3 and M-4 respectively (see Appendix A for an explanation of terms). The character of the area is quiet, rural mixed-use land. The A-weighted LA_{90} sound levels (the residual sound levels) were found to be low with the quietest community levels observed to be between 16 to 27 dB(A). Typical LA_{90} sound levels were in the mid-to-upper 20s dB(A) range which is also indicative of the broad area sound levels. Most of the sound observed was from distant traffic from Airline Road, sound from the substation adjacent to the proposed project and intermittent gunshot from the Kiowa Creek Sporting Club. Short duration "spikes" (LA_{10}) in sound are primarily due to local traffic on County Road 129. In general, the overall impression of the area is very quiet except for the short duration impulsive gunshot noise and occasional local traffic.

The typical and lowest A-weighted LA_{90} sound levels are summarized in Table 5.2

Table 5.2. Representative Lower Sound Levels Measured at Each Monitoring Location

Measurement Location	Typical LA_{90} dB(A)	Lowest LA_{90} dB(A)
M-1	28	22
M-2	28	22
M-3	31	27
M-4	24	16

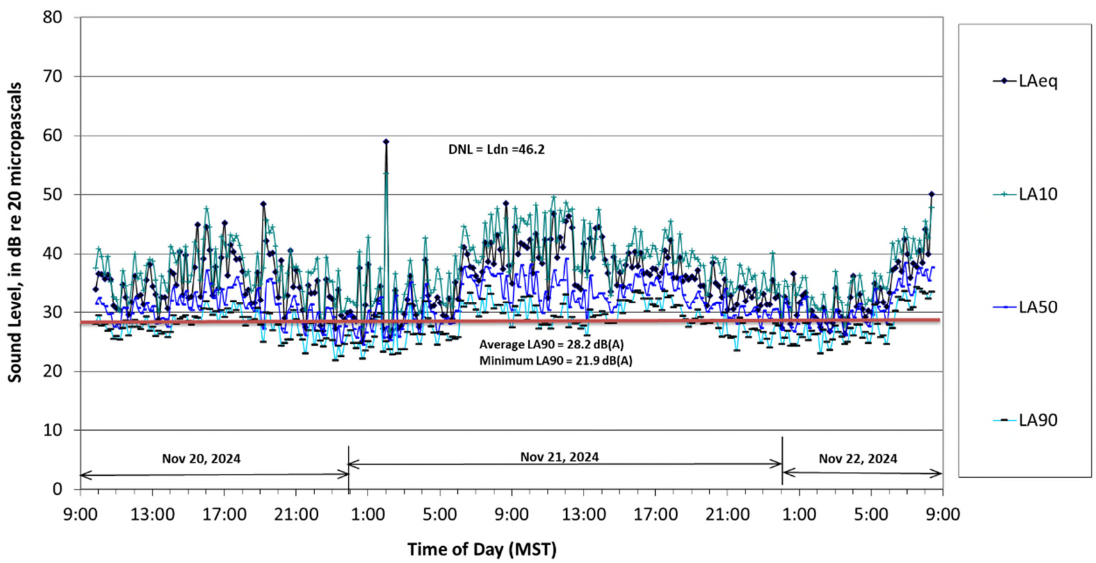


Figure F5-2. Location M-1 Sound Levels

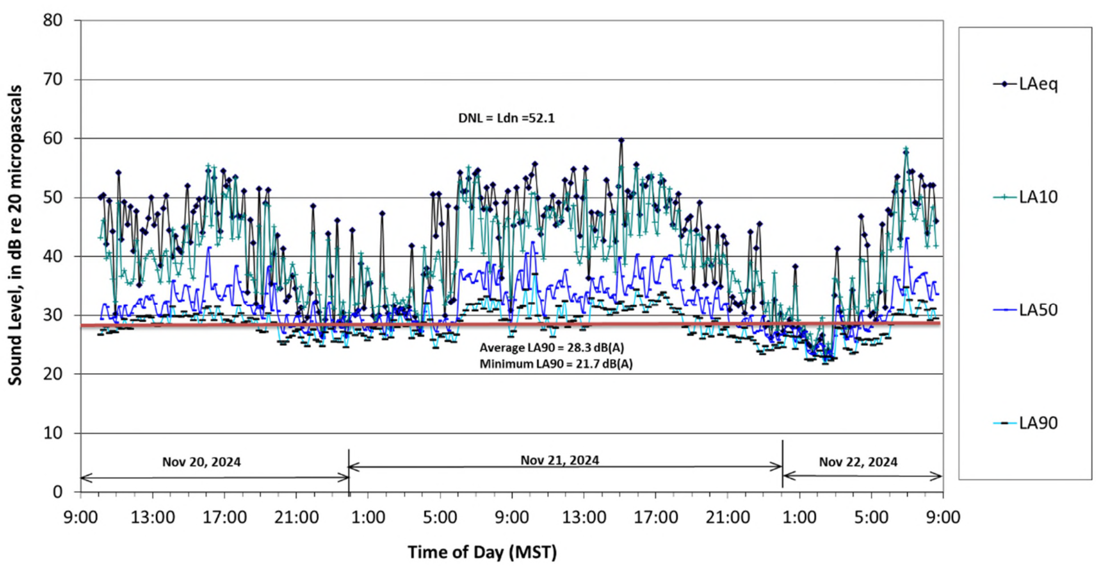


Figure F5-3 Location M-2 Sound Levels

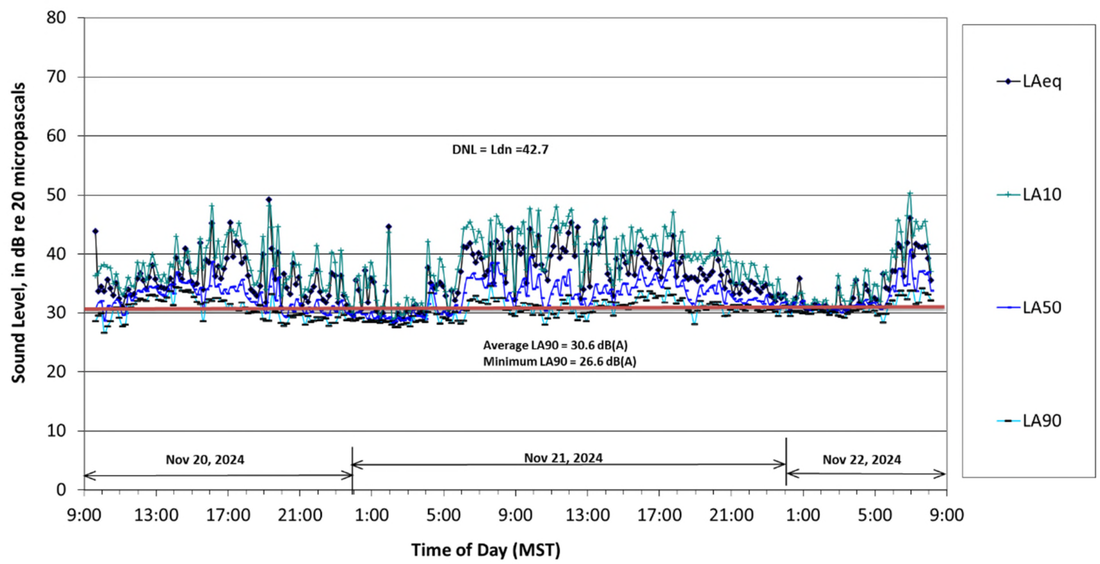


Figure F5-4. Location M-3 Sound Levels

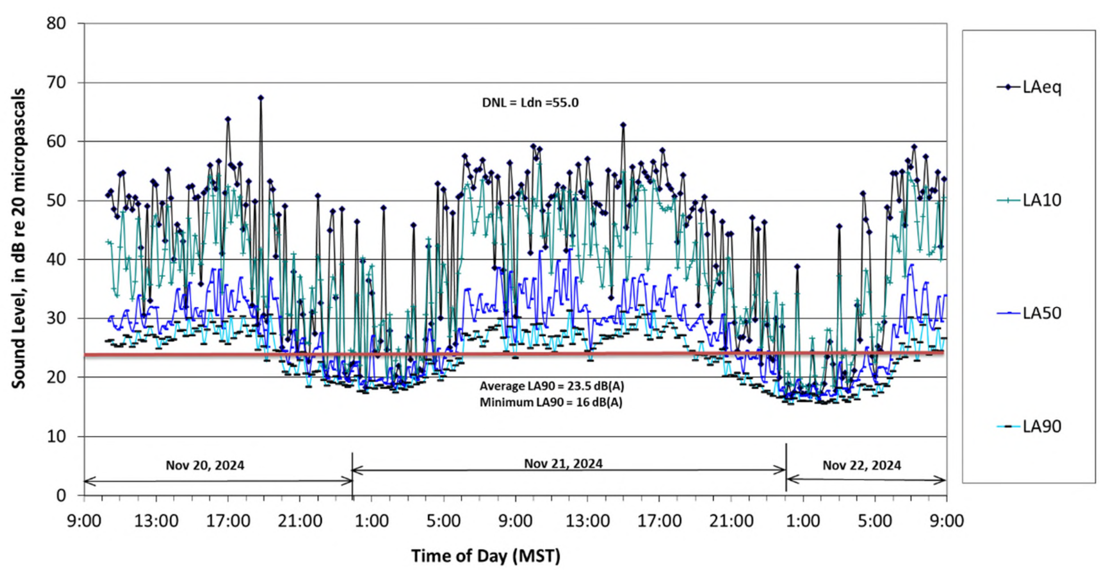


Figure F5-5. Location M-4 Sound Levels

6.0 PROJECT NOISE REQUIREMENTS

The current minimum noise standards are defined in the Colorado Statutes [1]. In addition to the minimum standards, other accepted A-weighted criterion for audible sound and C-weighted criterion for infrasound have been included for evaluation purposes.

6.1 Colorado Revised Statutes 2023[1]

The full text of the Colorado Revised Statutes 2023 TITLE 25, ARTICLE 12, Section 103 can be found in Appendix D. A condensed version is provided here.

25-12-103. Maximum permissible noise levels. *(1) Every activity to which this article is applicable shall be conducted in a manner so that any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Sound levels of noise radiating from a property line at a distance of twenty-five feet or more therefrom in excess of the dB(A) established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance:*

Zone	***7:00 a.m. to 7:00 p.m.***	***7:00 p.m. 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)*

(2) In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in subsection (1) of this section may be increased by ten dB(A) for a period of not to exceed fifteen minutes in any one-hour period.
(3) Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five dB(A) less than those listed in subsection (1) of this section.

6.2 USEPA and American National Standards Institute (ANSI) Acceptable Audible Sound

The USEPA [6] has published a report to define applicable goals for community noise levels. The report, often referred to as "the levels document," defines sound levels in terms of day/night average sound level, or DNL, for compatible land uses. The American National Standard, ANSI S12.9-2007(R2012), "Quantities and Procedures for Description and Measurement of Environmental Sound - Part 5: Sound Level Descriptors for Determination of Compatible Land Use"[7], uses an updated database to expand the EPA guidelines.

The day/night average sound level, DNL, is a 24-hour measurement with a mathematical weighting or penalty of 10 dB(A) applied to sound levels generated at nighttime between the hours of 10 PM and 7 AM. For residential *suburban homes* with extensive outdoor use, a DNL of 55 would be considered fully compatible with the ANSI S12.9 part 5 requirements while a DNL of 60 would be considered marginally compatible. The standard states, however, that rural areas are generally more sensitive to noise than suburban areas.

Although atypical, the new gas turbines could operate 24 hours per day. Therefore, to account for the DNL 10 dB(A) nighttime penalty, a facility operating 24-hours per day would need to achieve 48 dB(A) to achieve full compatibility of 55 DNL or 53 dB(A) to achieve marginal compatibility of 60 DNL for suburban residential use property.

<u>Note that DNL and LA_{eq} are NOT directly interchangeable metrics (see Appendix A for a detailed explanation).</u>

The American National Standard ANSI 12.9-Part 5 suggests yearly adjusted DNL, as shown in Figure F6-1, for a variety of land uses.

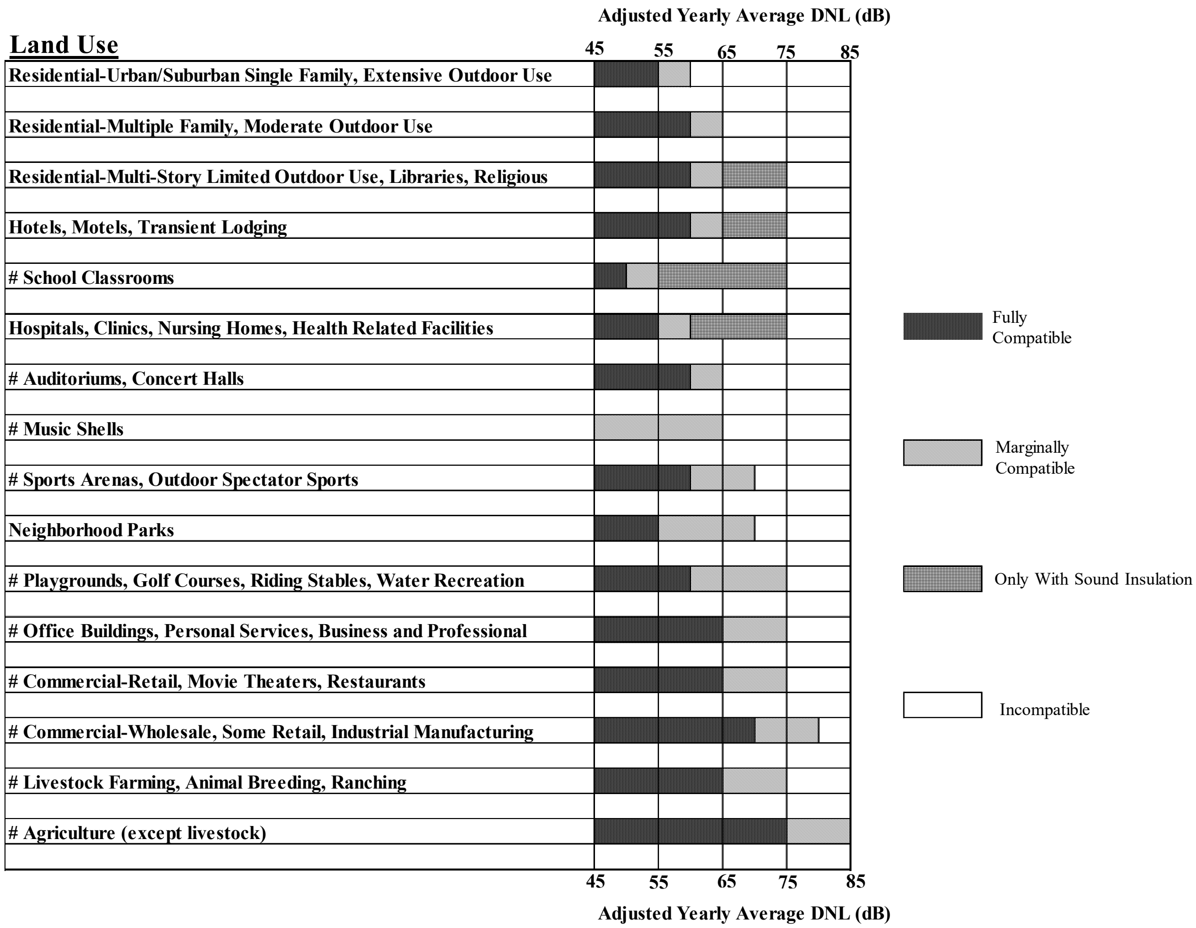


Figure F6-1. ANSI S12.9-2007(R2012)/Part 5 Compatible Land Use Chart

6.3 Sound Level Goals to Achieve a Negligible Increase in Community Noise

A difficult goal for the new gas turbine facility would be achieving no significant increase in sound levels measured at the residential properties. This would require setting the facility sound requirements equal to the existing lower envelope of the measured residential use sound levels. This goal, when added to the existing sound, will result in sound levels approximately 3 dB(A) higher than the existing sound. A 3 dB(A) increase is the smallest incremental change that a human's hearing can perceive. It should be noted that it is very unlikely that any facility could achieved this level of "quiet" at all locations given the extremely low existing sound levels.

Negligible noticeable increases in sound level would be obtained by meeting the sound level goals presented in Table 6.1.

Table 6.1 Sound Level Goals for No (or Negligibly) Noticeable Increase

Measurement Location	Low/Typical LA_{90} dB(A)
M-1	22-28
M-2	22-28
M-3	27-31
M-4	16-24

6.4 Low Frequency Infrasound Goals

Simple cycle gas turbines can produce substantial levels of low frequency noise (Infrasound) that has the potential to induce vibration in framed structures. The low frequency sound is generally not heard, but felt as vibration in the structure. According to ASME's B133.8 - 2011(R2022)[8], "*Gas Turbine Installation Sound Emissions, Nonmandatory Appendix B, Guide To Determining Specified C-Weighted Sound Levels,*" the C-weighted sound level outside the nearest framed structure with noise sensitive receptors should not exceed an upper limit of 75 dB(C) to 80 dB(C). The range of values is given because there is some uncertainty as to the sound level required to induce structural vibration in a framed structure.

6.5 Tonal/Impulsive Noise Goals and Requirements

Gas turbine facilities generally do not produce significant tonal or impulsive sounds in the community.

7.0 COMMUNITY NOISE MODEL AND ESTIMATED SOUND LEVELS

The environmental noise modeling was performed with a 3-D computer-based sound propagation model for calculating outdoor noise propagation in community and industrial environments. The computer model is based on the International Standard ISO 9613, parts 1 and 2[9,10]. The worldwide accepted standard specifies methods for calculating noise attenuation of outdoor (environmental) noise sources from a large variety of equipment under favorable (downwind) noise propagation conditions. Predictions made under favorable noise propagation conditions result in predicted sound levels that are usually conservatively high. In cases when the receiver of noise is upwind from the source, sound levels will be significantly lower than those predicted. However, there are anomalous situations that can occur that could result in occasional higher sound levels than those predicted. This would be associated with combinations of atmospheric conditions such as a temperature inversion combined with downwind conditions or sound traveling over a body of water that is cooler than the air above it.

The sound propagation model accounts for the following attenuation and reinforcement of sound:

- Spherical (or Hemispherical) Divergence.
- Atmospheric Absorption.
- Ground Absorption.
- Screening (sound barriers).
- Sound Reflections.

The geometric representation of the sound sources and structures considered are shown in Figure F7-1. Each sound source is modeled as a three-dimensional surface source. Large surfaces, such as buildings and enclosures are modeled as surfaces that create sound barriers and sound reflectors to the gas turbines and other noise sources. All sound receivers are modeled to be 5 feet above ground. The analytical noise model includes the GE LM2500Xpress noise components [11] and the exhaust equipment[12] and balance of plant equipment such as the main generator step up transformers, fuel gas conditioning and metering and instrument air compressors [13,14] only (i.e. no noise is modeled or included from the road or air traffic in the model). Sound levels used in the analysis are provided in Appendix C.

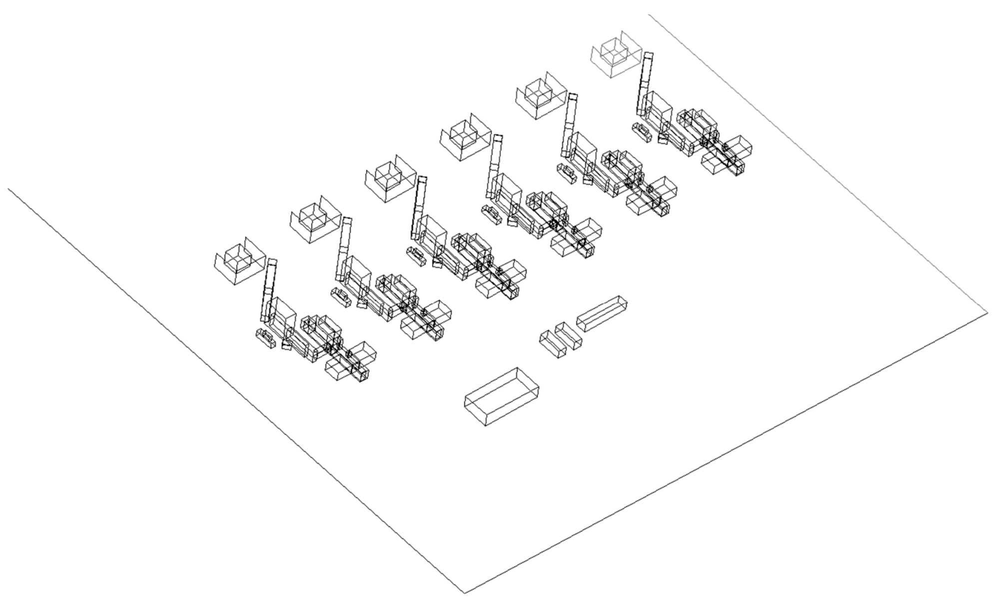


Figure F7-1. Wireframe of 3-D Analytical Acoustical Model of the Facility

7.1 Estimated A-weighted Sound Levels of the Canyon Peak Power Project

Each of the LM2500Xpress simple cycle gas turbines (GT) packages (without exhaust noise contributions) are estimated to achieve approximately 59 dB(A) at 400 feet. The GT units' exhaust systems will include and SCR and exhaust stack silencer. The SCR provides a substantial amount of low and mid-frequency noise reduction, thus minimizing the chances of infrasound (low-frequency sound) related noise issues. The gas turbine exhaust silencer was designed such that the overall plant community sound levels are a minor audible noise source that does not appreciably contribute to the overall gas turbine package noise. (i.e. the total sound of the gas turbine package plus exhaust stack is approximately equivalent to that produced by the gas turbine packages alone, about 59 dB(A) at 400 ft.) Additional facility noise abatement includes insulation and lagging to the fuel gas conditioning and metering piping and valves.

The estimated A-weighted sound contours of the Canyon Peak Power Project are shown in Figure F7-2 relative to the property boundaries. The maximum sound level at the property boundary is estimated to be 72 dB(A) or less.

The estimated community noise A-weighted sound contours of the facility are shown in Figure F7-3. The closest critical noise receptors are both located approximately a quarter mile from the centerlines of the gas turbine units and are located directly east and west of the proposed Canyon Peak Power Project facility. The estimated Canyon Peak Power Project sound level at these locations is approximately 53 dB(A). Other sensitive locations, located approximately a mile from the proposed facility are estimated to be 40 dB(A) or less.

The existing community sound was observed to be low, mostly in the mid-20's dB(A) range. Since the area is rural with low sound levels occurring throughout the daytime and nighttime, the facility will be audible within the community.

With the discussed noise abatement, the highest contributing noise sources of the gas turbine packages is the generator and its ventilation.

7.2 Estimated C-weighted Sound of the Canyon Peak Power Project

The C-weighted sound provides an indication of the facility's ability to cause an infrasound issue. The estimated C-weighted sound contours Canyon Peak Power Project are shown in Figure F7-4. The C-weighted sound levels are estimated to be below 75 dB(C) at the residential receptors and therefore meet the ASME B133.8 recommended criteria for minimizing the likelihood of infrasound induced vibrations.

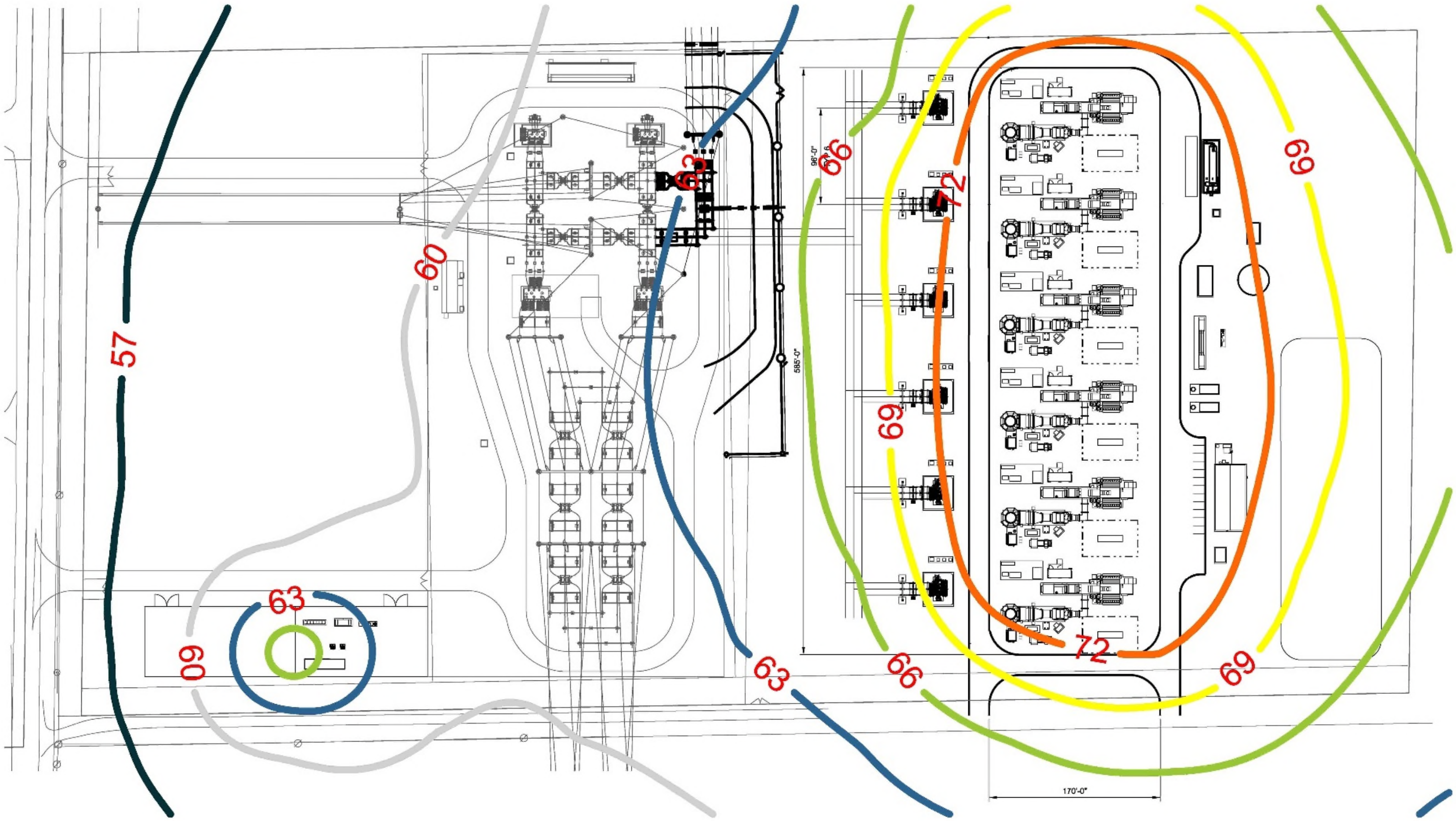


Figure F7-2. Analytically Estimated A-weighted Sound Levels of the Canyon Peak Power Project Relative to Property Boundaries

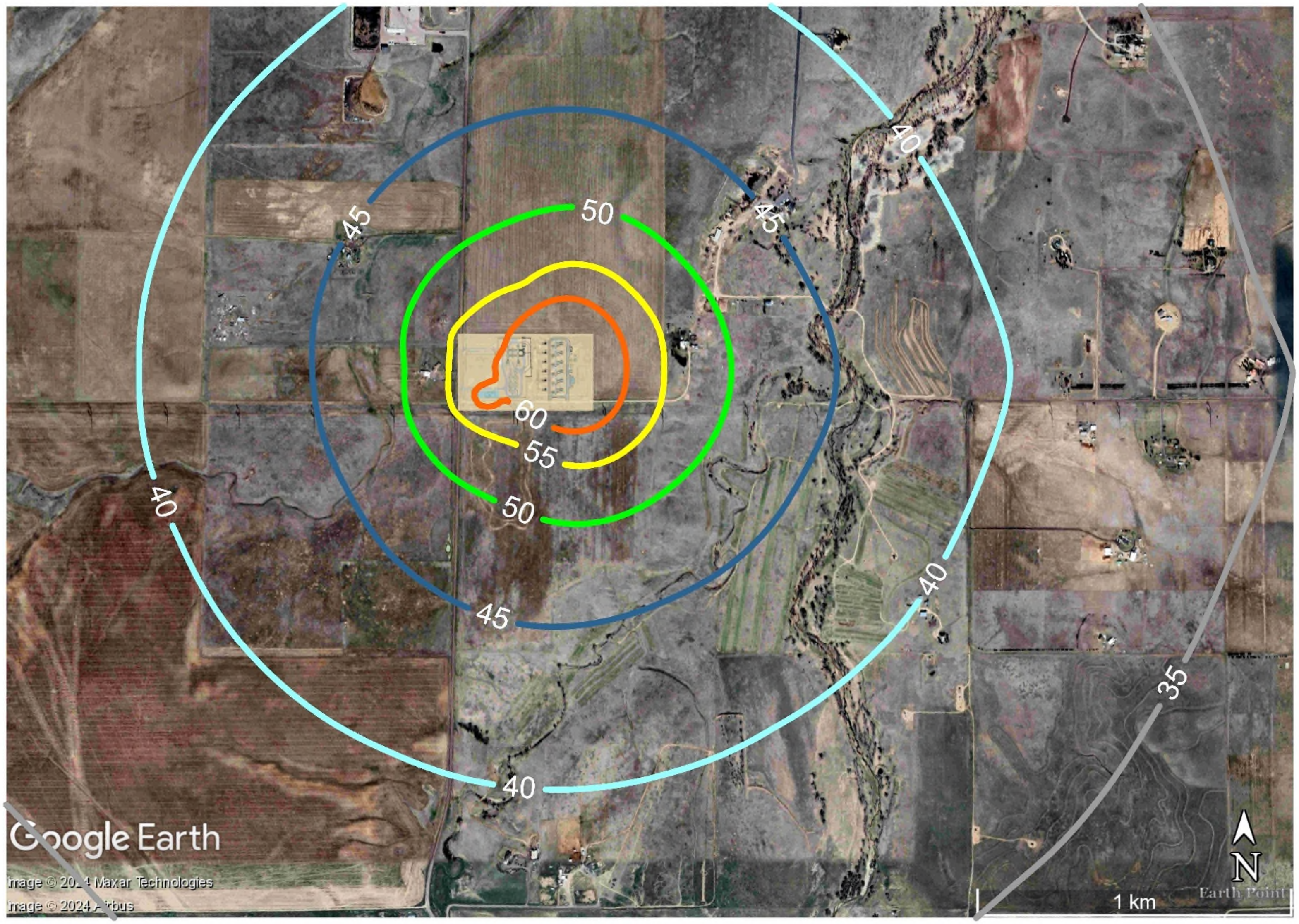


Figure F7-3. Analytically Estimated Community Noise A-weighted Sound Levels of the Canyon Peak Power Project

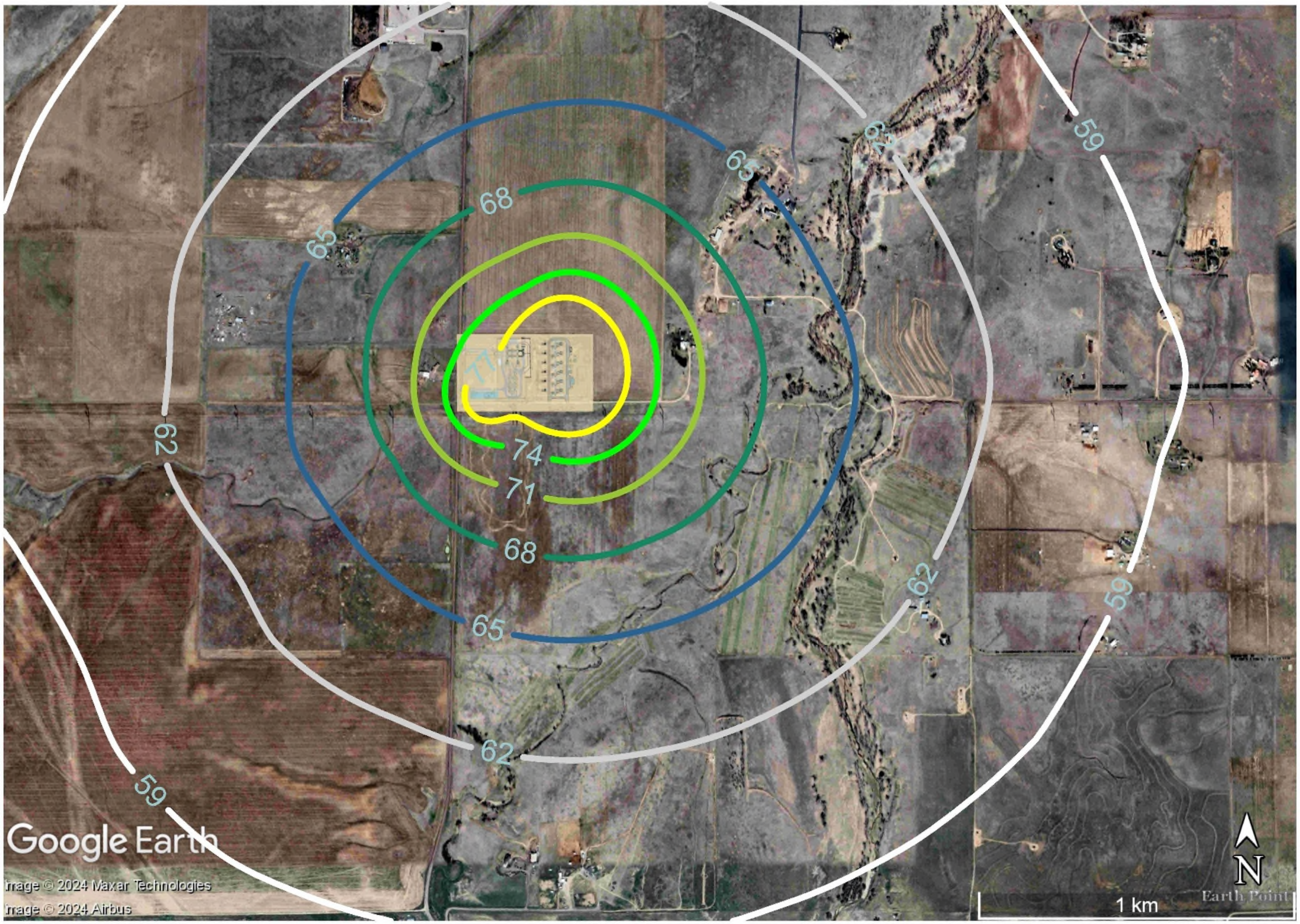


Figure F7-4. Analytically Estimated Community Noise C-weighted Sound Levels of the Canyon Peak Power Project

8.0 REFERENCES

1. Statutes and Codes
Colorado Revised Statutes 2023, ARTICLE 12, Section 103 "Maximum Permissible Noise Levels"

2. ANSI/ASA S1.4-2014/Part 1/ IEC 61672-1:2013 "*American National Standard Electroacoustics - Sound Level Meters - Part 1: Specifications (a nationally adopted international standard)*".

3. ANSI S12.9-2013/Part 3 "*Quantities and Procedures for Description and Measurement of Environmental Sound - Part 3: Short-term Measurements with an Observer Present*"

4. ASME PTC-36 – 2018, "*Measurement of Industrial Noise*"

5. ASTM E 1503 – 14, "*Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Sound Analysis System*"

6. U.S. EPA (U.S. Environmental Protection Agency). Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. 1974.

7. ANSI S12.9-2007(R2012), Part 5 "AMERICAN NATIONAL STANDARD, Quantities and Procedures for the Description and Measurement of Environmental Sound. Part 5: Sound Descriptors for Determination of Compatible Land Use."

8. *ASME B133.8 2011(R2022 "Gas Turbine Installation Sound Emissions"*

9. ISO 9613-1:1993, "*Acoustics - Attenuation of Sound During Propagation Outdoors - Part 1: Calculation of The Absorption of Sound by the Atmosphere"*

10. ISO 9613-2:1996, "*Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation*"

11. GE LM2500Xpress Sound Power Level Data, Customer 1672523, dated 12/10/2024

12. Braden Group Exhuast System Preliminary Design Data/Guarantees

13. Power Acoustics, Inc. equipment sound level database

14. Edison Electric Institute, "*Electric Power Plant Environmental Noise Guide*", Volume I, 2nd Edition, Published 1978 and Updated 1983.

APPENDIX A - Discussion of Acoustical Terms

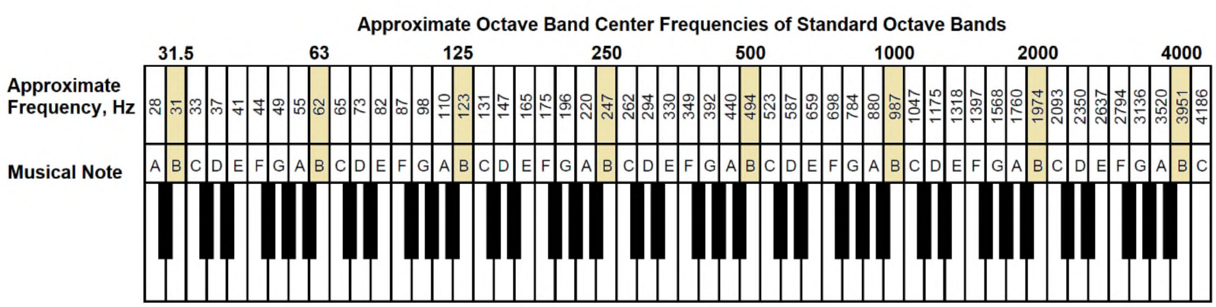
Assessing sound requires relationships between the physical properties of sound, which can be measured by instruments, and the corresponding human reaction through empirical means. Discussed within this Appendix is a description of terms necessary to understand the report.

Sound Level (Decibel)

Current sound measurement standards use a logarithmic decibel (dB) scale, which compares the measured sound pressure to a reference pressure of 20 micropascals. A sound pressure of zero (0) dB is approximately the lowest sound level humans can hear. Actual sounds, however, often cannot be distinguished if they are substantially below the existing ambient sound. As a basis of comparison, a 10 dB increase of a ***steady state sound*** (continuous, non-varying sound) is generally perceived as a doubling of sound level while increases in steady state sounds of 3 dB are considered just perceivable. Note sound levels described in decibels do not add arithmetically but the "sound pressures" do. Therefore, two sounds of equal magnitude will be 3 dB louder than a single sound source - i.e. 50 dB + 50 dB = 53 dB – not 100 dB and ten sound sources of equal magnitude will be 10 dB louder than a single sound source.

Sound Spectrum (Frequency)

Sound is comprised of a broad range of frequencies. The frequencies typically heard by humans are considered to range between 20-20,000 cycles per second (cps). A cycle per second is also called a "Hertz" or abbreviated as "Hz." To illustrate typical audible frequencies, we have annotated a piano keyboard as shown below. An increase in frequency of one octave means the frequency has doubled.



Range of Frequencies on a Standard Piano Keyboard

For scientific and industrial use, fixed "bands" or ranges of frequencies are used to describe the summation of many frequencies of the sound. Standardized octave band center frequencies are 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz. The lower range of the frequency is the octave band center frequency times $\sqrt{2}/2$ (0.707) and the upper range is the octave band center frequency times the $\sqrt{2}$ (1.414). The frequency content of noise sources is necessary to develop appropriate noise control.

A-weighting (Simulated Perceived Loudness By Humans)

The A-weighted sound level, dB(A), simulates (electronically through a filter network) the perceived response of the human ear. A-weighting deemphasizes very low frequencies and very high frequencies where humans hear the poorest. Although all frequencies of sound contribute to the A-weighted level, sounds between 250 Hz to 4000 Hz generally have the largest impact on measured A-weighted sound levels.

C-weighting (Often Used for Assessing Infrasound Induced Vibrations)
The C-weighted sound level, dB(C), is primarily a "flat frequency weighting" and is often used to characterize the effects of very low frequency sound (Infrasound) and its potential to induce vibration in structures.

Time Averaging of Sound and Statistics L_{eq}, L_{10}, L_{50}, and L_{90}
The equivalent sound pressure level, or L_{eq}, is the time-averaging of a fluctuating sound. The L_{eq} has the equivalent sound level as a steady state or non-varying sound that would be observed over the same period of time that the fluctuating sound was measured.

When evaluating ambient noise or sound that is influenced by transient or moving sources, statistical sound data are often used. Statistical sound data allows extraneous sounds to be deemphasized or shorter term transient sounds to be extracted. Sound statistics often used in evaluating environmental noise are L_{10}, L_{50}, and L_{90}. These statistics correspond to the sound level exceeded 10% of the time, the sound exceeded 50% of the time (the median sound level) and the sound exceeded 90% of the time respectively. Note the average or equivalent sound level, (L_{eq}), can be substantially different than the median sound level (L_{50}).

L_{90}, or the sound level exceeded 90 percent of the time, is commonly used to understand community sound levels since it tends to reduce the effect of short duration extraneous sounds not necessarily typical of the environment being measured. The L_{90} is thought of as the residual or broad area sound level in the community – basically the sound you hear when all the local traffic passes, no airplanes are overhead and localized human or mechanical noise are minimal. Think of the brief moment of quiet when you only hear the sound of distant road traffic. Another way of thinking about L_{90} is that data taken over a measurement time of 10 minutes would provide sound levels at or below the L_{90} for a total duration of only one (1) minute. Nine (9) minutes of the ten (10) minute data sample time, the sound level will exceed the L_{90} level.

L_{10}, or the sound exceeded 10% of the time, indicates that 1 minute out of ten, the sound level was equal to or higher than the value given. The L_{10} is useful in defining sounds that change in level due to transient sound sources, such as nearby movement of vehicles.

L_{50} is the "median sound level." Half the time the sound level was lower than the reported L_{50} and half the time it is higher than the reported L_{50}.

Compounding of Sound Descriptors
The use of dB(A) or dBA indicates the sound pressure level (in dB) has been A-weighted. Similarly, the use of LA_{eq}, LA_{10}, LA_{50}, and LA_{90} indicates the average or statistical values reported have been "**A-weighted**" where standard L_{eq}, L_{10}, L_{50}, and L_{90} represent unweighted or linear sound levels. Occasionally, a more cumbersome description, such as "A-weighted L_{xx}" or other statistic is used represent the LA_{eq}, LA_{10}, LA_{50}, or LA_{90}

Day Night Average Sound Level (DNL or Ldn)

Day Night Average Sound Level (DNL or Ldn) is a calculated noise metric used to reflect a person's cumulative exposure to sound over a 24-hour period. DNL takes into account the amount of noise (LA_{eq}) occurring throughout the day and night, but applies an additional 10dB weighting penalty for nighttime sound made between 10 PM and 7 AM. Unlike LA_{eq}, DNL is not a directly measured quantity, but rather is calculated metric using the mathematical equation shown below:

$$DNL = Ldn = 10\log_{10}\frac{1}{24}\left(\sum_{d=1}^{15} 10^{[Leq(d)]/10} + \sum_{n=1}^{9} 10^{[Leq(n)+10]/10}\right)$$

Sound Power Level

Sound power is the rate which sound energy is emitted per unit time. Sound power is not dependent on distance from the sound source or the environment the sound source is in. On the other hand, sound pressure is highly sensitive to its environment and distance from the sound source. Sound power is analogous to the power rating on a light bulb. For a given type of light bulb technology, a bulb with a higher power rating would produce more light. However, the environment the light bulb is put in (room paint color, lamp shape, distance from the light bulb, etc.) will determine how much light is ultimately observed.

When sound power is presented as a "level," it shares the same logarithmic decibel (dB) scale as sound pressure level but uses a reference of 1 picowatt as its basis.

Sound Losses, Noise Reduction or Attenuation

In an overly simplistic view, sound attenuation is the difference, in dB, between the sound incident on a device (such as a wall or muffler) and the sound that is transmitted through the device. It is typically reported as a function of frequency.

Some typical losses include:

- Transmission Loss (TL) is used to describe effectiveness in reducing noise from walls, silencers or enclosures after corrections for the influences of the environment have been made.

- Sound Transmission Class (STC) is a single number descriptor of Transmission Loss values that have been curve fit to a prescribed frequency spectrum shape. Higher numerical ratings are generally better at reducing noise than lower numerical ratings are but the detail of the reduction at individual frequencies is lost in the simplification.

- Noise Reduction (NR) is used to describe the in-situ difference of sound on the source side and receiver side of a noise control device.

- Insertion Loss (IL) and Dynamic Insertion Loss (DIL), which includes flow effects and flow noise, is used to describe the difference of sound measured or calculated on the receiver side of a noise control device before and after the noise control device was put into service (before and after insertion).

Examples of Common Noise Sources

The chart below is included to provide perspective on sound levels of common noise sources.

COMMON OUTDOOR ACTIVITIES	NOISE LEVEL dB(A)	COMMON INDOOR ACTIVITIES
	---110---	Rock Band
Jet Fly-over at 1000 ft		
	---100---	
Gas Lawn Mower at 3 ft		
	---90---	
Diesel Truck at 50 ft, at 50 mph		Food Blender at 1 m (3 ft)
	---80---	Garbage Disposal at 1 m (3 ft)
Noise Urban Area (Daytime)		
Gas Lawn Mower at 100 ft	**---70---**	Vacuum Cleaner at 10 ft
Commercial Area		Normal Speech at 3 ft
Heavy Traffic at 300 ft	**---60---**	
		Large Business Office
Quiet Urban Daytime	**---50---**	Dishwasher Next Room
Quiet Urban Nighttime	**---40---**	Theater, Large Conference Room (Background)
Quiet Suburban Nighttime		
	---30---	Library
Quiet Rural Nighttime		Bedroom at Night, Concert Hall (Background)
	---20---	
	---10---	
	---0---	
Lowest Threshold of Human Hearing		Lowest Threshold of Human Hearing

Source: California Dept. of Transportation Technical Noise Supplement, Oct. 1998, Page 18.

APPENDIX B - Reporting Consultant's Résumé

DAVID J. PARZYCH
Power Acoustics, Inc.

March 1998 to present

Dave Parzych has over 30 years of experience in acoustical engineering and noise control design and is the principal and founder of Power Acoustics, Inc. Since 1998, he has provided a full range of acoustical consulting services for over 300 clients and several hundred projects including; sound measurements, analytical modeling studies and working as an expert witness in industrial, commercial, transportation and residential applications. Mr. Parzych has also developed a commercial software package, SPM9613, used worldwide in community noise modeling.

He is known as an expert in outdoor sound propagation and modeling, power plant noise and Gas Turbine silencing. He has developed suitable community noise criteria, designed noise controls for and/or verified facility acoustical compliance through specialized sound tests for several dozen power plants situated throughout the world. He has also designed noise abatement for many industrial, commercial and residential buildings.

Dave has been an invited speaker and author in conference sessions sponsored by the Acoustical Society of America and the Institute of Noise Control Engineering on noise modeling and measurements of power plants, industrial facilities and modeling the performance of sound barrier walls. He has testified in several court cases, including Federal court, on noise prediction, acoustical measurements and data interpretation.

October 1992 to February 1998

Mr. Parzych was a Senior Noise Control Engineer and Technical Group Leader of Acoustics in the Environmental Engineering group at Westinghouse Power Generation. From 1992 through February of 1998 he led the development of noise control and state-of-the-art research in modeling and diagnostics techniques. Mr. Parzych was responsible for the acoustical silencing and design of combustion turbines, aerodynamic source modeling of turbo-machinery noise, overall acoustical design of combustion turbine, steam turbine and cogeneration projects and environmental modeling to determine community impacts and worker noise exposure.

October 1983 to October 1992

From 1983 to 1992, Mr. Parzych gained experience in aircraft noise through an intensive effort to develop a quiet counter-rotating Prop-Fan aircraft engine as an Analytical Acoustical Engineer at United Technologies Corp., Hamilton Standard Division. Mr. Parzych has been an investigator on several NASA funded research projects involving acoustics and unsteady aerodynamics of propellers, Prop-Fans and wind turbines.

<u>May 1982 to October 1983</u>
Dave began his professional career as an acoustical engineer in 1982 with General Dynamics, Electric Boat Division in Groton, Connecticut working in airborne and structureborne silencing for the on-board nuclear power plants used in the US NAVY submarine fleet.

EDUCATION

Bachelor of Science in Engineering, Acoustics, University of Hartford 1982
Continuing education in acoustics and noise control including aero-acoustics offered at the Catholic University in Washington D.C. and many seminars and conferences on acoustics and noise control.

CERTIFICATION AND PROFESSIONAL ACTIVITIES

- Board Certified - Institute of Noise Control Engineering
- Licensed Professional Engineer, State of Oregon, with specialty in Acoustical Engineering (PE18940)
- Full Member Acoustical Society of America
- Principal/Firm Member National Council of Acoustical Consultants
- Full Member ASME
- Full Member ASTM
- Chairman of ANSI B133.8, subcommittee 7, Gas Turbine Installation Sound Emissions (1997-2000)
- Member of ANSI B133.8, subcommittee 7, Gas Turbine Installation Sound Emissions (2000-2008)
- Member ASTM E33 Committee on Environmental Noise (current)
- Chairman ASME Codes and Standards Committee PTC-36 "Measurement of Industrial Sound" (2012-2015), Vice Chair (2015-2018)

PATENTS

Patent Number 5,709,529, January 20, 1998, "Optimization of Turbomachinery Harmonics"

TECHNICAL PAPERS

INTERNOISE 2018 Resolution of an Environmental Noise Problem Caused by a 345 KV Power Pole, 2018.

INTERNOISE 2015 ASME Noise Standards; Present and Future, 2015. (*Invited Paper*)

INTERNOISE 2012 Proceedings, Combustion turbine silencer design, selection and applications, 2012. (*Invited Paper*)

INTERNOISE 2009 Proceedings, Challenges of unanticipated power plant startup noise, 2009. (*Invited Paper*)

NOISE CON 2007 Proceedings, Methods to Eliminate Continuous and Variable Background Noise Sources, October 2007. (*Invited Paper*)

INTER-NOISE 2006 Proceedings, Modeling the reduced insertion loss of a sound barrier in a downward refracting atmosphere for a petrochemical plant, December 2006. (Co-authored)

INTER-NOISE 2006 Proceedings, Modeling uncertainty creep due to variability in model constituents, December 2006. (Co-authored)

NOISE CON'2004 Proceedings, Handling of Barriers in ISO 9613-2, July 2004. (*Invited Paper*)

NOISE CON'2003 Proceedings, Issues In Determining Sound Power Levels of Gas Turbine Exhausts, June 2003. (*Invited Paper*)

Air and Waste Management 94th Annual Conference Proceedings, Paper #603, Estimating Community Sound Levels of Large Industrial Facilities, June 2001.

Joint ASA, INCE, NOISE CON'2000 Proceedings, Using A Prediction Model To Allocate Allowable Noise Between Sources And Establish Equipment Noise Limits, 2000. (*Invited Paper*)

INTERNOISE'99 Proceedings, Predicting Far Field Sound Levels of Large Industrial Noise Sources Using Point Source Radiation Models, 1999. (*Invited Paper*)

NOISE CON'98 Proceedings, An Experimental Investigation of Combustion Turbine Exhaust Stack Silencer Performance, 1998.

NOISE CON'96 Proceedings, An Experimental Investigation of Combustion Turbine Exhaust Noise Sources, 1996

INTERNOISE'96 Proceedings, Low Frequency Noise - Approaches and Designs for Combustion Turbines, 1996, (Co-authored)

INTERNOISE'95 Proceedings, Understanding the Noise Generation Mechanisms of Industrial Combustion Turbines and Designing Effective Noise Control Treatments, 1995.

DGLR/AIAA, An Assessment of Wake Structure Behind Forward Swept and Aft Swept Prop-Fans at High Loading, 1992, (Co-authored)

DGLR/AIAA-92-02-049, Near Field Noise Theory for Propellers with Angular Inflow, 1992, (Co-authored)

AIAA-91-0705, Temporally and Spatially Resolved Flows Within and Aft of a Single Rotation Prop-Fan, 1991, (Co-authored)

AIAA-3979, Modal Evaluation of Noise Generated by the Front Rotor of a Counter-Rotating Prop-Fan, 1990.

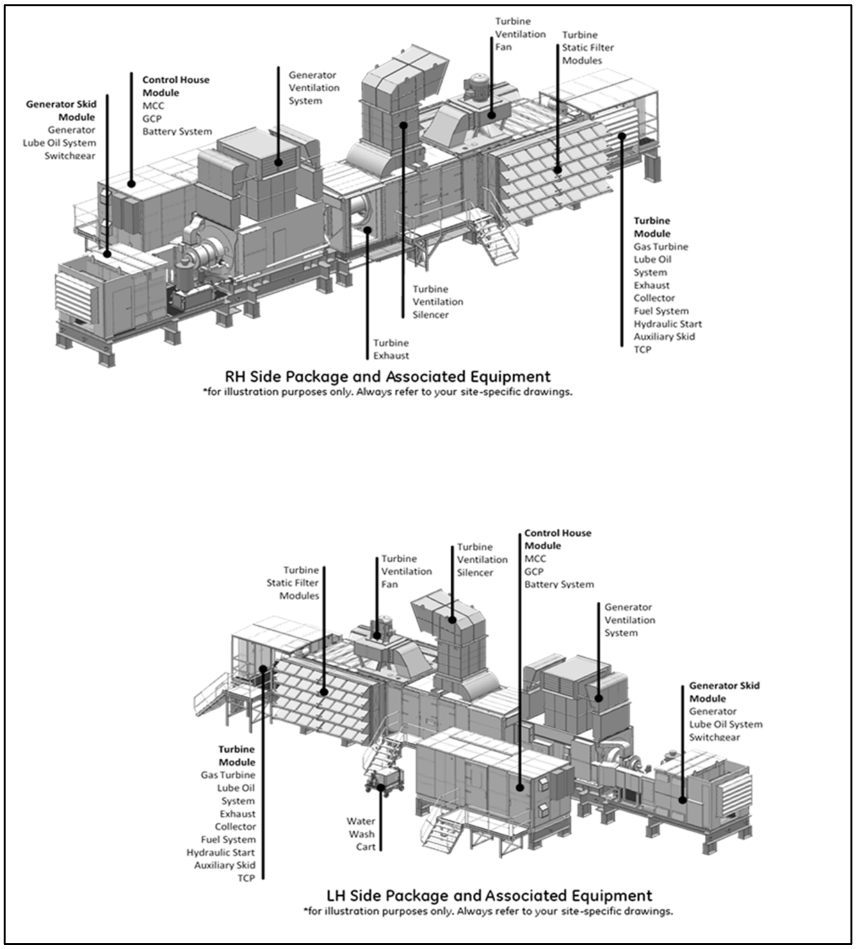
AIAA-90-3978, Vortex Structure of Wakes Behind an Advanced Propeller at Take-off Load Conditions, 1990, (Co-authored)

AIAA-89-1094, Interaction Noise Mechanisms for Advanced Propellers, Analytical Evaluation, 1989.

SAE 871839, Prop-Fan/Turboprop Acoustic Terminology, 1987.

AIAA-86-1895, Noise of the Fairey Gannett Counter Rotating Propeller, 1986.

APPENDIX C – Modeled Equipment Sound Sources



	Sound Power Level PWL (dB(A))									A
Frequency, Hz	31.5	63	125	250	500	1000	2000	4000	8000	(+/- 2dB)
Lmxpress	78.8	93.3	106.3	100.8	100.7	102	101.1	92.1	83.5	110
CNTRROOM	54.9	63.6	71.4	60.2	70.5	73.5	72.8	70	60.2	79.1
GLO 60Hz	67.3	77.8	89.5	80.6	78.4	85.8	77.9	71.6	60.3	92
TURBINE VENTILATION-60hz	70.3	82.3	89.8	86.5	83.6	92.8	86.7	79	72.5	96.3
FAN	65.4	78.9	86.2	89.8	95.6	94.7	90	84.7	72.1	99.7
AUX Skid	68.4	82.1	89.5	88.7	88.9	85.4	83.8	78	66.3	95.1
TURBINE ENCLOSURE	72.4	89	93	93.3	90.8	91.4	91.7	85.7	78.4	99.7
AIR_FILTER	71.6	86.1	98.5	95.9	96.5	97.5	92.6	85.1	76.1	103.8
GEN_TB_COUPLING 60Hz	53.6	67.3	71.1	64.9	66.8	70.3	70	64	65.5	77.3
GEN	72.4	86.4	104.9	95.6	91.4	94.8	98.9	86.5	78.6	106.8

LM2500Xpress with Un-weighted Sound Power Levels

		Octave Band Center Frequency (Hz)											
Type	**Description**	**16**	**31.5**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dB(A)**	**dB(C)**
	Un-weighted Sound Power Levels of GE LM2500xpress Components												
Lw:	CNTRROOM		94.3	89.8	87.5	68.8	73.7	73.5	71.6	69.0	61.2	**79**	**94**
Lw:	GLO 60Hz		106.7	104.0	105.6	89.2	81.6	85.8	76.7	70.6	61.3	**92**	**109**
Lw:	TURBINE VENTILATION-60hz		109.7	108.5	105.9	95.1	86.8	92.8	85.5	78.0	73.5	**96**	**112**
Lw:	FAN		104.8	105.1	102.3	98.4	98.8	94.7	88.8	83.7	73.1	**100**	**109**
Lw:	AUX Skid		107.8	108.3	105.6	97.3	92.1	85.4	82.6	77.0	67.3	**95**	**111**
Lw:	TURBINE ENCLOSURE		111.8	115.2	109.1	101.9	94.0	91.4	90.5	84.7	79.4	**100**	**117**
Lw:	AIR_FILTER		111.0	112.3	114.6	104.5	99.7	97.5	91.4	84.1	77.1	**104**	**117**
Lw:	GEN_TB_COUPLING 60Hz		93.0	93.5	87.2	73.5	70.0	70.3	68.8	63.0	66.5	**77**	**95**
Lw:	GEN		111.8	112.6	121.0	104.2	94.6	94.8	97.7	85.5	79.6	**107**	**122**
Lw:	**Linear sound power of All Sources of LM2500xpress**		**118.2**	**119.5**	**122.5**	**109.4**	**103.9**	**101.9**	**99.9**	**91.1**	**84.5**	**110**	**125**

Exhaust System

Un-weighted Sound Power Level at Turbine Exhaust as supplied by GE

UNSILENCED COMBUSTION EXHAUST (IN-DUCT SOUND POWER LEVELS AT THE DIFFUSER FLANGE)											
	PWL (dB re 10-12 watts)										
Frequency, Hz	31.5	63	125	250	500	1000	2000	4000	8000	Total, dB	Total, dBA
G4 UPT expected values	133	140	143	151.5	148.8	135.1	125.7	115.4	104	154	147.8

Non-contributing Exhaust System performance specification/guarantee

Acoustic Performance

Octave Band Center Frequency (Hz)	1/1 Octave Band Center Frequency									
	31.5	63	125	250	500	1000	2000	4000	8000	A-Wt
Unsilenced Lw	133	140	143	151.5	148.8	135.1	125.7	115.4	104	154

- The stack silencer shall be designed to reduce the Braden supplied exhaust stack to the following:
  - 85 dBA average Near Field silencing measured @ 3Ft horizontal from stack, 5Ft above grade.
  - 49 dBA average Far Field silencing measured @ 400Ft horizontal from the exhaust system, 5Ft above grade.

Estimated Transformer Sound Power Level CTG

MVA rating =	**33**	MVA
Measurement Surface Area =	**60**	m^2
Correction from Pressure at 0.3 meter to Sound Power =	**18**	**dB**
Approximate Standard NEMA Rating =	**73**	**dB**
Estimated Standard A-weighted Sound Power Level =	**91**	**dB Lw**

Octave Band Spectum Estimate, Lw

	31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
STD Transformer Spectrum*, Lw	**88**	**94**	**96**	**91**	**91**	**85**	**80**	**75**	**68**	**91**
Atmospheric Absorption	0	0	0	0	0	-1	-1	-3	-9	
Spherical divergence	-53	-53	-53	-53	-53	-53	-53	-53	-53	
Ground Plane Correction	3	3	3	3	3	3	3	3	3	
Sound Propagation Attenuation	-50	-50	-50	-50	-50	-50	-51	-53	-59	
STD Radiated SPL at 122 meters	38	44	46	41	41	35	29	23	9	41

* Spectrum base on Edison Electric Institute "Electric Power Plant Environmental Noise Guide"

Estimated Transformer Sound Power Level SUS Transformer

MVA rating =	**3.125**	MVA
Measurement Surface Area =	**33**	m^2
Correction from Pressure at 0.3 meter to Sound Power =	**15**	**dB**
Approximate Standard NEMA Rating =	**61**	**dB**
Estimated Standard A-weighted Sound Power Level =	**76**	**dB Lw**

Octave Band Spectum Estimate, Lw

	31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
STD Transformer Spectrum*, Lw	**73**	**79**	**81**	**76**	**76**	**70**	**65**	**60**	**53**	**77**
Atmospheric Absorption	0	0	0	0	0	-1	-1	-3	-9	
Spherical divergence	-53	-53	-53	-53	-53	-53	-53	-53	-53	
Ground Plane Correction	3	3	3	3	3	3	3	3	3	
Sound Propagation Attenuation	-50	-50	-50	-50	-50	-50	-51	-53	-59	
STD Radiated SPL at 122 meters	23	29	31	26	26	20	14	8	-6	26

* Spectrum base on Edison Electric Institute "Electric Power Plant Environmental Noise Guide"

Air Compressors and Gas Conditioning/metering

	Octave Band Center Frequency, Hertz									
	31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
Lw Spectrum of EEI Guide Compressor	90	86	91	90	88	91	96	93	86	100
Lw, Gas Conditioning and metering	119	117	107	96	86	79	82	82	80	96

* gas piping/valves include a minimum of 2 inches of insulation, a 1 lbs/ft^2 mass loaded wrap, and aluminum jacketing.

APPENDIX D – Colorado Revised Statutes 2023, ARTICLE 12, Noise Abatement

JUSTIA

Go to previous versions of this Section ↓

2023 Colorado Revised Statutes
Title 25 - PUBLIC HEALTH AND ENVIRONMENT (§§ 25-1-101 — 25-59-106)
ENVIRONMENTAL CONTROL (§§ 25-6.5-101 — 25-18.9-105)
Article 12 - NOISE ABATEMENT (§§ 25-12-101 — 25-12-110)
Section 25-12-103 - Maximum permissible noise levels

Universal Citation:
CO Code § 25-12-103 (2023)

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(1) Every activity to which this article is applicable shall be conducted in a manner so that any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Sound levels of noise radiating from a property line at a distance of twenty-five feet or more therefrom in excess of the db(A) established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance:

Zone	7:00 a.m. to next 7:00 p.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)

(2) In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in subsection (1) of this section may be increased by ten db(A) for a period of not to exceed fifteen minutes in any one-hour period.

(3) Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five db(A) less than those listed in subsection (1) of this section.

(4) This article is not intended to apply to the operation of aircraft or to other activities which are subject to federal law with respect to noise control.

(5) Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of project.

(6) All railroad rights-of-way shall be considered as industrial zones for the purposes of this article, and the operation of trains shall be subject to the maximum permissible noise levels specified for such zone.

(7) This article is not applicable to the use of property for purposes of conducting speed or endurance events involving motor or other vehicles, but such exception is effective only during the specific period of time within which such use of the property is authorized by the political subdivision or governmental agency having lawful jurisdiction to authorize such use.

(8) For the purposes of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

(9) 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 such sound level measurement.

(10) This article is not applicable to the use of property for the purpose of manufacturing, maintaining, or grooming machine-made snow. This subsection (10) shall not be construed to preempt or limit the authority of any political subdivision having jurisdiction to regulate noise abatement.

(11) This article is not applicable to the use of property by this state, any political subdivision of this state, or any other entity not organized for profit, including, but not limited to, nonprofit corporations, or any of their lessees, licensees, or permittees, for the purpose of promoting, producing, or holding cultural, entertainment, athletic, or patriotic events, including, but not limited to, concerts, music festivals, and fireworks displays. This subsection (11) shall not be construed to preempt or limit the authority of any political subdivision having jurisdiction to regulate noise abatement.

(12)

(a) Notwithstanding subsection (1) of this section, the public utilities commission may determine, while reviewing utility applications for certificates of public convenience and necessity for electric transmission facilities, whether projected noise levels for electric transmission facilities are reasonable. Such determination shall take into account concerns raised by participants in the commission proceeding and the alternatives available to a utility to meet the need for electric transmission facilities. When applying, the utility shall provide notice of its application to all municipalities and counties where the proposed electric transmission facilities will be located. The public utilities commission shall afford the public an opportunity to participate in all proceedings in which permissible noise levels are established according to the "Public Utilities Law", articles 1 to 7 of title 40, C.R.S.

(b) Because of the statewide need for reliable electric service and the public benefit provided by electric transmission facilities, notwithstanding any other provision of law, no municipality or county may adopt an ordinance or resolution setting noise standards for electric transmission facilities that are more restrictive than this subsection (12). The owner or operator of an electric transmission facility shall not be liable in a civil action based upon noise emitted by electric transmission facilities that comply with this subsection (12).

(c) For the purposes of this section:

(I) "Electric transmission facility" means a power line or other facility that transmits electrical current and operates at a voltage level greater than or equal to 44 kilovolts.

(II) "Rights-of-way for electric transmission facilities" means all property rights and interests obtained by the owner or operator of an electric transmission facility for the purpose of constructing, maintaining, or operating the electric transmission facility.

L. 71: p. 648, § 1. C.R.S. 1963: § 66-35-3. L. 82: (10) added, p. 424, § 1, effective March 11. L. 87: (11) added, p. 1154, § 1, effective May 20. L. 2004: (12) added, p. 736, § 2, effective July 1.

For the legislative declaration contained in the 2004 act enacting subsection (12), see section 1 of chapter 219, Session Laws of Colorado 2004.

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