Appendix G
Noise and Vibration

FOUNTAIN WIND ENERGY PROJECT NOISE TECHNICAL REPORT

Shasta County, California

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EXECUTIVE SUMMARY

This report provides a noise assessment of the Fountain Wind Energy Project (Project) proposed in an unincorporated area in the southern end of the Cascade Range in Shasta County, California. The Project proposes the construction, operation, maintenance, and decommissioning of up to 72 turbines, each having a generating capacity of 3 to 5.7 megawatts (MW), for a total nameplate generating capacity of up to approximately 216 MW. The lands underlying the Project are designated as Timber Production and Unclassified.

The closest residences are located about 2,200 feet from proposed turbines. The existing noise environment in the vicinity of nearby residences is defined primarily by natural sounds, such as wind rustling the leaves of foliage, insects, and birds. In locations adjacent to SR-299, traffic is the dominant noise source. Based on noise monitoring results, existing ambient noise levels range from 42 dBA L_{dn} at more remote locations to 54 dBA L_{dn} in locations adjacent to SR-299.

Noise associated with Project operations is not expected to exceed Shasta County noise standards or the supplementary criteria for low frequency and infrasonic noise at any residential property in the site vicinity. However, use of helicopters during construction and any nighttime construction located within 2,500 feet of residences would have the potential to cause sleep and/or speech interference. Noise reduction measures, including limiting helicopter and heavy construction near residential areas to daytime hours and minimizing helicopter use, are provided to minimize disruption and annoyance during construction.

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INTRODUCTION

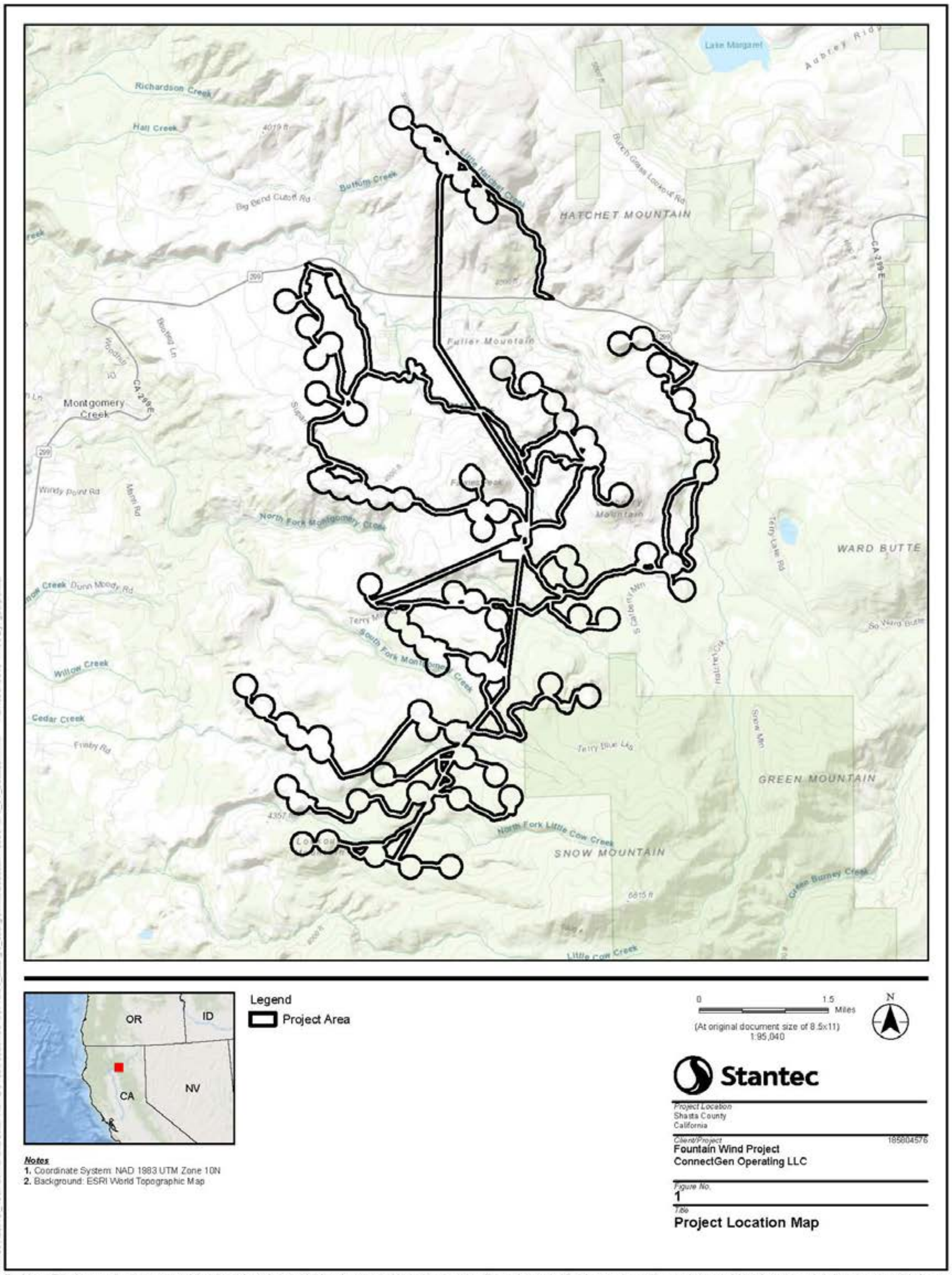
The Fountain Wind Energy Project (Project) proposes the construction, operation, maintenance, and decommissioning of up to 72 wind turbines and related infrastructure in the southern end of the Cascade Range in Shasta County, California (Figure 1). This Project proposes a reduction in turbines from the originally proposed project, for which an environmental noise study was prepared in March 2019.[1]

Each turbine would be no more than 679 feet above ground level at the top of the blade and would have a generating capacity of 3 to 5.7 megawatts (MW). The Project would have a total nameplate generating capacity of up to 216 MW. Associated infrastructure and ancillary facilities would include: a 34.5-kilovolt (kV) overhead and underground electrical collector system to connect turbines together and to an onsite collector substation; overhead and underground fiber-optic communication lines, an onsite switching station to connect the Project to the regional grid operated by the Pacific Gas and Electric Company (PG&E), a temporary construction and equipment laydown area, 14 temporary laydown areas distributed throughout the Project Site to store and stage building materials and equipment, an operation and maintenance (O&M) facility, up to four permanent meteorological (MET) towers and temporary, episodic deployment of mobile Sonic Detection and Ranging (SoDAR) or Light Detection and Ranging (LiDAR) systems, two storage sheds, and three temporary cement batch plants. New access roads would be constructed within the Project Site, and existing roads would be improved. The lands underlying the Project are designated as Timber Production and Unclassified.

This report includes basic information on noise measurement and assessment, applicable noise regulations and guidelines, an evaluation of the existing noise environment, an assessment of noise levels generated by Project construction and operations, and a discussion of potential noise reduction options, as needed.

[1] Illingworth & Rodkin, Inc., Fountain Wind Energy Project, Noise Technical Report, March 19, 2019.

Figure 1: Fountain Wind Project Site with Wind Turbine Layout



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FUNDAMENTALS OF ENVIRONMENTAL NOISE

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (*frequency*) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is intensity of sound waves combined with the reception characteristics of the ear. Intensity is a measure of the amplitude (height) of the sound wave.

There are several noise measurement scales which are used to describe noise. A *decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10-decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1.

Environmental noise is typically described in terms of the *sound pressure level,* the quantity that is directly measured by a sound level meter at a specified location. The strength of a wind turbine source, however, is often characterized by its *sound power level*. Sound power level is independent of the distance a receiver is from the source and is a property of the source alone. Knowing the sound power level of an idealized source and its distance from a receiver, the sound pressure level at the receiver point can be calculated based on geometrical spreading. Both sound pressure level and sound power level utilize the decibel scale, although the relative reference used is different between the two concepts. This approach is applied to wind turbine generators in the standard measurement techniques for determining the sound power or source level[1].

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level (dBA).* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2. The *C-weighed sound level (dBC)* also follows the frequency sensitivity of the human ear, but at much higher noise levels. This results in a flatter curve giving more emphasis to low frequency sounds.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as wind turbines, roadways, and airports. The accuracy of the predicted models depends upon the receptor's distance from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

For sound propagation outdoors, the sound level decreases with distance due to the spreading out of sound waves originating from the source. For an ideal "point" source, this geometrical or spherical spreading results in a reduction of sound pressure level of 6 dB per doubling of distance from the source. In addition, other phenomena can create excess attenuation. These include atmospheric absorption, ground absorption, and shielding. For sound propagation outdoors, there is almost always excess attenuation producing lower levels than what would be predicted by spherical spreading alone. At large distances attenuation by air absorption can be significant: approximately 4 dB per mile in the 500 Hz band at standard atmospheric conditions (68^{o}F and 50% humidity). Ground absorption is lower for a reflective surface such as pavement or water and higher for an absorptive surface such as lawn or soft forest floor. For sound propagating over soft ground at near grazing angles of incidence, excess attenuations of 20 to 30 dB can be measured due to interference effect of the direct and reflected sound. Shielding from intervening terrain, structures, or barriers can provide 5 to 20 dB of sound reduction if the line-of-sight between the source and receiver is broken. Under certain meteorological conditions, some of these excess attenuation mechanisms are reduced or eliminated, leaving spherical spreading as the primary determinate of sound level at a receiver location.

When more than one noise source contributes to the sound pressure level at a receiver point, the overall sound level is determined by combining the contribution of the sources. This is done by logarithmically adding the individual sound pressures together. The logarithmic addition of two sound sources that are independent and equal would result in a 3 dB increase over the level of each alone. In assessing environmental noise, a 3 dB increase in level is typically considered as just perceivable, while an increase of 1 dB is difficult to detect and within the accuracy limitations of the sound level meter and predicted models.

Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This *energy-equivalent sound/noise descriptor* is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration. Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level* (*CNEL*) is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level* (*DNL* or L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

TABLE 1 Definition of Acoustical Terms Used in this Report

Term	Definition
Decibel, dB	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20 micro Pascals.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e. g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Sound Power	Sound power is the rate at which sound energy is emitted, reflected, transmitted or received, per unit time. Sound power is a property of a sound source, equal to the total power emitted by that source in all directions and is neither room-dependent nor distance-dependent.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
C-Weighted Sound Level, dBC	The sound pressure level in decibels as measured using the C-weighting filter network. The C-weighting is very close to an unweighted or “flat” response. C-weighting is only used in special cases when low frequency noise is of particular importance.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.

Source: Handbook of Acoustical Measurements and Noise Control, Harris, 1998.

TABLE 2 Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), California Department of Transportation, September 2013.

FUNDAMENTALS OF NOISE AND VIBRATION FROM BLASTING

When explosive charges are detonated in rock, the blast has been designed so that most of the energy is used in breaking and displacing the rock mass. However, some of the energy can also be released in the form of transient stress waves, which in turn cause temporary ground vibration. Detonating charges also create rock movement and the release of high-pressure gas, which in turn, induces air-overpressure (blast noise).

The average person is quite sensitive to ground motion, and vibration levels as low as 0.01 in/sec can be detected by the human body. Frequency of motion or cycles per second is a measure of how many times a particle of ground moves back and forth (or up and down) in one second of time. Frequency is expressed in units of Hertz (Hz).

Noise from blasting or "blast noise" is primarily composed of sound pressures at frequencies below the threshold-of-hearing for humans (16 to 20 Hz). Hence, the common industry term for blast-induced noise is "air-overpressure". As its name implies, air-overpressure is a measure of the transient pressure changes above and below ambient atmospheric pressure. When calculating maximum overpressure values, the absolute value of the greatest pressure change is used — regardless of whether it is a positive or negative change.

When measurements include low frequency noise (2 Hz and higher) with a flat response, they are called "linear scale" measurements. Air-overpressure measurements are typically expressed in dB units, and when the scale is linear, the unit designation is "dB(L)." Regular acoustical noise measurements taken for the purpose of monitoring compliance with local noise ordinances almost always use weighted scales that discriminate against low frequency noise. Thus, for a similar noise source, A-weighted and C-weighted scales will usually record significantly lower levels of noise.

The regulatory limit defined by the former United States Department of the Interior, Bureau of Mines (US Bureau of Mines) for air-overpressure measured with 2-Hz response seismographs is 133 dB(L) (USBM 1971). Damage to old or poorly glazed windows does not occur until air-overpressure reaches about 150 dB(L). More importantly, since the decibel scale is a logarithmic ratio, the actual overpressure at 150 dB(L) is 0.092 pounds per square inch (psi), versus 0.013 psi at 133 dB(L). Therefore, the actual pressure at the 133 dB(L) limit, is over seven times (0.0915/0.0129) lower than the threshold damage level at 150 dB(L).

When blasting occurs at large distances from sensitive structures, the primary concern is damage to structures. Structural damage can be classified as cosmetic, such as paint flaking or minimal extension of cracks in building surfaces; minor, including limited surface cracking; or major, that may threaten the structural integrity of the building. Safe vibration limits that can be applied to assess the potential for damaging a structure vary by researcher. The damage criteria presented in Table 3 include several categories for ancient, fragile, and historic structures, the types of structures most at risk to damage. Most buildings are included within the categories ranging from "Historic and some old buildings" to "Modern industrial/commercial buildings". Construction-induced vibration that can be detrimental to the building is very rare and has only been observed in instances where the structure is at a high state of disrepair and the construction activity occurs immediately adjacent to the structure.

The annoyance levels shown in Table 3 should be interpreted with care since vibration may be found to be annoying at lower levels than those shown, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to an elevated human reaction, even though there is very little risk of actual structural damage.

TABLE 3 Reaction of People and Damage to Buildings from Continuous or Frequent Intermittent Vibration Levels

Velocity Level, PPV (in/sec)	Human Reaction	Effect on Buildings
0.01	Barely perceptible	No effect
0.04	Distinctly perceptible	Vibration unlikely to cause damage of any type to any structure
0.08	Distinctly perceptible to strongly perceptible	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected
0.1	Strongly perceptible	Threshold at which there is a risk of damage to fragile buildings with no risk of damage to most buildings
0.25	Strongly perceptible to severe	Threshold at which there is a risk of damage to historic and some old buildings.
0.3	Strongly perceptible to severe	Threshold at which there is a risk of damage to older residential structures
0.5	Severe - Vibrations considered unpleasant	Threshold at which there is a risk of damage to new residential and modern commercial/industrial structures

Source: Transportation and Construction Vibration Guidance Manual, California Department of Transportation, September 2013.

REGULATORY BACKGROUND

Noise from wind turbine generator operations is typically regulated at the County level. Applicable guidance from the Noise Element of the Shasta County General Plan and supplemental criteria for low frequency and infrasonic noise are described below.

Shasta County Noise Element. An objective of the Noise Element of the Shasta County General Plan is to protect County residents from the harmful and annoying effects of exposure to excessive noise. The General Plan considers residential land uses "generally acceptable" in noise environments of 60 dBA L_{dn} or less and "conditionally acceptable" in noise environments between 60 to 70 dBA L_{dn}. See Figure N-1.

In addition, the following Policies would be applicable to the Project:

N-b: Noise likely to be created by a proposed non-transportation land use shall be mitigated so as not to exceed the noise level standards of Table N–IV (shown below) as measured immediately within the property line of adjacent lands designated as noise-sensitive. (From Table N-IV: In rural areas where large lots exist, the exterior noise level standard shall be applied at a point 100' away from the residence.) Noise generated from existing or proposed agricultural operations conducted in accordance with generally accepted agricultural industry standards and practices is not required to be mitigated.

N-c: Where proposed non-residential land uses are likely to produce noise levels exceeding the performance standards of Table N–IV upon existing or planned noise-sensitive uses, an acoustical analysis shall be required as part of the environmental review process so that appropriate noise mitigation may be included in the project design. The requirements for the content of an acoustical analysis are given by Table N-V (not shown).

N-g: Existing noise-sensitive uses may be exposed to increased noise levels due to future roadway improvement projects as a result of increased traffic capacity and volumes and increases in travel speeds. In these instances, it may not be practical to reduce increased traffic noise levels consistent with those contained in Table N-VI (shown below). Therefore, as an alternative, the following criteria may be used as a test of significance for increases in the ambient outdoor activity areas of the noise level of noise-sensitive uses created as a result of a new roadway improvement project:

- Where existing traffic noise levels are less than 60 dB L_{dn}, a +5 dB L_{dn} increase will be considered significant; and
- Where existing traffic noise levels range between 60 and 65 dB L_{dn}, a +3 dB L_{dn} increase will be considered significant; and
- Where existing traffic noise levels are greater than 65 dB L_{dn}, a + 1.5 dB L_{dn} increase will be considered significant.

N-i: Where noise mitigation measures are required to achieve the standards of Tables N-IV and N-VI, the emphasis of such measures shall be placed upon site planning and project design. The use of noise barriers shall be considered a means of achieving compliance with the noise standards only after all other practical design-related noise mitigation measures have been integrated into the project.

Shasta County regulations do not address the operational characteristics of wind turbines. Wind turbines only operate when the wind exceeds a "cut-in" speed which is typically about 4 m/sec (8.9 mph). As a result, they do not produce noise continuously. For Shasta County, the noise limits are interpreted to be not-to-exceed levels, or essentially steady-state levels. Since wind turbines may operate day or night, the nighttime limits (50 dBA as measured immediately within the property line of adjacent lands designated as noise-sensitive) will be considered as the appropriate levels with which to compare the estimated noise levels produced by the proposed Project.

FIGURE N-1: TRANSPORTATION NOISE RELATED LAND USE COMPATIBILITY GUIDELINES FOR DEVELOPMENT

LAND USE CATEGORY		50	55	60	65	70	75	80
		COMMUNITY NOISE EXPOSURE L_{dn} OR CNEL, dB						
Residential, Theaters, Music Halls, Meeting Halls, Churches, & Auditoriums	G.A.	■	■					
	C.A.			▒	▒			
	G.U.					■	■	■
Transient Lodging - Motels, Hotels, & RV Parks	G.A.	■	■					
	C.A			▒	▒	▒		
	G.U.						■	■
Schools, Libraries, Museums, Nursing Homes, & Child Care	G.A.	■	■					
	C.A.			▒	▒	▒		
	G.U.						■	■
Playgrounds, Neighborhood Parks, & Amphitheaters	G.A.	■	■	■	■			
	C.A.					▒		
	G.U.						■	■
Office Buildings, Business, Commercial, & Professional	G.A.	■	■	■				
	C.A.				▒	▒		
	G.U.						■	■
Industrial, Manufacturing, Agriculture, & Utilities	G.A.	■	■	■	■			
	C.A.					▒	▒	▒
	G.U.							
Golf Courses, Outdoor Spectator Sports, & Riding Stables	G.A.	■	■	■	■			
	C.A.					▒	▒	
	G.U.							■

INTERPRETATION:

G.A. = **GENERALLY ACCEPTABLE**

Specified land use is satisfactory. No noise mitigation measures are required.

C.A. = **CONDITIONALLY ACCEPTABLE**

Use should be permitted only after careful study and inclusion of protective measures as needed to satisfy the policies of the Noise Element.

G.U. = **GENERALLY UNACCEPTABLE**

Development is usually not feasible in accordance with the goals of the Noise Element.

Source: Brown-Buntin Associates Inc, 1998

TABLE N-IV:
NOISE LEVEL PERFORMANCE STANDARDS FOR NEW PROJECTS AFFECTED BY OR INCLUDING NON-TRANSPORTATION SOURCES

Noise Level Descriptor	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Hourly L_{eq}, dB	55	50

The noise levels specified above shall be lowered by 5 dB for simple tone noises, noises consisting primarily of speech or music, or for recurring impulsive noises. These noise level standards do not apply to residential units established in conjunction with industrial or commercial uses (e.g., caretaker dwellings). The County can impose noise level standards, which are more restrictive than those specified above based upon determination of existing low ambient noise levels. In rural areas where large lots exist, the exterior noise level standard shall be applied at a point 100' away from the residence. Industrial, light industrial, commercial, and public service facilities which have the potential for producing objectionable noise levels at nearby noise-sensitive uses are dispersed throughout the County. Fixed-noise sources which are typically of concern include, but are not limited to, the following:

HVAC Systems	Cooling Towers/Evaporative Condensers
Pump Stations	Lift Stations
Emergency Generators	Boilers
Steam Valves	Steam Turbines
Generators	Fans
Air Compressors	Heavy Equipment
Conveyor Systems	Transformers
Pile Drivers	Grinders
Drill Rigs	Gas or Diesel Motors
Welders	Cutting Equipment
Outdoor Speakers	Blowers

The types of uses which may typically produce the noise sources described above include, but are not limited to: industrial facilities including lumber mills, trucking operations, tire shops, auto maintenance shops, metal fabricating shops, shopping centers, drive-up windows, car washes, loading docks, public works projects, batch plants, bottling and canning plants, recycling centers, electric generating stations, race tracks, landfills, sand and gravel operations, and athletic fields. Note: For the purposes of the Noise Element, transportation noise sources are defined as traffic on public roadways, railroad line operations, and aircraft in flight. Control of noise from these sources is preempted by Federal and State regulations. Other noise sources are presumed to be subject to local regulations, such as a noise control ordinance. Non-transportation noise sources may include industrial operations, outdoor recreation facilities, HVAC units, loading docks, etc.

Source: Shasta County Noise Element

Supplemental Criteria for Low Frequency and Infrasonic Noise. Neither the State of California nor Shasta County specifically address low frequency noise and infrasonic noise from wind energy or other projects. However, low frequency noise and infrasonic noise from wind energy projects should be explored as part of a complete noise assessment[2]. Other criteria can be considered to determine if the project would exhibit high infrasonic noise generation potential. In general, low frequency noise has been associated with older generation, downwind turbines. For these turbines, the wake of the tower interacts with the passing blades to generate pulses at the rate the blades pass the tower. Low frequency noise is typically minimized with upwind turbines. Objective sound pressure level guidelines can be inferred from several different sources.

One source of low frequency criteria is the Alameda County Standard Conditions of Permit Approval for Windfarms[3]. This document uses 70 dBC L_{dn} as the threshold for considering "reasonable complaints". Another source of low frequency criteria within the State of California is the Kern County Code[4]. Under this criteria, the low frequency noise levels at 50 feet from a residence are given below for 1/3 octave bands centered at 2 to 125 Hz as shown in Table 4. In the infrasonic range (below 20 Hz), the Table 4 criteria are actually lower than the established threshold of hearing by 18 to 37 dB[7]. As a result, achieving the values shown for the Kern County criteria should assure that any infrasonic noise generated by the Project will be sufficiently low in level to avoid any noise impact.

TABLE 4 Low frequency noise criteria used by Kern County

1/3 Octave Band Center Frequency, Hz	Noise Level Limit, dB
2 to 16	70
20	68
25	67
31.5	65
40	62
50	60
63	57
80	55
100	52
125	50

Finally, a simpler criterion based on the difference of overall levels has also been proposed as a predictor of annoyance. This occurs when the C-weighted level exceeds the A-weighted level by 20 dB or more[5].

EXISTING NOISE ENVIRONMENT

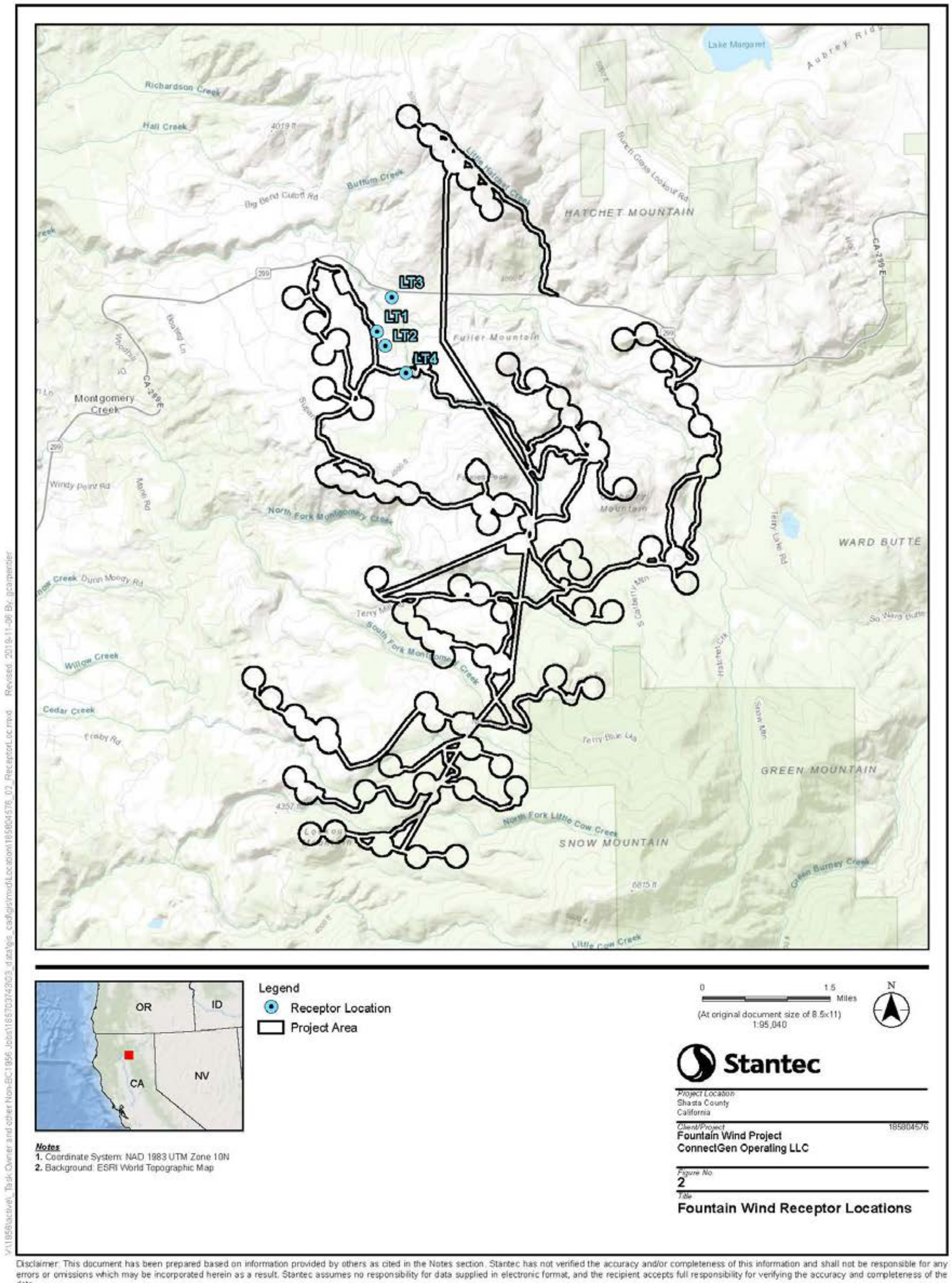
The Project Site is located in an unincorporated area of eastern Shasta County, approximately 1 mile west of the existing Hatchet Ridge Wind Project, 6 miles west of Burney, 35 miles northeast of Redding, immediately north and south of California State Route 299 (SR 299), and near the private recreational facility of Moose Camp. Other communities near the Project Area include Montgomery Creek, Round Mountain, and Wengler (each approximately 3 miles from the Project Site) and Big Bend (approximately 7 miles from the Project Site). The Project Site is located within the southern end of the Cascade Range with topography characterized by buttes and peaks separated by small valleys. The Lassen National Forest lies adjacent to the Project Site to the southeast and the Shasta-Trinity National Forest borders the Project Site to the north. Other surrounding lands are privately owned; many are used for timber harvesting purposes.

There are no residences within the bounds of the project. The closest residences are located about 2,200 feet from proposed turbines. The noise environment in the vicinity of nearby residences is defined primarily by natural sounds, such as wind rustling the leaves of foliage, insects, and birds. In locations adjacent to SR-299, traffic is the dominant noise source. The Project Site is under active timber management and noise associated with related vehicle trips along the roadway network are included in the ambient noise environment.

Noise Measurement Methods

To objectively characterize the noise environment, sound pressure levels were measured in and surrounding the Project Site. Long-term, unattended noise measurements were made at four locations in the vicinity of the Project Site at locations indicated as LT-1, LT-2, LT-3, and LT-4 in Figure 2. Measurements were conducted over an 8-day period from Sunday, August 19th, 2018 to Monday, August 27th, 2018. The sites were selected to represent the closest residences to the Project. Sites LT-1, LT-2, and LT-3 were selected at distances of about 100 feet from the closest residences, in the worst-case location relative to the proposed turbines. Due to the inaccessibility of the residence to the south (represented by LT-4), measurements were not attempted on this property, but rather were taken to be representative of the Project Site. The long-term noise levels were measured with Larson-Davis 820 precision Type 1 sound level meters (SLMs) fitted with a ½-inch pre-polarized condenser microphone and a windscreen. The meters were calibrated before and after the surveys with a 94 dB, 1000 Hz Larson-Davis acoustical calibrator.

Figure 2: Ambient Noise Measurement Locations



The long-term data were monitored in 10-minute intervals that were later combined to give hourly levels. The measured levels included the L_{eq}, L_{max}, L_{min}, L_1, L_2, L_{10}, L_{25}, L_{50}, and L_{90} for each 10-minute interval. The daily trends in noise levels for the long-term measurement site are presented in Appendix A.

Noise Measurement Results

Ambient Noise Levels. For purposes of comparison of ambient noise levels to those predicted for the Project, the primary metric of concern based on the Shasta County criteria is the hourly L_{eq}. These data are shown in Appendix A for each of the test days for each LT measurement. As indicated in the data, there is considerable variation in level between test days and times of day at each site. The average hourly L_{eq} values for the daytime hours (7:00 a.m. to 10:00 p.m.) and the nighttime hours (10:00 p.m. to 7:00 a.m.) are shown in Table 5 along with the day-night average levels for each LT measurement. At all sites, elevated noise levels occurring between approximately 7:00 pm and 11:00 pm are thought to be attributable to insect and other natural sounds. At all sites and on all measurement days, noise levels during these hours increased substantially (15 to 20 dB) around 8:00 pm and then dropped off slowly between 8:00 pm and 11:00 pm.

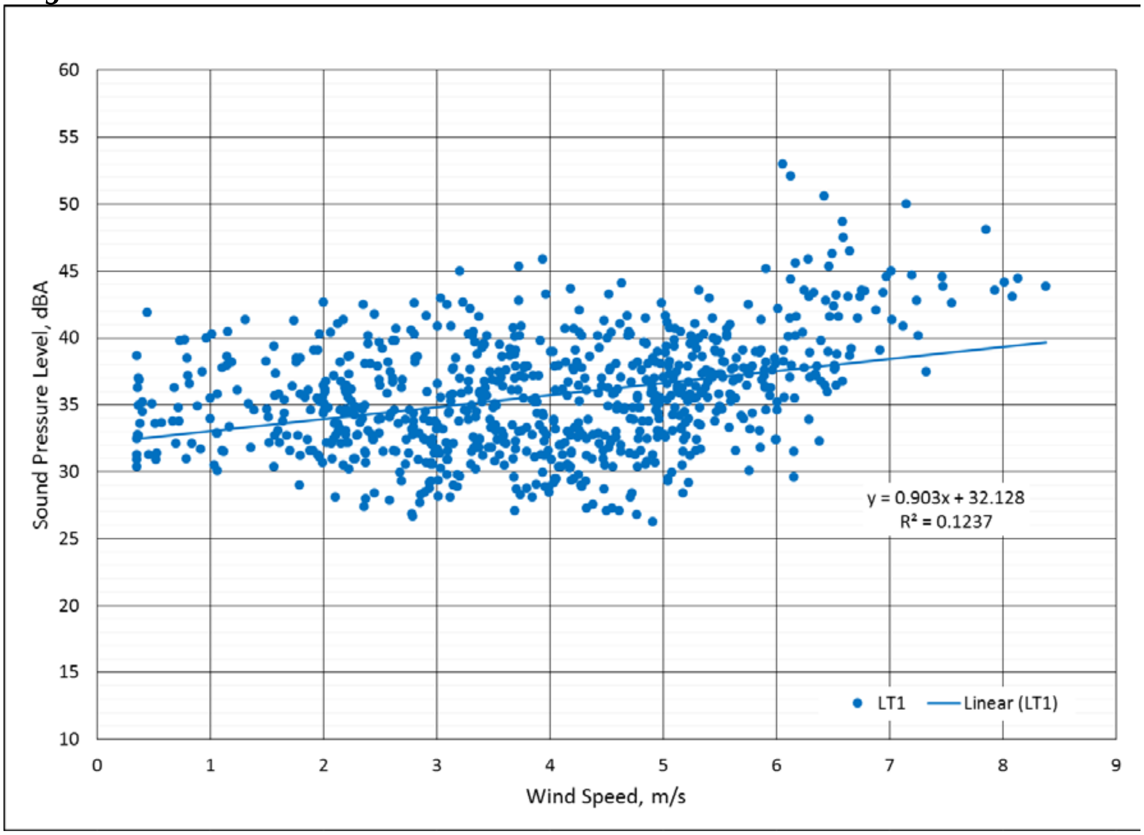
Table 5: Summary of Ambient Levels at Long-Term Measurement Locations

Location	Time Period	Hourly L_{eq}		Standard Dev., dB	L_{dn}, dBA
		Average, dBA	Range, dBA		
LT-1	Daytime	40	28-49	4.4	43-45
	Nighttime	36	32-45	3.5	
LT-2	Daytime	38	28-50	5.2	42-44
	Nighttime	34	28-42	3.5	
LT-3	Daytime	47	39-53	3.5	53-54
	Nighttime	46	40-53	3.6	
LT-4	Daytime	42	38-49	2.8	47-50
	Nighttime	42	38-48	2.9	

Daytime vs. Nighttime Noise Levels. As indicated in Table 5, daytime noise levels were about 4 dBA greater than nighttime noise levels at locations LT-1 and LT-2, but were similar between daytime and nighttime periods at LT-3 and LT-4. The noise environment at LT-1, LT-2, and LT-4 is primarily comprised of natural sounds, such as wind rustling the leaves of foliage, insects, and birds, and vehicular traffic on local logging roads. At LT-3, noise from occasional traffic on SR-299 is the primary noise source, along with evening insect noise; however, insect noise is similar in level to the traffic noise at this site and does not appear to significantly affect the L_{50} and L_{eq} levels. The L_{dn} values calculated for each LT locations are also provided in Table 5 and range from 42 dBA L_{dn} at more remote locations (LT-2) to 54 dBA L_{dn} in locations adjacent to SR-299 (LT-3). The noise floor identified in the data at LT-4 is due to the noise floor of the sound level meter. These trends can be observed in greater detail on the figures given in Appendix A.

Effects of Wind Speed on Noise Levels. To document the effect of wind speed on the ambient noise levels, wind speed data were reviewed from meteorological towers located near the Project site. The 10-minute L_{eq} levels measured at the four long-term noise monitoring locations from August 19th, 2018 to August 27th, 2018 were plotted against average 10-minute wind speed. As an example, the sound pressure level (L_{eq}) versus wind speed at location LT-1 is shown in Figure 4. Similar trends were seen at of the LT sites. Based on review of Figure 3 (and similar charts for the other LT locations), higher noise levels were observed under wind speeds exceeding 6 m/s. However, considerable scatter is apparent in the data; R^2 values of 0.12 or less at all locations indicate very low correlation between wind speed and noise level. Higher wind speed may result in a stronger correlation; however, based on the data reviewed, the noise environment at these sites is not directly correlated with wind speed.

Figure 3: 10-Minute L_{eq} level versus wind speed from nearby meteorological tower for long-term noise measurement location LT-1



NOISE ASSESSMENT

The noise assessment consisted of a review of the construction and operational details of the Project, calculation of noise levels at nearby noise sensitive areas based on the proposed turbine layout, the assessment of the predicted levels relative to the appropriate regulations and guidelines, and the discussion of noise reduction strategies, as necessary. The following criteria, which generally follow the California Environmental Quality Act (CEQA) Guidelines, Appendix G, were used to evaluate the significance of environmental noise resulting from the Project:

- **Noise Levels in Excess of Standards:** A noise impact would be identified if the Project would exceed 55 dBA during daytime hours (7:00 am to 10:00 pm), 50 dBA during nighttime hours (10:00 pm to 7:00 am), and/or 60 dBA L_{dn} at noise sensitive uses (residences). *Shasta County General Plan Policy N-b and Figure N-1.*

- **Permanent Noise Increases:** A noise impact would be identified if operational noise generated by the Project would substantially increase noise levels at sensitive receivers in the vicinity. Shasta County defines noise level increases of 3 dBA L_{dn} or greater to be considered significant where exterior noise levels would exceed the generally acceptable noise level standard (60 dBA L_{dn} for residential land uses). Where noise levels would remain at or below the normally acceptable noise level standard with the Project, noise level increases of 5 dBA L_{dn} or greater would be considered significant. *Shasta County General Plan Policy N-g*

- **Supplemental Criteria for Low Frequency and Infrasonic Noise:** The threshold for concern for low frequency noise occurs when the C-weighted level exceeds the A-weighted level by 20 dB or more or if the 1/3rd octave band thresholds shown in Table 4 are exceeded.

- **Temporary Noise Increase from Construction:** A temporary noise impact would be identified if construction-related noise would temporarily increase ambient noise levels at sensitive receptors. Hourly average noise levels exceeding 60 dBA L_{eq} at residential land uses, and the ambient by at least 5 dBA L_{eq}, for a period of more than one year would constitute a significant temporary noise increase at adjacent residential land uses. For temporary noise increases due to construction traffic, Shasta County's 3 and 5 dBA L_{dn} increase criteria would apply, as described above.

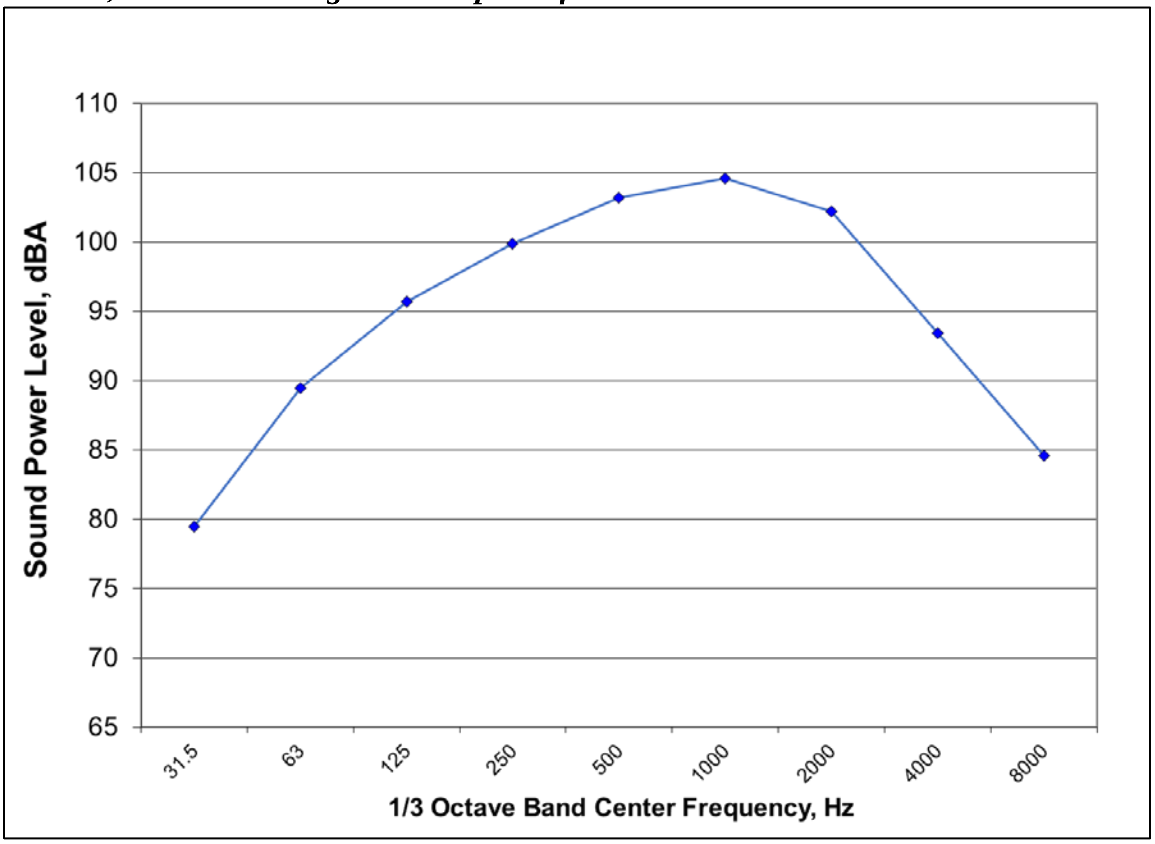
- **Groundborne Vibration from Blasting:** A vibration impact would be identified if the Project blasting for construction would generate groundborne vibration levels exceeding 0.3 in/sec PPV or groundborne noise exceeding 133 dB(L). *See Table 3 and discussion.*

NOISE GENERATED DURING OPERATIONS

Wind Turbine Operation

The Project is located on approximately 4,400 acres of land in the southern end of the Cascade Range in Shasta County, California. The proposed, 72-turbine layout is shown in Figure 1. Based on preliminary design, the Nordex N163/5.X turbine was selected as the worst-case, loudest turbine that is anticipated to be used at the site. This turbine has a maximum sound power level of 109.2 dBA and a hub height of 118 m (387 feet). One-third octave band data for this turbine is shown in Figure 4.

Figure 4: One-third octave band sound power levels for the Nordex N163/5.X Wind Turbine, with a Hub Height Wind Speed of 15 m/s



As sound spreads out from a noise source, physics dictates an attenuation of 6 dB for each doubling of distance from the source. The closest residences are located about 2,200 feet from adjacent turbines. Given the long propagation distances and mountainous terrain between the turbines and the closest receptors, turbine sound would be subject to additional attenuation by shielding from intervening terrain, atmospheric absorption, and ground absorption. Some variation in noise exposure at residences will occur with variations in temperature gradients and/or wind speed gradients, which vary over time.

Noise Levels in Excess of Standards

SoundPLAN Version 8.1 was used to calculate noise levels at adjacent noise sensitive locations, assuming a worst-case condition with operation of all wind turbines simultaneously. SoundPLAN is a three-dimensional ray-tracing program, which takes into account the topography of the area and the spectral characteristics of the noise sources. These results include the effect of atmospheric attenuation, ground reflection/absorption, and topography. Neutral environmental conditions are assessed for CEQA purposes, i.e., no wind or temperature gradients.

Figure 5 shows the calculated future A-Weighted noise contours generated during a worst-case scenario with all wind turbines operating simultaneously. Contours are shown for the area surrounding the Project, much of which is currently undeveloped. Receptor locations are representative of the worst-case existing residential locations, located 100 feet from the residences themselves in the direction of the closest turbine. For LT-1, LT-2, and LT-3, these locations are the same as the ambient measurement locations. For LT-4, a location representative of the receptor further to the south was selected (R-4).

The calculated levels at each of the nearest existing noise sensitive receptors under this same worst-case scenario are shown in tabular form in Table 6, which gives A-Weighted L_{eq} and L_{dn} results at each location. Measurement and receptor locations are indicated in Figures 2 and 5.

TABLE 6: Project Generated Sound Pressure Levels at Nearby Residences

Receiver	A-Weighted L_{eq}, dBA	L_{dn}[1], dBA
LT-1	40	46
LT-2	40	46
LT-3	38	45
R-4	43	50

[1] Assumes continuous simultaneous operation of all turbines, 24-hr/day.

As shown in Table 6, A-Weighted L_{eq} levels would range from 38 to 43 dBA at the nearest existing residences and L_{dn} levels, assuming a worst-case scenario with turbine operating continuously for 24-hr/day, would range from 45 to 50 dBA. Therefore, wind turbine noise levels would not be anticipated to exceed the County's daytime (55 dBA L_{eq}), nighttime (50 dBA L_{eq}), or L_{dn} (60 dBA L_{dn}) thresholds.

Figure 5a: Fountain Wind Energy Project A-Weighted Contours

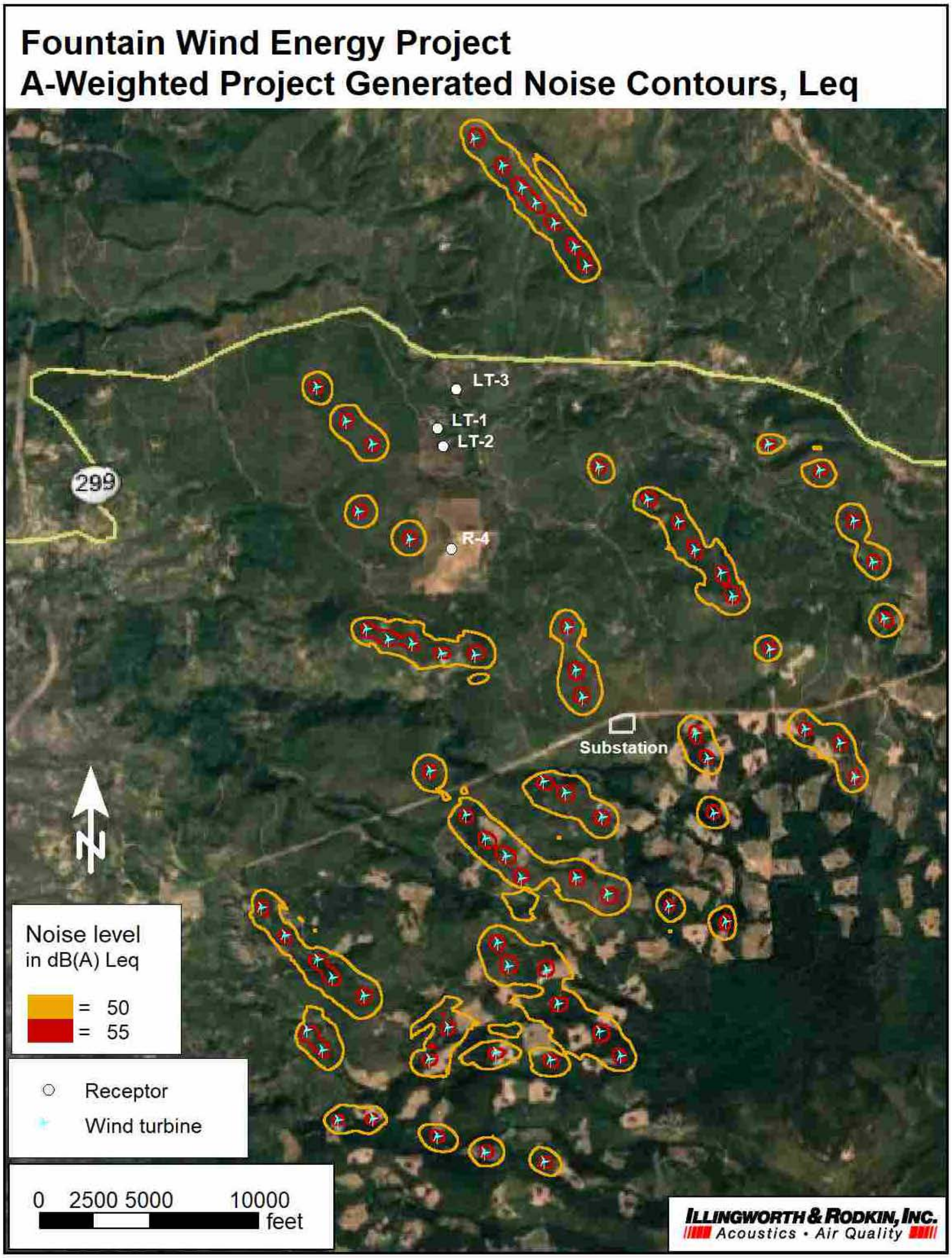
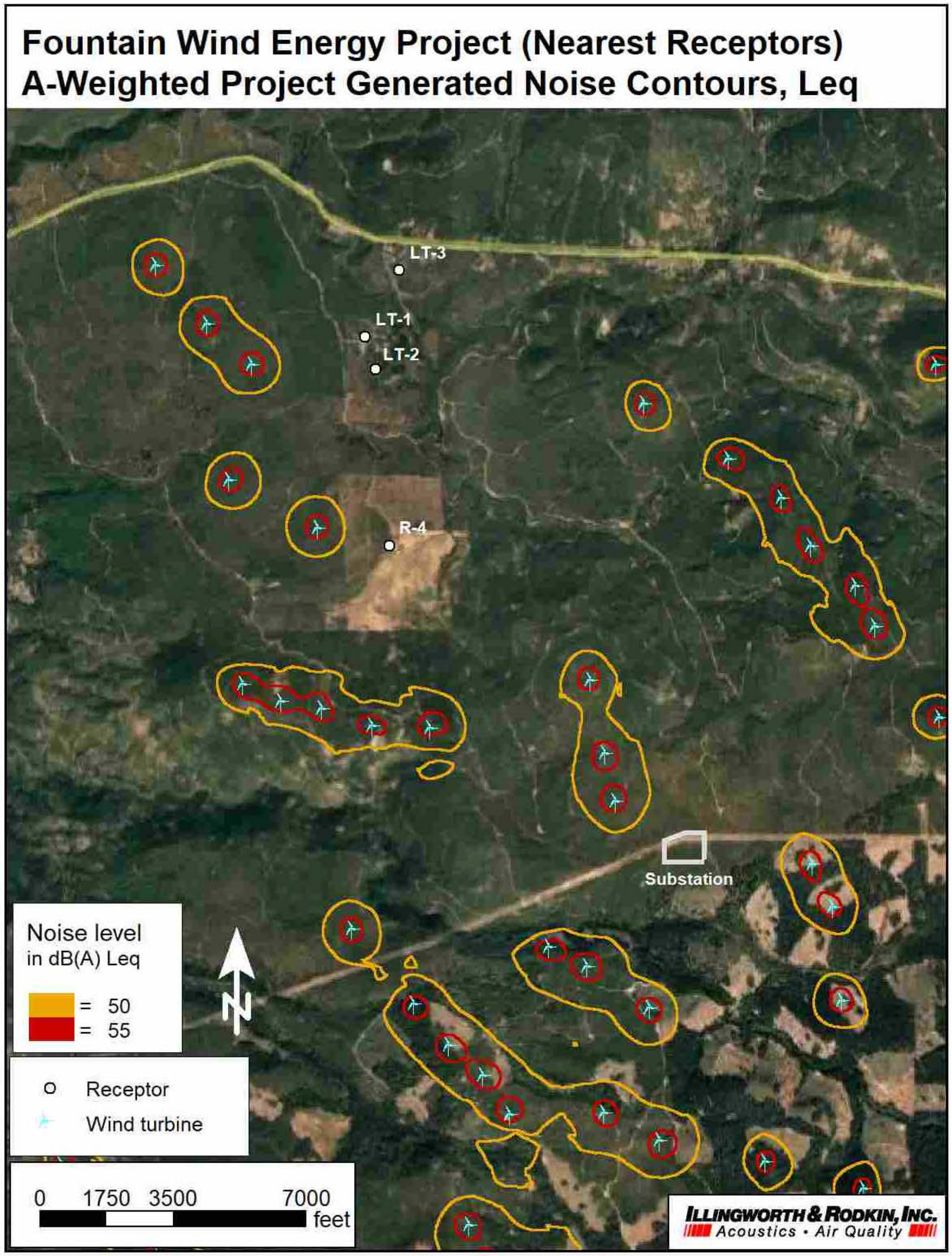


Figure 5b: Fountain Wind Energy Project A-Weighted Contours, Nearest Receptors



Permanent Noise Increases

Table 7 shows existing ambient and calculated L_{dn} noise levels resulting from the worst-case wind turbine scenario discussed above, with all turbines operating simultaneously 24-hr/day. Ambient L_{dn} levels are based on noise measurements and observations made during the noise monitoring survey.

TABLE 7: Increase in L_{dn} Resulting from Project Operations, 100% Operations

Receiver	Average Ambient L_{dn}, dBA	Project Generated L_{dn}[1], dBA	Existing + Project L_{dn}[1], dBA	L_{dn} Increase[2], dBA
LT-1	44	46	48	4.1
LT-2	43	46	48	5.0
LT-3	54	45	54	0.5
R-4	49	50	52	3.3

[1] Assumes continuous simultaneous operation of all turbines, 24-hr/day.
[2] Results were rounded to the nearest decibel. In some cases, this can result in relative changes that may not appear intuitive. For example, the difference between 64.4 (64) and 64.5 (65) is 0.1 (0), not 1.

As indicated in Table 7, worst-case wind turbine operation would result in L_{dn} noise levels increases of 0.5 to 5.0 dBA at the nearest surrounding residences, assuming 100% operations. Ambient noise levels at all receptors are below 60 dBA L_{dn}; therefore, the 5 dBA increase threshold would apply. Noise increases at all receptors would be 5.0 dBA L_{dn} or less. More likely assumptions, assuming 30, 40, 50, and 85% operations, would result in lower Project generated L_{dn} levels and thus lower noise level increases at residences. Likewise, selection of a lower noise turbine would result in lower Project generated L_{dn} levels and thus lower noise level increases at residences.

Low Frequency and Infrasonic Noise

Spectral data for the worst-case wind turbine scenario are shown in Figure 4. Table 8 shows the differences between the A-Weighted and C-Weighted levels, as calculated at each receptor location.

TABLE 8: Difference Between A-Weighted and C-Weighted Results

Receiver	A-Weighted L_{eq}, dBA	C-Weighted L_{eq}, dBC	L_{dn}[1], dBA	L_{dn}[1], dBC	dBC – dBA, dB
LT-1	39.5	58.4	46	65	18.9
LT-2	39.5	58.5	46	65	19.0
LT-3	38.2	57.7	45	64	19.5
R-4	43.3	61.0	50	67	17.7

[1] Assumes continuous simultaneous operation of all turbines, 24-hr/day.

As shown in Table 8, the difference between the A-Weighted and C-Weighted levels are anticipated to be 17.7 to 19.5 dB. These differences are below the 20-dB threshold of concern for low frequency noise relative to A-weighted levels. Levels are also 5 dB or more below the Kern County thresholds shown in Table 4 and the standard condition of approval used in Alameda County (70 dBA dBC). As a result, low frequency noise from the turbines is anticipated to be below any of the typical regulations or guidelines if the A-weighted sound level limits are achieved.

Onsite Collector Substation and Switching Station

An onsite collector substation and switching station (Substation) would increase the voltage of the electricity from the collection system's 34.5 kV to 230 kV to match the voltage of the existing PG&E 230 kV line. The closest existing residential areas are 1.5 miles to the northwest and southwest from the Substation location (see Figure 5). The basic elements of the substation facilities include a control house, a bank of one or two main transformers, outdoor breakers, capacitor banks, relaying equipment, high-voltage bus work, steel support structures, an underground grounding grid, and overhead lightning-suppression conductors.

The primary operational noise sources proposed at the Substation are anticipated to be transformers. A typical transformer would be estimated to generate a noise level of 72 dB at a distance of 6 feet during full load with fans and pumps running. With two transformers running simultaneously, the noise level would be 3 dB higher. Based on noise measurements made at the Bridgeville Substation in Humboldt County, California, steady state noise levels in the range of 47 to 54 dBA L_{eq} would be anticipated at the fence line of the Substation. Equipment-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 10 dBA or more noise reduction at distant receptors. At a distance of 1.5 miles, Substation noise would be inaudible.

Corona Noise

The project proposes overhead transmission lines ranging from 34.5 kV to 230 kV to match the voltage of the existing PG&E 230 kV line. A short 230kv line interconnection to the existing system will be installed at the sub/switching. The remainder of the line that runs north to south within the Project Site would be a 34.5 KV.

The localized electric field near an energized conductor can be sufficiently concentrated to produce a small electric discharge, which can ionize air close to the conductors. This effect is called corona, and it is associated with all energized electric power lines. Corona can result in the production of small amounts of sound. Corona noise is typically characterized as a hissing or crackling sound, which may be accompanied by a 120-hertz hum. Slight irregularities or water droplets on the conductor and/or insulator surface accentuate the electric field strength near the conductor surface, making corona discharge and the associated audible noise more likely. Therefore, audible noise levels from transmission lines are generally higher during wet weather.

Using computer modeling software developed by the Bonneville Power Administration (BPA)[6], audible noise values can be calculated for transmission lines experiencing corona activity. This modeling indicates that, during wet weather conditions, audible noise levels of up to 46 dBA would occur within the ROW for a transmission line operating at 230 kV. The 34.5 kV lines would likely be inaudible outside the ROW. Noise from lower voltage lines and/or during dry conditions would be lower.

At the closest residence, located more than 2,000 feet from the proposed lines, noise levels from the 230 kV lines would be 25 to 35 dBA lower than the levels within the ROW, resulting in levels that are well below ambient noise levels and most likely inaudible.

Shielding by buildings or terrain can provide an additional 5 to 10 dBA or more noise reduction at distant receptors.

Other Operations and Maintenance Activities

The Project anticipates employing up to 12 full-time employees. Operation and maintenance activities would generally occur during normal workday hours from Monday to Friday. Turbines would be monitored and controlled 24 hours a day, seven days a week, using a remote off-site monitoring system. This system would allow a remote operator to perform self-diagnostic tests and system checks, establish operating parameters, and ensure that the turbines are operating at peak performance. In the event of winds or gusts above the maximum operating parameters, the turbines would automatically shut down.

Routine maintenance activities are expected to include, but not be limited to: checking torque on tower bolts and anchors; checking for cracks and other signs of stress on the turbine tower and other turbine components; inspecting for leakage of lubricants, hydraulic fluids and other hazardous materials, and replacing them as necessary; inspecting the grounding cables, wire ropes and clips, and surge arrestors; cleaning; and repainting. Most routine maintenance activities would occur within and around the tower and the nacelle. Cleanup from routine maintenance activities would be performed at the time maintenance was performed. While performing most routine maintenance activities, staff would travel via pickup or other light-duty trucks.

Each turbine would also be serviced twice a year, or as needed. Turbine servicing would require maintenance staff to climb towers and service turbine parts by performing activities such as removing the turbine rotor and replacing generators and bearings. Scheduled maintenance may require the use of a crane within the 65- to 95-foot diameter areas around the turbines.

Although unlikely, non-routine maintenance such as repair or replacement of rotors or other major components could become necessary. Such maintenance would involve use of one or more cranes and equipment transport vehicles, though the cranes would not be as large as the track-mounted cranes needed to erect the turbine towers. Permanent access roads would be periodically graded and compacted in order to minimize erosion. Catch basins, roadway ditches, and culverts would be cleaned and maintained regularly

The addition of 12 vehicles daily spread throughout the existing logging roadway network in the vicinity of the Project would not be anticipated to measurably change the noise environment (increase would be less than 1 dBA L_{dn}). Maintenance operations would be located as close as about 2,000 feet from existing residences. Maintenance noise levels were calculated using the Federal Highway Administration (FHWA) software - Roadway Construction Noise Model (RCNM). A crane is calculated to generate a maximum instantaneous noise level of 49 dBA L_{max} and 41 dBA L_{eq} at a distance of 2,000 feet, not taking into account any noise reduction from intervening shielding by structures or terrain. Maintenance operations would be occasional at each individual turbine, with servicing occurring only twice a year. Although maintenance operations may occasionally be audible during quiet ambient conditions when located nearest noise sensitive locations, ambient noise levels would not be affected on an hourly or daily average basis.

NOISE GENERATED DURING CONSTRUCTION

Neither Shasta County nor the State of California specify quantitative thresholds for the impact of temporary increases in noise due to construction. The threshold for speech interference indoors is 45 dBA. Assuming a 15 dB exterior-to-interior reduction for standard residential construction with windows open and a 25 dB exterior-to-interior reduction for standard commercial construction, assuming windows closed, this would correlate to an exterior threshold of 60 dBA L_{eq} at residential land uses. Therefore, the Project would be considered to generate a significant temporary construction noise impact if Project construction activities exceeded 60 dBA L_{eq} at nearby residences and exceeded the ambient noise environment by 5 dBA L_{eq} or more for a period longer than one year.

The Project construction period is expected to last 18 to 24 months. Construction would be completed during daylight hours, typically from 7:00 am to 5:00 pm but may be earlier or later during the summer months. There may be circumstances where these hours need to be extended earlier or later, such as during the delivery of superloads, and nighttime construction may occur to avoid traffic, adjust for high winds during daylight hours, and to facilitate schedule. The construction workforce is estimated to include up to 400 construction workers at any given time.

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise-sensitive areas. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (e.g., early morning, evening, or nighttime hours), the construction occurs in areas immediately adjoining noise-sensitive land uses, or when construction lasts over extended periods of time.

Project construction activities would include grading, widening of existing and construction of new access roads, transportation of turbine components, clearing of laydown areas, construction of turbine foundations, assembly and erection of turbines, construction of substation and O&M Building, and installation of the underground and overhead collection system. Blasting and helicopters may be necessary in some areas. Pile driving is not anticipated as a method of construction.

Heavy Equipment Use

During each stage of construction, there would be a different mix of equipment operating, and noise levels would vary by stage and vary within stages, based on the amount of equipment in operation and the location at which the equipment is operating. Typical construction noise levels at 50 feet for equipment likely to be used in the construction of a wind facility are shown in Table 9. Most demolition and construction activities at a wind turbine facility generate noise levels in the range of 80 to 85 dBA L_{max} at 50 feet from the source. Hourly average noise levels would also be in the range of 80 to 85 dBA L_{eq} during periods of heavy construction.[7] Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 20 dBA noise reduction at distant receptors.

TABLE 9 Construction Equipment 50-foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)[1,2]	Impact/Continuous
Backhoe	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Grader	85	Continuous
Paver	85	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Truck (dump, delivery)	84	Continuous
Vibratory Compactor	80	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

[1] Measured at 50 feet from the construction equipment, with a "slow" (1 sec.) time constant.

[2] Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.

[3] Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

Source: Mitigation of Nighttime Construction Noise, Vibrations and Other Nuisances, National Cooperative Highway Research Program, 1999.

The closest residences are located approximately 2,000 feet from turbine construction areas. At this distance, hourly average noise levels from heavy construction activities would be in the range of 48 to 53 dBA L_{eq}, not taking into account any shielding from intervening terrain or structures. These noise levels could, at times, be audible at receptors, particularly during nighttime construction activities, but would not be anticipated to cause sleep or speech interference or affect the overall ambient noise levels in these locations. Construction activities at any individual turbine location would be limited to a relatively short period of time as construction proceeds to other turbines throughout the Project Site.

The closest existing residences to Substation and O&M Building construction are 1.5 miles to the northwest and southwest from the Substation location. At this distance, construction noise levels would be less than 40 dBA L_{eq} and would not be anticipated to be distinguishable from ambient noise levels.

Roadway construction activities could occur as close as 580 (LT-2) to 1,170 (R-4) feet from the nearest residences. At a distance of 580 feet, noise from heavy construction activities would be in the range of 59 to 64 dBA L_{eq}, not taking into account any shielding from intervening terrain or structures. At 1,170 feet, noise from heavy construction activities would be in the range of 53 to 58 dBA L_{eq}. Roadway construction would typically occur for relatively short periods of time in any specific location as construction proceeds along the roadway. Although construction located nearest residences would not be expected to cause sleep or speech interferences, noise levels could exceed ambient levels by as much as 20 dBA at LT-2 when construction is located adjacent to noise sensitive locations.

Construction Truck Trips

Construction traffic entering the Project Site will comprise of trips by construction workers, material delivery, and equipment delivery. All traffic will reach the site using SR 299. Three access roads are proposed to coincide with existing logging roads at the intersections with SR 299. Based on the available traffic volumes from Caltrans,[8] SR 299 carries an existing peak hour traffic volume of about 320 vehicles per hour with a truck percentage of 13.79%.

During construction, the project will employ an estimated 400 construction workers, project management staff, equipment operators, survey staff, and delivery vehicle drivers during the peak period, with the average number of workers on-site in the range of 325 workers. The material delivery vehicle trips will be spread out throughout the day. The maximum number of aggregate deliveries per day is approximately 90 deliveries (180 trips), constrained by the loading and unloading times. The maximum number of concrete deliveries per day is approximately 50 deliveries (100 trips), constrained by the rate that ready mix plants can batch concrete, and the rate the contractor can unload trucks. The maximum rate of deliveries is approximately 6 to 8 per hour, equivalent to placing a wind turbine foundation during a single work shift. The estimated total number of construction trips occurring over the 18 to 24 month construction period is projected to be 93,088 trips.

Construction and post-construction traffic volumes were provided in the project's traffic study.[9] The post-construction scenario would be equivalent to existing conditions, as it includes only a minimal number (6) of employees accessing the site for maintenance and operations. Based on a comparison between provided construction peak hour volumes and post construction peak hour volumes, project construction is calculated to result in a traffic noise increase of about 2 dBA on SR 299 in the vicinity of the site. This increase would be below the County's 3 dBA L_{dn} and 5 dBA L_{dn} thresholds for noise increases due to permanent project operations.

Construction traffic peak hour volumes on the existing logging roads are anticipated to increase from 24 to 40 trips on the west access road, 12 to 128 trips on the north access road, and 12 to 273 trips on the east access road. Assuming a worst-case analysis with 50% of these vehicles (both existing and project construction vehicles) being heavy trucks, the calculated noise levels at a distance of 50 feet from the center of the road would be 58 dBA L_{eq} on the west access road, 63 dBA L_{eq} on the north access road, and 66 dBA L_{eq} on the east access road.

Ambient noise levels at receptors along local access roads are below 60 dBA L_{dn}; therefore, the 5 dBA increase threshold would apply. The closest residence to the west access road (represented by LT-1) is located about 300 feet from the center of the road. At this distance, the peak hour noise level generated by the 28 project construction related trips (14 light vehicles and 14 heavy trucks) would be 44 dBA L_{eq}. The existing daytime peak hour noise level at this residence ranges from 43 to 49 dBA L_{eq} (see Table 5 and Appendix A). The resulting peak hour noise levels with combined ambient and project construction traffic noise levels would be 47 to 50 dBA L_{eq}. This would equate to a 1 to 4 dBA noise increase above existing ambient levels, which would be below the 5 dBA threshold. Considering construction is proposed to occur during daytime hours, noise increases on a day-night average (L_{dn}) basis would be lower. If construction activities were required during nighttime hours, construction traffic could be redirected to use alternative access routes such as the north and east access roads to avoid construction-related noise near residential uses. There are no noise sensitive receptors adjacent to the north and east access roads, therefore use of these roads, even during night time hours would not exceed ambient noise standards for residential uses.

Helicopter Use

Helicopters may be used to string overhead collector lines. Helicopter overflights could generate noise levels of up to 100 dBA at a distance of 100 feet.[10] Helicopter overflights and activities would be intermittent and would not be located at a single location for any extended period. Noise levels, attenuating at approximately 6 dBA per doubling of distance, would be approximately 74 dBA at 2,000 feet. This noise level would be anticipated to cause speech interference outdoors and sleep disturbance indoors, assuming a 15 dBA exterior-to-interior noise reduction with windows partially open.

Blasting

In rocky areas, blasting may be necessary to loosen rock before excavation. If blasting is necessary, a Blasting Plan would be prepared to identify the locations that are anticipated to require blasting. All applicable federal, state, and local regulations for blasting procedures would be identified in the Blasting Plan and would be followed. The Blasting Plan also would specify the times and distances where explosives would be permitted to avoid impacts to environmental sensitivities and the human environment. The County and emergency responders would be notified in accordance to the blasting plan, but at the very least no later than at least 24-hours in advance of blasting.

When blasting occurs at large distances from sensitive structures, the primary concern is cosmetic damage to structures. Cosmetic damage (e.g., minor cracking in plastered walls) can occur as a result of ground-borne vibration or acoustic overpressures. The US Bureau of Mines has analyzed the effects of blast-induced vibration on buildings in USBM RI 8507[11], and these findings have been applied to vibrations emanating from construction equipment on buildings[12]. Figure 6 presents the damage probability as reported in USBM RI 8507 and reproduced by Dowding. California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for structurally sound buildings designed to modern engineering standards, and 0.3 in/sec PPV for buildings that are found to be structurally sound but where structural damage is a major concern. The more conservative limit (0.3 in/sec PPV) is used in this analysis. As indicated in Figure 6, the US Bureau of Mines studies indicate no observations of “threshold damage” (referred to as cosmetic damage elsewhere in this report), “minor damage” or “major damage” at vibration levels of 0.4 in/sec PPV or less.

<u>Blasting Vibration Levels</u>

Vibration from blasting events on the Project Site were calculated using methods established by the former US Bureau of Mines. Ground vibration levels were calculated using the following equation, representing the upper range of levels established by the US Bureau of Mines for various soil conditions:

$$PPV = 300 \times (D/W^{1/2})^{-1.6}$$

Where: PPV = Peak Particle Velocity (in/sec)
D = Distance from explosive charge to receptor (ft)
W = Weight of explosive charge per delay (lbs)

Blasting could be located as close as 2,000 feet from existing residential areas. Calculated ground vibration levels are summarized in Table 10 for a variety of charge weights and distances. Receptors located further from blasting activities would experience lower vibration levels.

TABLE 10 Worst-Case Blasting Ground Vibration Levels, in/sec PPV

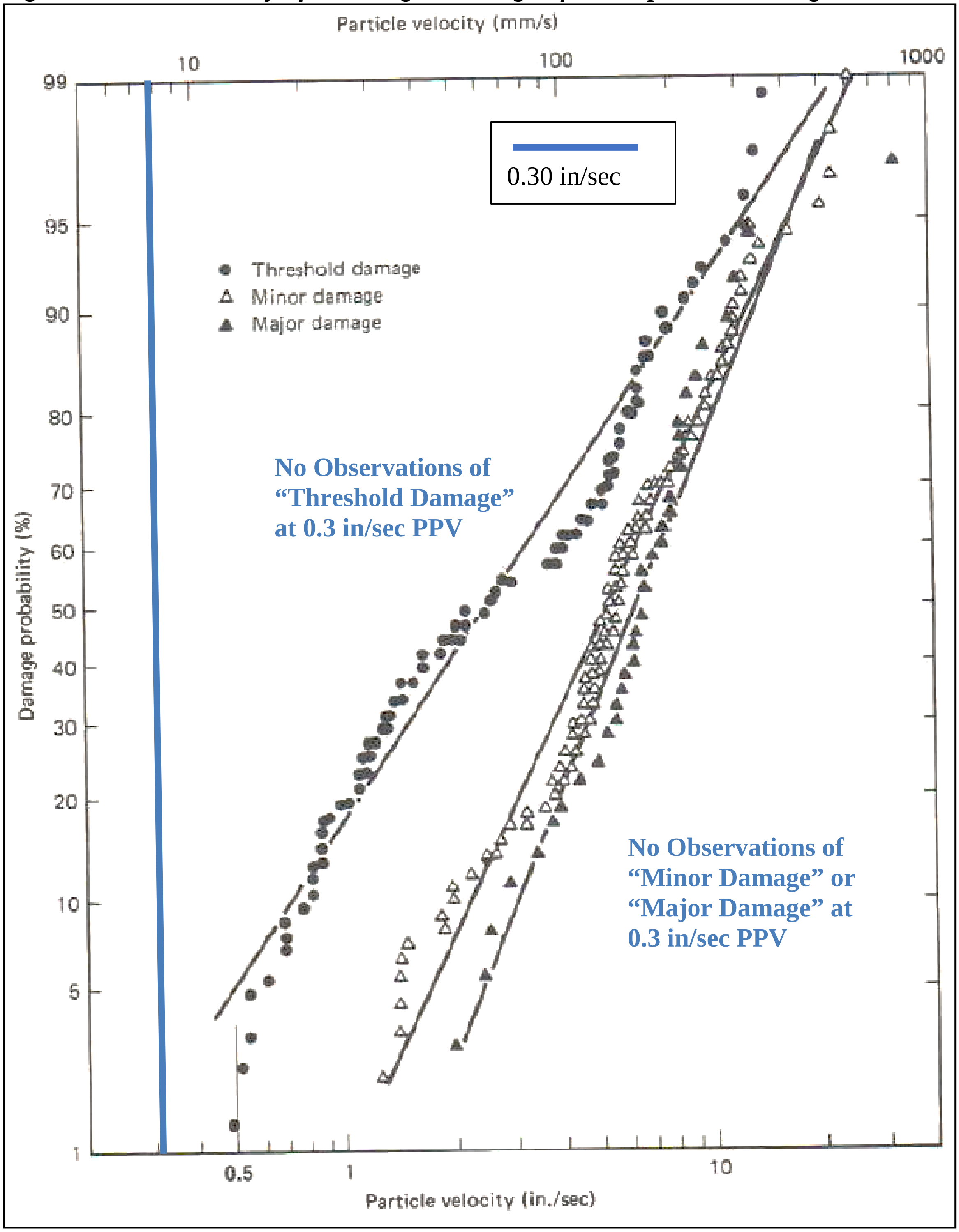
Distance, ft	**Blasting Level (in/sec PPV) for Various Explosive Charge Weights per Delay (lbs)**		
	175 lbs	**350 lbs**	**700 lbs**
2,000 feet	0.098	0.170	0.296
3,000 feet	0.051	0.089	0.155
4,000 feet	0.032	0.056	0.098

As shown in Table 10, worst-case blasting, using a charge weight of 700 lbs/delay within 2,000 feet of sensitive structures, could generate groundborne vibration levels as high as 0.296 in/sec PPV. These vibration levels would be below the 0.3 in/sec PPV threshold. As indicated in Figure 6, structures adjacent to potential blast areas would be unlikely to experience any level of cosmetic or structural damage, assuming a maximum vibration level of 0.3 in/sec PPV. Vibration levels would be lower at locations further from blasting or when lower charge weights are used.

Blasting Noise Levels

For blasts previously monitored by Illingworth & Rodkin, Inc. in Northern California, the highest peak overpressure was 116 dB(L) at 2,240 feet. Noise from blasting events would be anticipated to drop off at a rate of about 6 dB per doubling of distance. At the closest residences to potential blasting, located 2,000 feet from the nearest wind turbine construction area, peak overpressures of about 117 dB(L) would be anticipated, which are well below the 133 dB(L) criteria to avoid damage. Peak overpressure is controlled by charge confinement. The standard procedure for confining the charge is to place the explosives deep in the drilled blast hole and then to backfill the remainder of the hole with crushed rock. Assuming standard blast confinement techniques are used, Project-related damage from acoustic overpressures is not expected for any residence. Although these low frequency overpressures could potentially be audible, the Shasta County noise criteria do not apply to this type of impulsive noise. While residents may occasionally hear sounds from blasting events, these sounds would occur on an infrequent basis during construction. These brief intermittent events would not be expected to substantially increase hourly average or daily average noise levels.

Figure 6 Probability of Cracking and Fatigue from Repetitive Loading



Source: Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996 as modified by Illingworth & Rodkin, Inc., March 2019.

RECOMMENDED NOISE REDUCTION MEASURES

Implementation of the following best management practices for construction would reduce construction noise levels emanating from the site and minimize disruption of nearby residents.

- Limit construction operations located within 2,500 feet of residences to daytime hours only.

- Minimize helicopter use, as feasible.

- Prohibit nighttime helicopter use.

SUMMARY

Based on the above findings, noise associated with Project operations is not expected to exceed Shasta County noise standards or the supplementary criteria for low frequency and infrasonic noise at any residential property in the site vicinity. However, use of helicopters during construction and any nighttime construction located within 2,500 feet of residences would have the potential to cause sleep and/or speech interference. Noise reduction measures, including limiting helicopter and heavy construction near residential areas to daytime hours and minimizing helicopter use, are provided to minimize disruption and annoyance during construction.

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