Noise Technical Report for the Sand Hill Wind Project Alameda County, California

Prepared for:

New Dimension Energy Company, LLC
221 Crescent Street, Suite 103A
Waltham, MA 02453
Contact: Peter Pawlowski
240.351.5000

Prepared by:

ICF International
630 K Street, Suite 400
Sacramento, CA 95814
Contact: David Buehler
916.737.3000

July 2013

ICF International. 2013. *Noise Technical Report for the Sand Hill Proposed Wind Project, Alameda County, California*. July. (ICF 00151.13.) Sacramento, CA. Prepared for New Dimension Energy Company, LLC, Waltham, MA.

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Acronyms and Abbreviations

applicant	Sand Hill Wind, LLC
APWRA	Altamont Pass Wind Resource Area
AWEA	American Wind Energy Association
CEQA	California Environmental Quality Act
CNEL	Community Noise Equivalent Level
County	Alameda County
CUP	Conditional Use Permit
dB	decibels
dBA	A-weighted sound level
EPA	U.S. Environmental Protection Agency
FTA	Federal Transit Administration
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
L_{dn}	day-night Level
L_{eq}	equivalent sound level
L_{eq}[h]	1-hour A-weighted equivalent sound level
L_{max}	maximum sound level
L_{xx}	percentile-exceeded sound level
m/s	meters/second
mPa	micro-Pascals
MW	megawatt
proposed project	Sand Hill Wind Project
WTGS	Wind Turbine Generation Systems

Noise Technical Report for the Proposed Sand Hill Wind Project

Sand Hill Wind LLC (Sand Hill, the applicant) has proposed a repowering program that would entail the removal of existing turbines previously owned by SeaWest Power Resources LLC on multiple parcels in the Altamont Pass Wind Resource Area (APWRA) (Figure 1). Sand Hill would replace the older turbines with a new technology turbine known as a mixer-ejector, or shrouded, wind turbine. Sand Hill seeks to accomplish the repowering in two or more phases through 2016. The project would require a conditional use permit (CUP) in accordance with the Alameda County Zoning Ordinance. An application for a CUP was submitted to Alameda County (County) on January 15, 2013, for the Initial Repower portion of the project.

This report provides an assessment of noise associated with the Initial Repower portion of the project described below. This report discusses environmental noise fundamentals, applicable noise regulations and policies, existing noise conditions, and an evaluation of noise effects associated with implementation of the proposed project. This report has been prepared to assess noise impacts in keeping with the requirements of the California Environmental Quality Act (CEQA) so that the information herein can be readily incorporated into the project's environmental document.

Project Description

The first phase of the project, referred to as the Initial Repower, would involve the removal of 70–80 existing turbines (totaling approximately 4 megawatt [MW]) and installation of 40 shrouded turbines of equal total capacity (approximately 4 MW) to assess the functionality of the new shrouded turbine design and determine the extent to which it reduces impacts on birds and bats compared to the mortality associated with the existing turbines. The performance assessment would consist of an avian validation study (avian study) funded by a Public Interest Energy Research Grant from the California Energy Commission.

The 40 shrouded turbines would be distributed among the existing facilities; the remainder of the existing turbines (other than those removed as part of the Initial Repower) would be left in place for at least 1 year as controls for the avian study that would be conducted to test the shrouded turbines' efficacy in reducing avian and bat mortality rates.

The applicant would use the test results of the avian study and shrouded turbine performance data to inform its approach to repowering the remainder of the existing turbines (approximately 320 turbines) in future phases. Subsequent repowering phases would repower up to an additional 32 MW of generating capacity, for an ultimate project total of 36 MW.

Because of the proposed project's co-location with existing turbines, no new access roads, substation facilities, interconnection lines, or operations and maintenance (O&M) facilities would be necessary. However, some access roads may require widening. New pads would be constructed for the shrouded turbines, as well as new connections to the existing power collection system and temporary laydown areas.

Each shrouded turbine would be a maximum of 190 feet tall, with a maximum hub height of 120 feet and a maximum diameter of 70 feet. Each tower's foundation would require an excavation approximately 56 feet in diameter to a depth of 8 feet. The permanent disturbance area of each turbine would be approximately 64 feet in diameter (approximately 3,215 square feet).

Assembly pads would be constructed at each turbine site. The pads would be level areas approximately 100 by 100 feet with gravel cover to support the construction equipment and to reduce dust. The temporary pads would be removed and restored on completion of construction. Each pad would entail disturbance of approximately 0.325 acre, for a total disturbance area of 13 acres.

In addition to the pad area for each turbine, the Initial Repower phase would require four temporary laydown areas of 5 acres each to store turbine components, construction equipment, job trailers, and construction materials. These areas would be restored to preproject conditions on completion of construction.

Environmental Noise Fundamentals

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air) to a hearing organ, such as a human ear. *Noise* is defined as sound that is objectionable because it is disturbing or annoying.

In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receiver, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receiver determine the sound level and characteristics of the noise perceived by the receiver.

Sound Descriptors

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or Hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz). High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hz. The audible frequency range for humans is generally between 20 Hz and 20,000 Hz.

The amplitude of pressure waves generated by a sound source determines the loudness of that source. Sound pressure amplitude is measured in micro-Pascals (mPa). One mPa is approximately one hundred-billionth (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 to 100,000,000 mPa. Because of this huge range of values, sound is rarely expressed in terms of mPa. Instead, a logarithmic scale is used to describe *sound pressure level* (also referred to simply as *sound level*) in terms of decibels (dB). The threshold of hearing for young people is about 0 dB, which corresponds to 20 mPa.

The dB scale alone does not adequately characterize how humans perceive noise. The dominant frequencies of a sound have a substantial effect on the human response to that sound. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by characteristics of the human ear.

Human hearing is limited in the range of audible frequencies as well as in the way it perceives the sound pressure level in that range. In general, people are most sensitive to the frequency range of

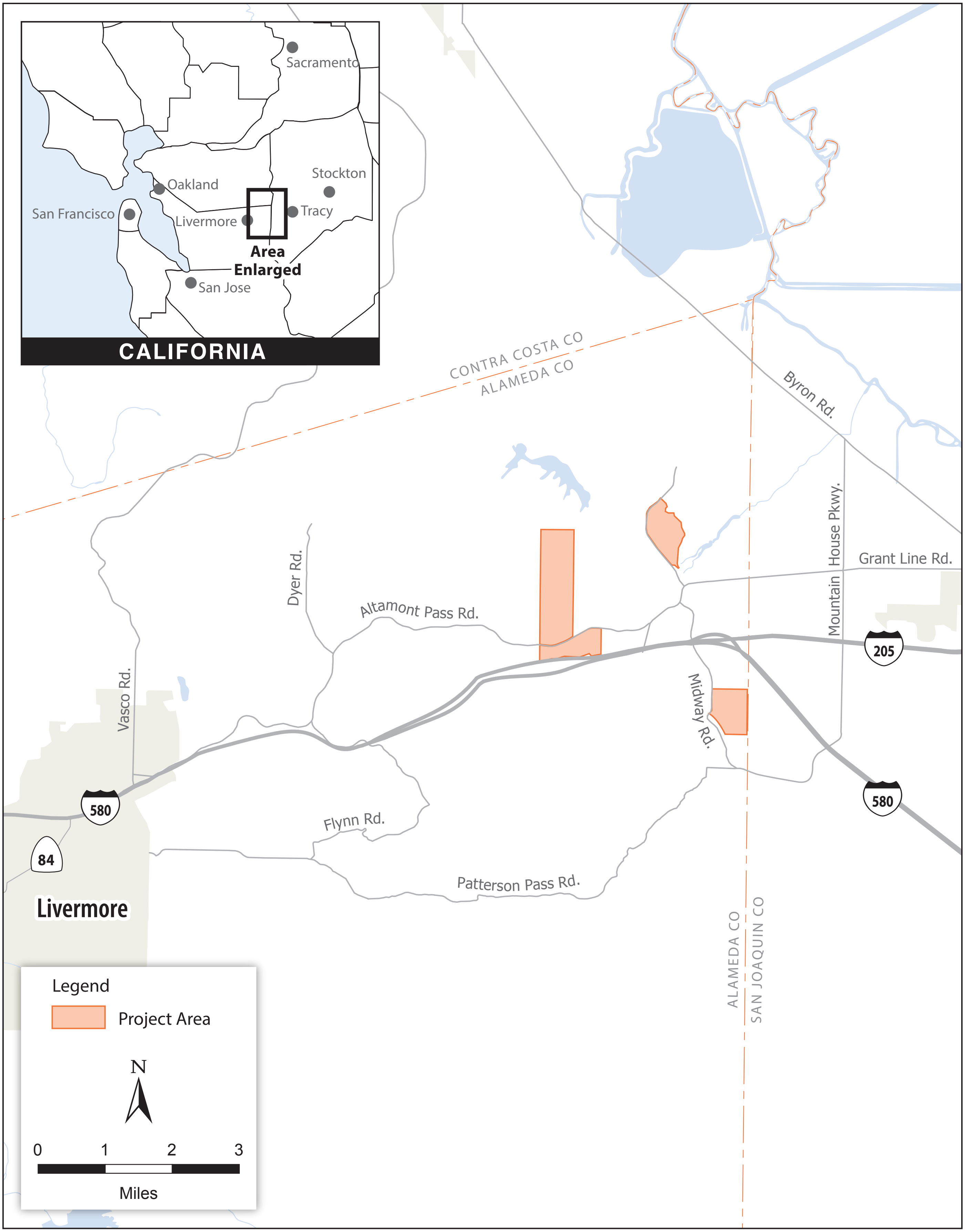

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Figure 1
Project Location

1,000–8,000 Hz and perceive sounds within that range better than sounds of the same amplitude in higher or lower frequencies. To approximate the response of the human ear, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. Then, an *A-weighted sound level* (expressed in units of dBA) can be computed based on this information.

The A-weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. When people make judgments of the relative loudness or annoyance of a sound, their judgments correlate well with the A-scale sound levels of those sounds. Table 1 describes typical A-weighted sound levels for various noise sources.

Table 1. Typical A-Weighted Sound Levels

Common Outdoor Activities	Sound Level (dBA)	Common Indoor Activities
	— 110 —	Rock band
Jet flying at 1,000 feet		
	— 100 —	
Gas lawn mower at 3 feet		
	— 90 —	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	— 80 —	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	— 70 —	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	— 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
	— 20 —	
		Broadcast/recording studio
	— 10 —	
Lowest threshold of human hearing	— 0 —	Lowest threshold of human hearing

Source: California Department of Transportation 2006.

Other weighting networks have been devised to address high noise levels or other special problems (e.g., B-, C-, and D-scales). C-weighted sound levels are sometimes considered for wind turbine noise analysis. The C-weighted sound level or dBC gives more weight to lower frequency noise. C-weighting is very close to an unweighted or *flat* response. When evaluating sounds that have varying amounts of low-frequency energy, A-weighted sound levels will not indicate the low frequency variations, but C-weighted sound levels will.

Noise in most typical environments fluctuates over time. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors most commonly used in environmental noise analysis.

- **Equivalent Sound Level (L_{eq}):** L_{eq} represents an average of the sound energy occurring over a specified period. In effect, L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour A-weighted equivalent sound level (L_{eq}[h]) is the energy average of A-weighted sound levels occurring during a 1-hour period.
- **Percentile-Exceeded Sound Level (L_{xx}):** L_{xx} represents the sound level exceeded for a given percentage of a specified period (e.g., L_{10} is the sound level exceeded 10% of the time, and L_{90} is the sound level exceeded 90% of the time).
- **Minimum and Maximum Sound Level (L_{min} and L_{max}):** L_{min} is the lowest A-weighted sound level during a specified period, while L_{max} is the highest.
- **Day-Night Level (L_{dn}):** L_{dn} is the energy average of A-weighted sound levels occurring over a 24-hour period, with a 10-dB penalty added to A-weighted sound levels occurring between 10 p.m. and 7 a.m.
- **Community Noise Equivalent Level (CNEL):** Much like L_{dn}, CNEL is the energy average of the A-weighted sound levels occurring over a 24-hour period, with a 10-dB penalty added to A-weighted sound levels occurring between 10 p.m. and 7 a.m. and a 5-dB penalty added to the A-weighted sound levels occurring between 7 p.m. and 10 p.m.

Decibel Addition

Because decibels are logarithmic units, sound pressure levels cannot be added or subtracted through ordinary arithmetic. On the dB scale, a doubling of sound energy corresponds to a 3-dB increase. In other words, when two identical sources are each producing sound of the same loudness, their combined sound level at a given distance would be 3 dB higher than one source under the same conditions. For example, if one wind turbine produces a sound pressure level of 70 dBA, two wind turbines would not produce 140 dBA—rather, they would combine to produce 73 dBA. The cumulative sound level of any number of sources such as wind turbines can be determined using decibel addition.

Perception of Sound Level Changes

Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1-dB changes in sound levels when exposed to steady, single-frequency (pure tone) signals in the mid-frequency (1,000–8,000 Hz) range. In typical noisy environments, changes in noise of 1–2 dB are generally not perceptible. However, it is widely accepted that people are able to begin to detect sound level increases of 3 dB in typical noisy environments. Further, a 5-dB increase is generally perceived as a distinctly noticeable increase, and a 10-dB increase is generally perceived as a doubling of loudness. Accordingly, a doubling of sound energy (e.g., doubling the volume of traffic on a highway) that would result in a 3-dB increase in sound would generally be barely detectable.

Sound Propagation

When sound propagates over distance, it changes in level and frequency. The manner in which noise reduces with distance depends on the factors described in the next sections.

Geometric Spreading

Sound from a stationary localized source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound level attenuates (or decreases) at a rate of 6 dB for each doubling of distance from a point source. The strength of the source 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. If the sound power level of an idealized source and its distance from a receiver are known, sound pressure level at the receiver point can be calculated based on geometric spreading. This approach is applied to wind turbine generators in the standard measurement techniques for determining the sound power or source level (Illingworth & Rodkin 2009).

A number of factors can modify the sound level associated with spherical spreading. The first factor is the ground, which acts as a reflecting plane. If the ground is hard, sound energy is reflected off the ground and typically increases A-weighted sound levels by 3 dB. If the ground plane is acoustically soft or absorptive (such as grassland or a plowed field), some sound energy is absorbed by the ground and the increase from reflection will be less than 3 dB.

Other Factors that Affect Propagation

Additional factors that affect sound propagation are often grouped under the term *excess attenuation*. Excess attenuation is any additional attenuation that is not attributed to simple spherical spreading. Excess attenuation includes shielding effects from barriers (hills or structures); attenuation effects associated with vegetation, trees, rain, sleet, snow, or fog; and attenuation associated with wind and temperature gradients. Excess attenuation is almost always present under outdoor propagation conditions. For sound propagating over soft ground at near grazing angles of incidence, excess attenuations of 20–30 dB can be measured as a result of the interference effect of the direct and reflected sound. However, under certain meteorological conditions, some of these excess attenuation mechanisms are reduced or eliminated, leaving spherical spreading as the primary determinant of sound level at a receiver location (Illingworth & Rodkin 2009).

Other Factors Related to Wind Turbines

Operating wind turbines can generate two types of sound: mechanical sound from components such as gearboxes, generators, yaw drives, and cooling fans; and aerodynamic sound from the flow of air over and past the rotor blades. Modern wind turbine design has greatly reduced mechanical sound, which can generally be ignored in comparison to the aerodynamic sound, which is often described as a swishing or whooshing sound.

Wind turbines produce a broadband sound (i.e., the sound covers a wide range of frequencies, including low frequencies). Low-frequency sounds are in the range of 20 to 100 Hz, and infrasonic sound (or infrasound) is low-frequency sound of less than 20 Hz. Low-frequency sound propagates over longer distances than higher frequency sound, is transmitted through buildings more readily, and can excite structural vibrations (e.g., rattling windows or doors). The threshold of perception, in decibels, also increases as the frequency decreases. For example, in the frequency range where humans hear best (in the low kilohertz), the threshold of hearing is at about 0 dB, but at a frequency of only 10 Hz, the threshold of hearing is about 100 dB (Rogers 2006).

Older wind turbines—particularly those in which the blades were on the downwind side of the tower—produced more low-frequency sound because their towers blocked wind flow, causing the blades to pass through more turbulent air. Modern, upwind turbines produce a broadband sound that includes low-frequency sounds, but not at significant levels. A primary cause for low-frequency sounds in modern turbines is the blade passing through the change in air flow at the front of the tower, and this can be aggravated by unusually turbulent wind conditions. This effect is generally referred to as blade amplitude modulation because the aerodynamic noise generated by the blades (the swishing sound) is modulated as the turbine blades pass through uneven air velocities. The uneven air that causes this effect may be due to interaction of other turbines, excessive wind shear, or topography (Bowdler 2008).

Wind generates sound. The amount of sound generated can vary widely depending primarily on the amount of vegetation in the area and the speed of the wind. For a given wind speed the sound level in a desert with no trees or vegetation will be different from that in a highly vegetated area. When trees are in full leaf, wind in the trees rustles the leaves and high frequency sound is produced. The amount of sound generated depends on wind speed, the distance to the trees or foliage, and the approximate frontal area of the trees or foliage as seen from the observed position. Sound levels generated by wind can range from about 20 dBA to 60 dBA for wind speeds in the range of 2–20 miles per hour (Hoover & Keith 2000).

Regulatory Setting

Federal, state, and local agencies regulate different aspects of environmental noise. Generally, the federal government sets noise standards for transportation-related noise sources closely linked to interstate commerce. These include aircraft, locomotives, and trucks. The state government sets noise standards for transportation noise sources such as automobiles, light trucks, and motorcycles. Noise sources associated with industrial, commercial, and construction activities are generally subject to local control through noise ordinances and general plan policies. Local general plans identify general principles intended to guide and influence development plans.

Federal

The federal Noise Control Act of 1972 (Public Law 92-574) established a requirement that all federal agencies administer their programs to promote an environment free of noise that would jeopardize public health or welfare. The U.S. Environmental Protection Agency (EPA) was given the following responsibilities.

- Providing information to the public regarding identifiable effects of noise on public health and welfare.
- Publishing information on the levels of environmental noise that will protect the public health and welfare with an adequate margin of safety.
- Coordinating federal research and activities related to noise control.
- Establishing federal noise emission standards for selected products distributed in interstate commerce.

The Noise Control Act also directed that all federal agencies comply with applicable federal, state, interstate, and local noise control regulations.

Although EPA was given a major role in disseminating information to the public and coordinating federal agencies, each federal agency retains authority to adopt noise regulations pertaining to agency programs. EPA can, however, require other federal agencies to justify their noise regulations in terms of Noise Control Act policy requirements.

In 1974, in response to the requirements of the federal Noise Control Act, EPA identified indoor and outdoor noise limits to protect public health and welfare (communication disruption, sleep disturbance, and hearing damage). Outdoor L_{dn} limits of 55 dB and indoor L_{dn} limits of 45 dB are identified as desirable to protect against speech interference and sleep disturbance for residential, educational, and healthcare areas. Sound-level criteria to protect against hearing damage in commercial and industrial areas are identified as 24-hour L_{eq} values of 70 dB (both outdoors and indoors).

State

Part 2, Title 24 of the California Code of Regulations, California Noise Insulation Standards, establishes minimum noise insulation standards to protect persons within new hotels, motels, dormitories, long-term care facilities, apartment houses, and dwellings other than single-family residences. Under this regulation, interior noise levels attributable to exterior noise sources cannot exceed 45 L_{dn} in any habitable room. Where such residences are located in an environment where exterior noise is 60 L_{dn} or greater, an acoustical analysis is required to ensure that interior levels do not exceed the 45 L_{dn} interior standard.

The *State of California General Plan Guidelines* (Office of Planning and Research 2003) identifies guidelines for the noise elements of local general plans, including a sound level/land use compatibility chart that categorizes, by land use, outdoor L_{dn} ranges in up to four categories (normally acceptable, conditionally acceptable, normally unacceptable, and clearly unacceptable). For many land uses, the chart shows overlapping L_{dn} ranges for two or more compatibility categories.

The noise element guideline chart identifies the normally acceptable range of L_{dn} values for low-density residential uses as less than 60 dB and the conditionally acceptable range as 55–70 dB. The normally acceptable range for high-density residential uses is identified as L_{dn} values below 65 dB, and the conditionally acceptable range is identified as 60–70 dB. For educational and medical facilities, L_{dn} values below 70 dB are considered normally acceptable, and L_{dn} values of 60–70 dB are considered conditionally acceptable. For office and commercial land uses, L_{dn} values below 70 dB are considered normally acceptable, and L_{dn} values of 67.5–77.5 dB are categorized as conditionally acceptable. When noise levels are in the conditionally acceptable range, new construction should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation requirements are included in the design.

These overlapping L_{dn} ranges are intended to indicate that local conditions (existing sound levels and community attitudes toward dominant sound sources) should be considered in evaluating land use compatibility at specific locations.

Local

General Plan Noise Element

The Alameda County General Plan Noise Element (Alameda County 1975) contains goals, objectives, and implementation programs for the entire county to provide its residents with an environment that is free from excessive noise, and promotes compatibility of land uses with respect to noise. The Noise Element does not explicitly define the acceptable outdoor noise level for the backyards of single-family homes or common outdoor spaces of multifamily housing projects, but it recognizes the EPA noise level standards for residential land uses. These standards are an exterior L_{dn} of 55 dBA and an interior L_{dn} of 45 dBA. (The L_{dn} measurement, which also includes a 10 dB weighting for nighttime sound, is approximately equal to the CNEL for most environmental settings.) The Noise Element also references noise and land use compatibility standards developed by an Association of Bay Area Governments–sponsored study.

East County Area Plan

Alameda County's *East County Area Plan* (Alameda County 2000) contains the goal, policies, and implementation programs related to community noise and windfarms, excerpted below.

Goal: To minimize East County residents and workers exposure to excessive noise.

Policy 170: The County shall protect nearby existing uses from potential traffic, noise, dust, visual, and other impacts generated by the construction and operation of windfarm facilities.

Policy 288: The County shall endeavor to maintain acceptable noise levels throughout East County.

Policy 289: The County shall limit or appropriately mitigate new noise sensitive development in areas exposed to projected noise levels exceeding 60 dB based on the California Office of Noise Control Land Use Compatibility Guidelines.

Policy 290: The County shall require noise studies as part of development review for projects located in areas exposed to high noise levels and in areas adjacent to existing residential or other sensitive land uses. Where noise studies show that noise levels in areas of existing housing will exceed "normally acceptable" standards (as defined by the California Office of Noise Control Land Use Compatibility Guidelines), major development projects shall contribute their pro-rated share to the cost of noise mitigation measures such as those described in Program 104.

Program 74: The County shall amend the Zoning Ordinance to incorporate siting and design standards for wind turbines to mitigate biological, visual, noise, and other impacts generated by windfarm operations.

Program 104: The County shall require the use of noise reduction techniques (such as buffers, building design modifications, lot orientation, sound walls, earth berms, landscaping, building setbacks, and real estate disclosure notices) to mitigate noise impacts generated by transportation-related and stationary sources as specified in the California Office of Noise Control Land Use Compatibility Guidelines.

Noise Ordinance

Alameda County's Noise Ordinance (County General Code, Chapter 6.60) allows higher noise exposure levels for commercial properties than for residential uses, schools, hospitals, churches, or libraries. These standards augment the state-mandated requirements of the Alameda County Building Code, which establishes standards for interior noise levels consistent with the noise insulation standards in the California State Building Code. Table 2 shows the number of cumulative minutes that a particular external noise level is permitted, as well as the maximum noise allowed under the Alameda County General Code.

Table 2. Alameda County Exterior Noise Standards

Cumulative Number of Minutes in any 1-hour Period	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Residential uses, schools, hospitals, churches, and libraries		
30	50 dBA	45 dBA
15	55 dBA	50 dBA
5	60 dBA	55 dBA
1	65 dBA	60 dBA
Maximum (0)	70 dBA	65 dBA
Commercial uses		
30	65 dBA	60 dBA
15	70 dBA	65 dBA
5	75 dBA	70 dBA
1	80 dBA	75 dBA
Maximum	85 dBA	80 dBA

The County Zoning Ordinance (County General Code, Chapter 17) restricts noise from commercial activities by prohibiting any use that would generate a noise or vibration that is discernible without instruments beyond the property line. This performance standard does not apply to transportation activities or temporary construction work.

The provisions of the ordinance do not apply to noise sources associated with construction, provided the activities do not take place before 7 a.m. or after 7 p.m. on any day except Saturday or Sunday, or before 8 a.m. or after 5 p.m. on Saturday or Sunday.

Conditional Use Permits

The County's CUPs for the continued operation of the APWRA windfarms after 2005, regulated by Resolution Number R-2005-463, identify the following specific conditions regarding noise.

21. Noise Standards: Wind turbines shall be operated so as to not exceed the County's noise standard of 55 dBA (L_{dn}) or 70 dBC (L_{dn}) as measured in both cases at the exterior of any dwelling unit. If the dwelling unit is on land under lease from the Permittee, the applicable standard shall be 65 dBA (L_{dn}) and 70 dBC (L_{dn}).

22. Noise Complaints: In the event a reasonable complaint is received by the Building Official alleging the presence of sound levels from a wind turbine or windfarm exceeding 55 dBA (L_{dn}) at a dwelling that was existing at the time this permit was issued (or 65 dBA (L_{dn}) if the dwelling is on land under lease for a windfarm), or 70 dBC (L_{dn}) as measured at the exterior of the dwelling:

    a. The Building Official shall report this matter to the Permittee and to the Planning Director and upon receipt of such report, this matter shall be brought to hearing pursuant to Section 17.54.650 and may be considered as provided by Section 17.54.030 of the Alameda County Ordinance Code; and

b. Upon receipt of the report of the Building Official, the Planning Director shall commission a qualified firm to make a site specific study and furnish a report and recommendation on the circumstances, if any, which would render the project in conformance with all applicable noise conditions; the report shall also include a recommendation to the Board of Zoning Adjustments who will make the final determination as to whether subsection (d) shall be imposed.

c. For a minimum 30-day period from the date of notification, at the time and place as may be agreed upon by the parties involved, Permittee shall attempt in good faith to negotiate a resolution of this matter with the party making the allegation; any such resolution shall be reported to the Planning Director in a timely manner; and

d. Following the review period as provided under subsection (c) and until the conclusion of the revocation procedures as provided by Section 17.54.030, up to one fourth of the wind turbines authorized by this permit to be constructed or maintained that are in closest proximity to the dwelling of the party making the allegation, shall be made inoperative.

Methods for measuring and reporting acoustic emissions from wind turbines and windfarms shall be equal to or exceed the minimum standards for precision described in American Wind Energy Association (AWEA) Standard, AWEA 2.1 - 1989 titled *Procedures for the Measurement and Reporting of Acoustic Emissions from Wind Turbine Generation Systems (WTGS) Volume I: First Tier.*

The Planning Director, in consultation with the Alameda County Environmental Health Services Agency, shall establish criteria for noise samples and measurement parameters such as the duration of data collection, time of day, wind speed, atmospheric conditions and direction as set forth in the Wyle Research Report.

23. Noise Enforcement Deposits: The Permittee shall as condition of the continued operation of the Facility as approved under this Permit maintain a $2,000.00 cash deposit for use in the investigation and evaluation of a noise complaint as provided in Condition 22 herein above. If all or any part of said cash deposit is depleted by such activities, the Permittee shall restore the balance of the deposit to the original $2,000.00. In the course of the review of this permit on the third anniversary of its issuance, if warranted by the record, the requirement of this $2,000.00 deposit may be deleted and funds paid by the Permittee may be returned to the Permittee.

The Resolution approving the CUPs for windfarm operations included a finding that as a land use, the wind energy use "is properly related to other land uses and transportation and service facilities in the vicinity, in that … d) Although some residents may object to the visual, noise, or other effects of the turbines, the County has determined that the wind energy projects are in compliance with the conditions of approval and are an acceptable use in the area."

Existing Noise Environment

The project area is primarily undeveloped rural agricultural land with some scattered residences. Noise sources in the project area include traffic on local and distant roadways, existing wind turbines, and natural sources such as birds and wind blowing through tall grass. Existing noise levels in the project area are described here on the basis of measured data.

Noise monitoring was conducted at seven locations in the project area identified as M1 through M7. Figure 2 shows the location of each monitoring position. Positions M1 and M6 were selected to capture sound levels at positions close to existing operating turbines. The remaining positions were selected to be representative of residences in the project area.

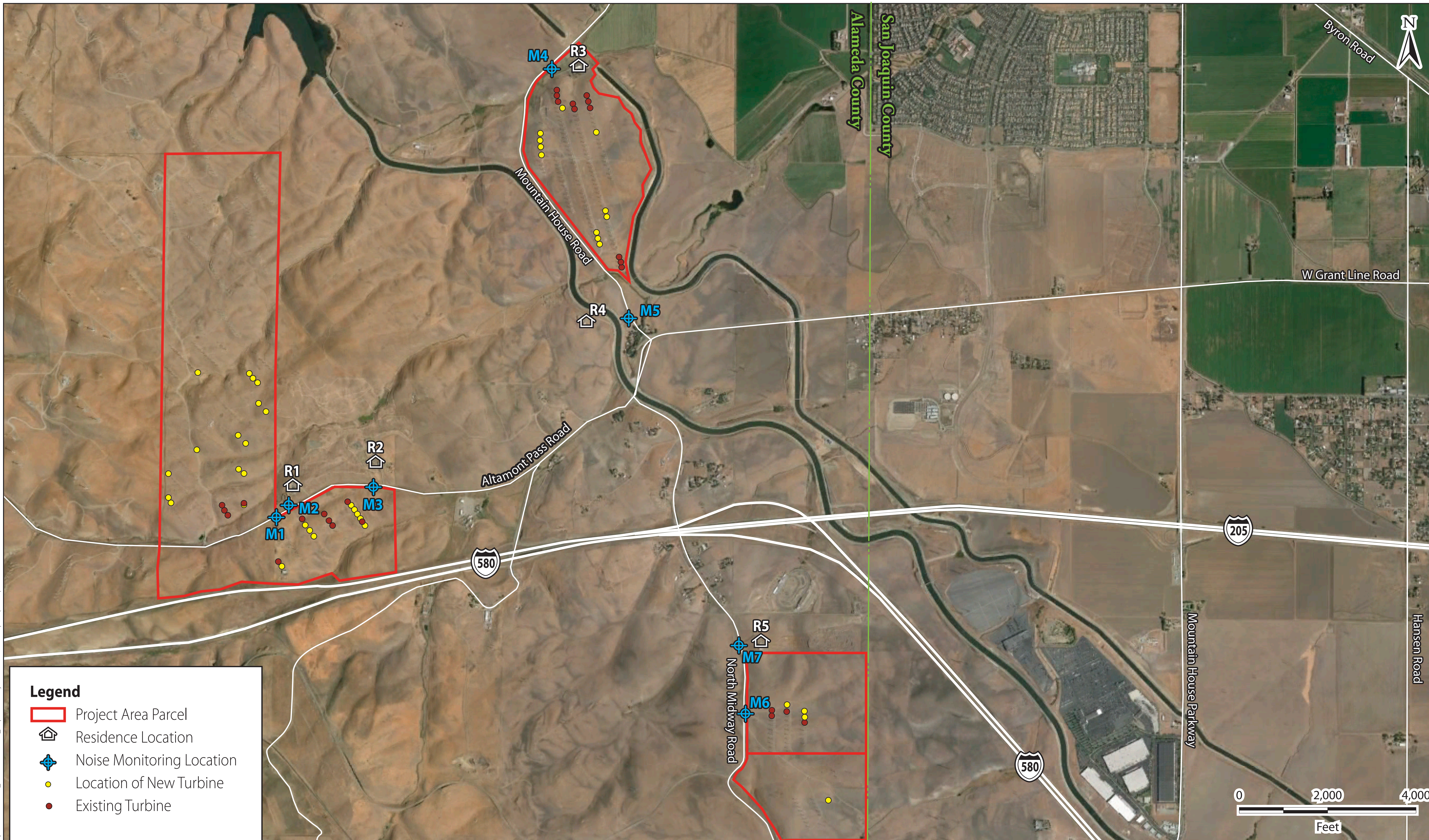

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Figure 2
Noise Monitoring and Residence Locations

Noise levels were measured with a Larson Davis Model 812 Type 1 sound level meter utilizing 0.50-inch microphone and 3.0-inch-diameter windscreen. The microphone at each location was placed 5 feet above the ground. The calibration of each meter was checked before and after the measurement period with a Larson Davis Model CA250 calibrator. Measurements were taken over a 5-minute period with a focus on sound from wind turbines. The meter was paused when aircraft, vehicles, or other intermittent sources unrelated to wind turbine operation were present. Average wind speed during the measurement session was captured with a Kestrel 3000 portable weather station.

Position M1

Position M1 was located along Altamont Pass Road. This position is not representative of any residences but rather was intended to capture a measurement very near an existing operating turbine. The nearest operating turbine was about 300 feet from the measurement position. Many turbines in this area were not operating and appeared to be nonfunctional. The average wind speed during the measurement session was 12.2 mph (5.5 meters/second).

Table 3 summarizes key measurement data taken during the measurement. Sound from the turbines was audible along with sound from wind blowing through the grass.

Table 3. Summary of Measurements at M1

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M1	10:17 a.m.	5 min	58.4	67.9	54.7	60.4	58.3	57.5	55.9
Coordinates. Latitude: 37.742760°. Longitude: -121.604732°									

Position M2

Position M2 was sited on Altamont Pass Road near residence R1. The nearest operating turbine was about 380 feet from the measurement position. Many turbines in this area were not operating and appeared to be nonfunctional. The average wind speed during the measurement session was 12.1 mph (5.4 meters/second).

Table 4 summarizes key measurement data taken during the measurement. Sound from the turbines was audible along with sound from wind blowing through the grass.

Table 4. Summary of Measurements at M2

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M2	10:38 a.m.	5 min	56.1	62.6	53.6	57.6	56.0	55.5	54.3
Coordinates: Latitude: 37.743564°. Longitude: -121.603492°									

Position M3

Position M3 was sited on Altamont Pass Road near residence R2. The nearest operating turbine was about 750 feet from the measurement position. Many turbines in this area were not operating and appeared to be nonfunctional. The average wind speed during the measurement session was 12.1 mph (5.4 meters/second).

Table 5 summarizes key measurement data taken during the measurement. Sound from the turbines was audible along with sound from wind blowing through the grass. Some high-pitched squeaking sounds from the turbines were noticeable.

Table 5. Summary of Measurements at M3

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M3	10:38 a.m.	5 min	53.3	67.2	49.1	54.5	62.9	52.3	50.5
Coordinates: Latitude: 37.744771°. Longitude: -121.596957°									

Position M4

Position M4 was sited on Mountain House Road near residence R3. The nearest operating turbine was about 590 feet from the measurement position. All but a few of the turbines in this area were operating. The average wind speed during the measurement session was 13.3 mph (5.9 meters/second).

Table 6 summarizes key measurement data taken during the measurement. Sound from the turbines was audible along with sound from wind flowing through the grass. A constant high-pitched sound was also noted.

Table 6. Summary of Measurements at M4

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M4	11:24 a.m.	5 min	56.7	73.6	51.2	57.4	56.1	55.6	53.8
Coordinates: Latitude: 37.771736°. Longitude: -121.583022°									

Position M5

Position M5 was sited on Mountain House Road near residence R4. The nearest operating turbine was about 1,200 feet from the measurement position. All but a few of the turbines in this area were operating. The average wind speed during the measurement session was 6.8 mph (3.0 meters/second).

Table 7 summarizes key measurement data taken during the measurement. Sound from the turbines was not distinctly audible, but the high-pitched sound noticed at Position M4 was occasionally audible. The sound of wind flowing through the grass was audible.

Table 7. Summary of Measurements at M5

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M5	11:43 a.m.	5 min	47.0	60.3	40.8	50.0	46.6	45.6	43.1
Coordinates: Latitude: 37.755704°. Longitude: -121.576477°									

Position M6

Position M6 was sited North Midway Road. This position is not representative of any residences but rather was intended to capture a measurement very near an existing operating turbine. The nearest operating turbine was about 315 feet from the measurement position. All but a few of the turbines in this area were operating. The average wind speed during the measurement session was 5.8 mph (2.6 meters/second).

Table 8 summarizes key measurement data taken during the measurement. Sound from the turbines was audible along with sound from wind flowing through the grass.

Table 8. Summary of Measurements at M6

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M6	12:18 p.m.	5 min	50.	55.0	44.6	52.1	50.5	49.6	47.1
Coordinates: Latitude: 37.730386°. Longitude: -121.566884°									

Position M7

Position M5 was sited on North Midway Road near residence R5. The nearest operating turbine was about 1,710 feet from the measurement position. All but a few of the turbines in this area were operating. The average wind speed during the measurement session was 13.7 mph (6.1 meters/second).

Table 9 summarizes key measurement data taken during the measurement. Sound from the turbines was not audible at this position. The sound of wind flowing through the grass was audible.

Table 9. Summary of Measurements at M7

Position	Start Time	Duration	L_{eq}	L_{max}	L_{min}	L_{10}	L_{33}	L_{50}	L_{90}
M7	12:36 p.m.	5 min	56.8	65.4	50.9	59.1	56.9	55.6	52.6
Coordinates: Latitude: 37.734758°. Longitude: -121.567326°									

Impact Discussion

Analysis Methods

Wind Turbine Noise

The turbines proposed for this project employ a new shrouded wind turbine technology. The shrouded turbine, also known as Mixer Ejector Wind Turbine, has a hub height of 118 feet and shroud diameter of 66 feet. San Hill conducted A preliminary sound test was over a 2-day period at a location approximately 28 miles west of Rosamond, CA. The test methodologies were based on the International Electrotechnical Commission (IEC) Standard 61400-11, "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques," 2nd Ed., 2002. The wind speed range reflected in the test data was 5.5–10 meter/second (m/s), with the majority of data collected between 7 and 8.5 m/s.

To connect the turbine to the power grid, a load bank with an outlet decibel reading of approximately 105 dBA was located approximately 75 feet from the turbine. The IEC Standard 61400-11 specifies 1 minute average sampling time. However, because the load bank could only be shut down for 20-second intervals, the sound measurements for this test were limited to 20-second intervals. In addition, the sound tests were conducted with blade pitch restrictions placed on the test turbine.

Relevant data were collected during the allowable 20-second load bank shutdown period and analyzed with a spectrum analyzer. A linear regression analysis of sound levels versus wind speed was completed, as well as time histories of sound levels over the monitoring period. Within the aforementioned site constraints, the results of the testing provide a general indication of expected sound emission levels (at wind speeds up to approximately 8 m/s).

Table 10 provides the results of this test and shows octave band sound power levels in terms of statistical sound levels (L_{10}, L_{50}, and L_{90}).

Table 10. Octave Band Sound Levels for Proposed Turbines

Octave band	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
L_{10}	66.8	85.3	96.8	95.0	93.3	93.6	91.5	91.2
L_{50}	61.2	79.6	87.3	88.0	86.3	87.2	85.5	87.6
L_{90}	56.1	75.3	80.3	80.6	78.5	79.7	79.3	81.0

L_{eq} values are typically used for the purposes of impact assessment. Measurement results in Tables 3 through 9 indicate that the L_{eq} value is typically less than the L_{10} value and greater than the L_{50} value. For the purposes of this assessment, the reported L_{10} values in Table 10 are conservatively assumed to be representative of L_{eq} levels produced by the proposed wind turbines.

Sound levels at various distances are calculated on the basis of hemispherical point source attenuation using the following equation (Hoover & Keith 2000):

$L_p = L_w - 10\log 2\pi d^2 + 10$

Where:

L_p = sound pressure level
L_w = sound power level
d = distance from source in feet

Atmospheric molecular absorption based on “standard” day conditions (64°F and 70% humidity) was also included in the calculation (Hoover & Keith 2000). Attenuation values per 1,000 feet is summarized in Table 11.

Table 11. Octave Band Sound Levels for Proposed Turbines

Octave band	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Atmospheric absorption	0.1	0.2	0.4	0.7	1.5	3.0	7.6	13.7

Using the L_{10} values in Table 10 and the atmospheric absorption values in Table 11 single turbine sound levels at various distances are summarized in Table 12.

Table 12. Predicted Sound Levels at Various Distances from a Single Turbine

Distance (feet)	dBA
500	48.9
1,000	42.2
1,500	38.1
2,000	35.2
2,500	32.8
3,000	30.9
3,500	29.2
4,000	27.7

Cumulative sound levels from multiple new turbines are calculated at a given receptor by determining the sound level for each turbine at that receptor and then summing the values using decibel addition. Only turbines located within a distance 3.16 times the distance to the nearest turbine were included in the calculation. Sound produced by turbines beyond this distance would be 10 dB less than the sound produced by the closest turbine, and therefore would not significantly contribute to the overall sound level.

Decommissioning and Construction Activities

Decommissioning and construction activities would involve the use of heavy equipment. To assess impacts equipment associated with these activities, equipment is identified and noise is evaluated using methods recommended by the Federal Transit Administration (2006).

Thresholds of Significance

For this analysis, a noise impact was considered significant under CEQA if it would result in any of the following environmental effects, which are based on professional practice and State CEQA Guidelines Appendix G (14 CCR 15000 et seq.).

- Exposure of residences to predicted noise from new wind turbines in excess of 55 dBA (L_{dn}) where predicted noise is greater than existing noise levels.
- Exposure of residences to an increase in noise of more than 5 dB from the addition of the new wind turbines.
- Exposure of residences to equipment noise associated with decommissioning and construction activities that exceeds Alameda County Noise Ordinance standards during non-exempt hours. (50 dBA during daytime hours and 45 dBA during nighttime hours). The provisions of the ordinance do not apply to noise sources associated with construction, provided the activities do not take place before 7 a.m. or after 7 p.m. on any day except Saturday or Sunday, or before 8 a.m. or after 5 p.m. on Saturday or Sunday.

Impact Assessment

Impact NOI-1: Exposure of residences to noise from new wind turbines (less than significant)

Table 13 summarizes predicted noise levels at residential locations in the project area and provides a comparison to existing measured noise levels nearby. A daily L_{dn} value can be calculated from a constant sound source by adding 6.4 dBA to the constant sound level. Assuming that a new turbine could produce a constant sound level over a 24-hour period, the L_{dn} value can be estimated by adding 6.4 dB to the L_{eq} value, based, as indicated above, on the conservative assumption that the L_{10} results in Table 10 are representative of the turbine L_{eq} levels. Table 13 also includes an estimate of the predicted L_{dn} value from the new turbines at each receiver.

Table 13. Summary of Predicted Noise from New Turbines

Residence*	Existing Level (dBA-L_{eq})	Distance to Nearest New Turbine (ft)	3.16 X Nearest Distance (ft)	Number of New Turbines within 3.2 X Distance	Noise Level of New Turbines (dBA-L_{eq})	Estimated L_{dn} from New Turbines
R1 (M2)	56.1	785	2,480	17	51.7	58.1
R2 (M3)	53.3	1,080	3,410	19	48.9	55.3
R3 (M4)	56.7	810	2,560	7	47.4	53.8
R4 (M5)	47.0	1,740	5,500	12	42.9	49.3
R5 (M7)	56.8	1,480	4,680	4	41.6	48.0

*Corresponding noise monitoring position is shown in parentheses.

The results in Table 13 indicate that the noise generated by the new turbines would exceed 55 L_{dn} at residences R1 and R2, which are adjacent to the highest concentration of new turbines. However, because predicted noise levels are less than existing measured noise levels, the noise impact at these locations and at the remaining locations is considered to be less than significant. No mitigation is required.

Impact NOI-2: Exposure of residences to noise during decommissioning and construction activities (less than significant with mitigation)

Decommissioning and construction activities are expected to commence in 2014. Decommissioning (facility removal, site restoration, and reclamation) activities associated with the existing turbine sites would occur concurrent with construction activities for the new turbines. Decommissioning and construction would take place over a 6- to 9-month period. These activities would occur between 7:00 a.m. and 7:00 p.m. Monday through Friday and between 8:00 a.m. and 6:00 p.m. on Saturdays and Sundays. Table 14 lists typical construction equipment that is expected to be used for decommissioning and construction activities.

Table 14. Project Construction Equipment

Equipment Type	Project Use
Bulldozer	Road and pad construction
Grader	Road and pad construction; yards
Compactor	Road and pad compaction
Water Trucks	Compaction, erosion, and dust control
Backhoe	Excavating trenches for underground utilities
Excavator	Foundation construction
Loader, rubber-tired and skid	Move and carry soils and other construction debris/equipment
Rollers	Compaction, erosion, and dust control
Concrete trucks and pumps	Pouring tower and other structure foundations
Heavy and intermediate cranes	Off-loading and erecting towers and turbines
Cement and gravel haul trucks	Hauling road and pad construction materials
Semi-trailer trucks	Delivering towers, turbines and other equipment
Pickup trucks	General use and hauling minor equipment
Small hydraulic cranes/forklifts	Loading and unloading equipment
Four-wheeled all-terrain vehicles	Access and underground electrical line installation
Rough-terrain forklift	Lifting equipment

Table 15 summarizes typical noise levels produced by equipment anticipated to be used for this project (Federal Transit Administration 2006). L_{max} sound levels at 50 feet are shown along with the typical acoustical use factors. The acoustical use factor is the percentage of time each piece of construction equipment is assumed to be operating at full power (i.e., its noisiest condition) during construction operation and is used to estimate L_{eq} values from L_{max} values. For example the L_{eq} value for a piece of equipment that operates at full power 50% of the time (acoustical use factor of 50) is 3 dB less than the L_{max} value.

Table 15. Typical Construction Equipment Noise Levels

Equipment Type	Represented Equipment from Federal Transit Administration 2006	Typical L_{max} Source Level at 50 Feet (dBA)	Acoustical Use Factor	L_{eq} Source Level at 50 Feet
Bulldozer	Dozer	82	40	78
Grader	Grader	85	40	81
Compactor	Compactor	83	20	76
Water truck	Flatbed truck	71	40	67
Backhoe	Backhoe	78	40	74
Excavator	Excavator	81	40	77
Loader, rubber-tired and skid	Front end loader	74	40	70
Roller	Roller	80	20	73
Concrete trucks and pump	Concrete mixer truck	79	40	75
Heavy and intermediate crane	Crane	81	16	73
Cement and gravel haul truck	Dump truck	76	40	72
Semi-trailer truck	Dump truck	76	40	72
Pickup truck	Pickup truck	75	40	71
Small hydraulic crane/forklift	Pickup truck	75	40	71
Four-wheeled all-terrain vehicle	Pickup truck	75	40	71
Rough-terrain forklift	Pickup truck	75	40	71

Potential project-related activities have been placed into two general categories. These categories and the pieces of equipment likely to be associated with each are summarized in Table 16, along with the combined noise level of equipment associated with each category.

Table 16. Combined Noise Level of Construction Equipment

Activity Category	Equipment	Sound Level (L_{max}) at 50 feet	Sound Level (L_{eq}) at 50 feet
1—Earthwork associated with road upgrades, pad preparation, trenching, erosion control, existing pad removal, restoration	Bulldozer	82	78
	Grader	85	81
	Compactor	83	76
	Excavator	81	77
	Backhoe	78	74
	Roller	80	73
	Combined Noise Level	90	85
2—Installation of new turbines, removal of old turbines	Crane	81	73
	Semi-trailer truck	76	72
	Pickup truck	75	71
	Forklift	75	71
	Combined Noise Level	84	78

Based on point source attenuation of 7.5 dB per doubling of distance (6 dB per doubling for geometry and 1.5 dB per doubling for ground absorption), potential construction noise levels at various distances for each category have been calculated relative to the Alameda County Noise Ordinance standards. Table 17 summarizes the results of this analysis and identifies distances within which Alameda County noise standards could be exceeded as a result of these activities.

Table 17. Decommissioning Noise Analysis

Relevant Standard	Category 1	Category 2
Distance to 70 dBA, L_{max} dBA (7:00 a.m. to 10:00 p.m.)	311 feet	175 feet
Distance to 65 dBA, L_{max} (10:00 p.m. to 7:00 a.m.)	493 feet	277 feet
Distance to 50 dBA (7:00 a.m. to 10:00 p.m.)	1,268 feet	650 feet
Distance to 45 dBA (10:00 p.m. to 7:00 a.m.)	2,010 feet	1,030 feet

Several residences are within several hundred feet of where turbine removal, installation, and restoration activities could occur. The results in Table 17 indicate that these activities could result in noise that exceeds Alameda County Noise Ordinance standards during non-exempt hours. This impact is therefore considered to be significant. Implementation of Mitigation Measure NOI-2 would reduce this impact to a less-than-significant level.

Mitigation Measure NOI-2: Employ noise-reducing practices during decommissioning

The project applicant will employ a combination of the following noise-reducing construction practices so that construction noise does not exceed Alameda County Noise Ordinance standards at the relevant property lines. Measures that can be used to limit noise include, but are not limited to those listed below.

- Prohibit noise-generating activities before 7 a.m. and after 7 p.m. on any day except Saturday or Sunday, and before 8 a.m. and after 5 p.m. on Saturday or Sunday.
- Locate equipment as far as practical from noise-sensitive uses.
- Require that all construction equipment powered by gasoline or diesel engines have sound-control devices that are at least as effective as those originally provided by the manufacturer and that all equipment be operated and maintained to minimize noise generation.
- Use noise-reducing enclosures around noise-generating equipment where practicable.
- Implement other measures with demonstrated practicability in reducing equipment noise, upon prior approval by the County.

In no case will the applicant be allowed to use gasoline or diesel engines without muffled exhausts.

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