APPENDIX A

BACKGROUND INFORMATION ON ENVIRONMENTAL ACOUSTICS

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The following discussion provides background information on environmental acoustics and terminology used to describe and evaluate noise. Important physical characteristics of environmental noise include frequency, amplitude, and time-varying character.

A-Weighted Decibels
Most sounds consist of a broad range of sound frequencies. Because the human ear is not equally sensitive to all frequencies, several frequency-weighting schemes have been used to develop composite decibel scales that approximate the way the human ear responds to sound levels. The "A-weighted" decibel scale (dBA) is the most widely used for the purpose.

Ambient Sound
Ambient sound is the all-encompassing sound associated with a given community site, usually being a composite of sounds from many sources, near and far, with no particular sound being dominant.

Anomalous Excess Attentuation
Large-scale effects of wind speed, wind direction, and thermal gradients in the air can cause large differences in sound transmission over large distances. These effects when combined result in anomalous excess attenuation, which can be applied to long-term sound-level estimates. Additional sound attenuation on the order of about 1 to 2 per 1,000 feet can occur.

Attenuation from Barriers
Any solid structure such as a berm, wall, or building that blocks the line of sight between a source and receiver serves as a sound barrier and will result in additional wound attenuation. The amount of additional attenuation is a function o f the difference between the length of the sound path over the barrier and the length of the direct line of site path. Thus, the sound attenuation of a barrier between a source and a receiver that are very far apart will be mush less than the attenuation that would result if either the source or the receiver is very close to the barrier.

Community Noise Equivalent Level
The community noise equivalent level (CNEL) is also used to characterize average sound levels over a 24-hour period, with weighting factors included for evening and nighttime sound levels. Leq values for the evening period (7:00 p.m. – 10:00 p.m.) are increased by 5 dB, while Leq values for the nighttime period (10:00 p.m. – 7:00 a.m.) increased by 10 dB. For given set of sound measurements, the CNEL and Leq are often used interchangeably. Noise fro aircraft operations in California is commonly expressed in terms of CNEL.

Day-Night Average Sound Level
Average sound exposure over a 24-hour period is often presented as a day-night average sound level (DNL). DNL values are calculated from hourly DNL values, with the Leq values for the nighttime period (10:00 p.m. – 7:00 a.m.) increased by 10 dB to reflect the greater disturbance potential from nighttime noises.

Decibel
The increment of measure for noise. The nature of the decibel scale is such that the individual sound levels for different sound sources cannot be added directly to give the combined sound level of these sources. Two sound sources producing equal sound levels at a given location will produce a composite sound level that is 3 dB greater than either sound. When two sound sources differ by 10 dB, the composite sound level will be only 0.4 dB greater than the louder source alone.

Most people have difficulty distinguishing the louder of two sound sources if they differ by less than 1.5-2.0 dB. Research into the human perception of changes in sound level indicates the following:

- A 3-dB change is just perceptible,
- A 3-dB change is clearly perceptible, and
- A 10-dB change is perceived as being twice or half as loud.

A doubling or halving of acoustic energy will change the resulting sound level by 3 dB, which corresponds to a change that is just perceptible. In practice, this means that a doubling of traffic volume on a roadway, doubling the number of people in a stadium, or doubling the number of wind turbines in a wind farm will, a s a general rule, only result in a 3 dB, or just perceptible, increase in noise.

Distance Attenuation
As a general rule, sound from localized or point sound sources spreads out as it travels away from the source and the sound level drops at a rate of 6 dB per doubling of distance. If the sound source is long in one dimension, such as traffic on a highway or a long train, the sound source is considered to be a line source. As a general rule, the sound level from a line source will drop off at a rate of 3 dB per doubling of distance. If the intervening ground between the line source and the receptor is acoustically "soft" (e.g., ground vegetation, scattered trees, clumps of bushes), an attenuation rate of 4.5 dB per doubling of distances is generally used.

Equivalent Sound Level
Time-varying sound levels are often described in terms of an equivalent constant decibel level. Equivalent sound levels (Leq) are used to develop single-value descriptions of average sound exposure over various periods of time. Such average sound exposure values often include additional weighting factors for annoyance potential attributable to time of day or other considerations. The Leq data used for these average sound exposure descriptors are generally based on A-weighted sound level measurements.

Frequency
The frequency, or pitch, of sound refers to the number of complete pressure fluctuations, or cycles, that occur in a one second period. Cycles per second are commonly referred to as Hertz (HZ). Hu8man hearing is in the range of 20 HZ to 20,0000 Hz.

Molecular Absorption
Air absorbs sound energy as a function of the temperature, humidity of the air, and frequency of the sound. Additional sound attenuation on the order of 1 to 2 dB per 1, 000 feet can occur.

Noise Contour Map
A noise contour map is a map depicting lines of equal sound levels and is analogous to a topographical map which shows lines of equal elevation.

Noise
Airborne sound is the rapid fluctuation of air pressure above and below atmospheric pressure that is received by the ear and perceived by the brain as sound. Noise is defined as unwanted or undesired sound. Frequency (pitch) and sound level (loudness) are the primary parameters used to describe sound. The time varying character of sound is addressed by using the various averaging methodologies described below.

Other Atmospheric Effects
Short-term atmospheric effects relating to wind and temperature gradients can cause bending of sound waves and can influence changes in sound levels at large distances. These effects can either increase or decrease sound levels depending on the orientation of the source and receptor and the nature of the wind and temperature gradient. Because these effects are normally short-term, it is generally not practical to include them in sound propagation calculations. Understanding these effects, however, can help explain variations that occur between calculated and measured sound levels.

Outdoor Sound Propagation
There are a number of factors that affect how sound propagates outdoors. These

factors, described by Miller (1982), are summarized below.

Sound Level
Sound level meters measure the pressure fluctuations caused by sound waves. Because of the ability of the human ear to respond to a wide dynamic range of sound pressure fluctuations, loudness is measured in terms of decibels (dB) on a logarithmic scale. This results in a scale that measures pressure fluctuations in a convenient notation and corresponds tour auditory perception of increasing loudness.