

## 3.8 Noise and Vibration

This section describes the regulatory and environmental settings for noise and vibration in the Plan Area. Impacts that would result from implementing the proposed action and alternatives are described in Chapter 4, *Environmental Consequences*, along with mitigation measures to reduce impacts, where appropriate.

### 3.8.1 Regulatory Setting

There are no federal, state, or local laws or regulations for vibration that are relevant to the proposed action or alternatives. However, there are guidelines for assessing the impacts of groundborne vibration, and these are discussed below in Section 3.8.2, *Environmental Setting*. Because there are no laws or regulations for vibration, the following regulatory summary focuses on noise only.

#### Federal

There are no federal laws or regulations pertaining to noise that are relevant to the proposed action or alternatives.

#### State

##### California Code of Regulations, Title 24, Part 2

Title 24 of the California Code of Regulations, Part 2, 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 that are attributable to exterior noise sources cannot exceed the 45 day-night level ( $L_{dn}$ ) in any habitable room. Where such residences are located in an environment in which 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.

##### California Administrative Code, Title 4

California requires each local government to implement a noise element as part of its general plan. California Administrative Code, Title 4, has guidelines for evaluating the compatibility of various land uses as a function of community noise exposure. These guidelines are shown in Table 3.8.1.

**Table 3.8.1. State Land Use Compatibility Standards for Community Noise Environment**

Land Use Category	Community Noise Exposure—L <sub>dn</sub> or CNEL (dB)							
	50	55	60	65	70	75	80	
Residential—low-density single family, duplex, mobile homes	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Residential— multi-family	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Transient lodging—motels, hotels	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Schools, libraries, churches, hospitals, nursing homes	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Auditoriums, concert halls, amphitheaters	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Sports arenas, outdoor spectator sports	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Playgrounds, neighborhood parks	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Golf courses, riding stables, water recreation, cemeteries	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Office buildings, business commercial and professional	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable
Industrial, manufacturing, utilities, agriculture	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable	Normally Acceptable

**Normally Acceptable:** Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.

**Conditionally Acceptable:** New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features are included in the design. Conventional construction, but with closed windows and fresh air supply systems or air conditioning will normally suffice.

**Normally Unacceptable:** New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design.

**Clearly Unacceptable:** New construction or development generally should not be undertaken.

Source: California Governor’s Office of Planning and Research 2003.

CNEL = community noise equivalent level.  
dB = decibel.  
L<sub>dn</sub> = day-night level.

## Local

### Placer County General Plan

Section 9 (the Noise Element) of the *Placer County General Plan* lists goals, associated policies, and implementation measures related to noise (Placer County 2013). The Noise Element does not include guidelines related to construction activities, including those that would be associated with habitat restoration. However, the tables included below provide context for generally accepted non-transportation and transportation noise levels in the county.

The maximum allowable noise exposure limits for non-transportation noise sources are shown in Table 3.8-2, and the maximum allowable noise exposure limits for transportation noise sources in Placer County are summarized in Table 3.8-3. As discussed above, Placer County's general plan does not specifically address construction noise level limits. Construction noise level limits and restrictions on hours for construction are determined on a project-by-project basis through environmental review, conditioning of entitlements, and the application of County Code requirements for individual projects using the general plan's noise level standards as guidance for acceptable levels.

**Table 3.8-2. Placer County Allowable  $L_{dn}$  Noise Levels within Specific Zone Districts**

Zone District of Receptor	Property Line of Receiving Use	Interior Spaces
Residential adjacent to industrial	60	45
Other residential	50	45
Office/professional	70	45
Transient lodging	65	45
Neighborhood commercial	70	45
General commercial	70	45
Heavy commercial	75	45
Limited industrial	75	45
Highway service	75	45
Shopping center	70	45
Industrial	–	45
Industrial park	75	45
Industrial reserve	–	–
Airport	–	45
Unclassified	–	–
Farm	– <sup>a</sup>	–
Agriculture exclusive	– <sup>a</sup>	–
Forestry	–	–
Timberland preserve	–	–
Recreation and forestry	70	–
Open space	–	–
Mineral reserve	–	–

**Table 3.8-2 (Continued)**

Source: Excerpted from Placer County 2013:Table 9-1.

## Notes:

- Except where noted otherwise, noise exposures will be those which occur at the property line of the receiving use.
  - Where existing transportation noise levels exceed the standards of this table, the allowable  $L_{dn}$  shall be raised to the same level as that of the ambient level.
  - If the noise source generated by, or affecting, the uses shown above consists primarily of speech or music, or if the noise source is impulsive in nature, the noise standards shown above shall be decreased by 5 dB.
  - Where a use permit has established noise level standards for an existing use, those standards shall supersede the levels specified in [*Placer County General Plan*] Table 9-1 and Table 9-3. Similarly, where an existing use which is not subject to a use permit causes noise in excess of the allowable levels in [*Placer County General Plan*] Tables 9-1 and 9-3, said excess noise shall be considered the allowable level. If a new development is proposed which will be affected by noise from such an existing use, it will ordinarily be assumed that the noise levels already existing or those levels allowed by the existing use permit, whichever are greater, are those levels actually produced by the existing use.
  - Existing industry located in industrial zones will be given the benefit of the doubt in being allowed to emit increased noise consistent with the state of the art at the time of expansion. In no case will expansion of an existing industrial operation because to decrease allowable noise emission limits. Increased emissions above those normally allowable should be limited to a one-time 5 dB increase at the discretion of the decision making body.
  - The noise level standards applicable to land uses containing incidental residential uses, such as caretaker dwellings at industrial facilities and homes on agriculturally zoned land, shall be the standards applicable to the zone district, not those applicable to residential uses.
  - Where no noise level standards have been provided for a specific zone district, it is assumed that the interior and/or exterior spaces of these uses are effectively insensitive to noise.
- <sup>a</sup> Normally, agricultural uses are noise insensitive and will be treated in this way. However, conflicts with agricultural noise emissions can occur where single-family residences exist within agricultural zone districts. Therefore, where effects of agricultural noise upon residences located in these agricultural zones is a concern, an  $L_{dn}$  of 70 dBA (A-weighted decibel) will be considered acceptable outdoor exposure at a residence.

Applicable to New Projects Affected by or Including Non-Transportation Noise Sources.

**Table 3.8-3. Placer County Maximum Allowable Noise Exposure for Transportation Noise Sources**

Land Use	Outdoor Activity Areas <sup>a</sup> L <sub>dn</sub> /CNEL	Interior Spaces	
		L <sub>dn</sub> /CNEL	L <sub>eq</sub> , dB <sup>b</sup>
Residential	60 <sup>c</sup>	45	–
Transient lodging	60 <sup>c</sup>	45	–
Hospitals, nursing homes	60 <sup>c</sup>	45	–
Theaters, auditoriums, music halls	–	–	35
Churches, meeting halls	60 <sup>c</sup>	–	40
Office buildings	–	–	45
Schools, libraries, museums	–	–	45
Playgrounds, neighborhood parks	70	–	–

Source: Placer County 2013:Table 9-3.

CNEL = community noise equivalent level.

dB = decibel.

L<sub>dn</sub> = day-night level.

L<sub>eq</sub> = equivalent sound level.

- <sup>a</sup> Where the location of outdoor activity areas is unknown, the exterior noise level standard shall be applied to the property line of the receiving land use.
- <sup>b</sup> As determined for a typical worst-case hour during periods of use.
- <sup>c</sup> Where it is not possible to reduce noise in outdoor activity areas to 60 L<sub>dn</sub>/CNEL or less using a practical application of the best-available noise reduction measures, an exterior noise level of up to 65 dB L<sub>dn</sub>/CNEL may be allowed provided that available exterior noise level reduction measures have been implemented and interior noise levels are in compliance with this table.

## Placer County Noise Ordinance

The Placer County Noise Ordinance (Placer County Code Section 9.36.060) states noise limits for sensitive receptors, as excerpted below.

- A. It is unlawful for any person at any location to create any sound, or to allow the creation of any sound, on property owned, leased, occupied or otherwise controlled by such person that:
1. Causes the exterior sound level when measured at the property line of any affected sensitive receptor to exceed the ambient sound level by five dBA; or
  2. Exceeds the sound level standards as set forth in Table 1 [see Table 3.8-4 of this EIS/EIR], whichever is the greater.
- B. Each of the sound level standards specified in Table 1 [Table 3.8-4] shall be reduced by five dB for simple tone noises, consisting of speech and music. However, in no case shall the sound level standard be lower than the ambient sound level plus five dB.
- C. If the intruding sound source is continuous and cannot reasonably be discontinued or stopped for a time period whereby the ambient sound level can be measured, the sound level measured while the source is in operation shall be compared directly to the sound level standards of Table 1 [Table 3.8-4]. (Ord. 5280-B, 2004)

**Table 3.8-4. Placer County Sound Level Standards (onsite)**

Sound Level Descriptor	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Hourly $L_{eq}$ , dB	55	45
Maximum level ( $L_{max}$ ), dB	70	65

Source: Placer County Code, 9.36.060:Table 1.

dB = decibel.

$L_{eq}$  = equivalent sound level.

$L_{max}$  = maximum sound level.

The noise ordinance provides an exception for construction noise (in Municipal Code Section 9.36.030) as long as all construction equipment is “fitted with factory installed muffling devices and that all construction equipment shall be maintained in good working order.”

Allowable time periods for this construction noise are as follows: 6 a.m. to 8 p.m., Monday through Friday; and 8 a.m. to 8 p.m., Saturdays and Sundays.

### Sutter County General Plan

Excerpted below are the relevant goal and policies from the *Sutter County General Plan* that pertain to noise and vibration (Sutter County 2011).

#### Goal

**N 1.** Protect the health and safety of County residents from the harmful effects of exposure to excessive noise and vibration.

#### Policies

**N 1.2. Exterior Incremental Environmental Noise Standards.** Require new development to mitigate noise impacts on noise sensitive uses where the projected increases in exterior noise levels exceed those shown in Table 3.6-2 [see Table 3.8-5 of this EIS/EIR].

**Table 3.8-5. County of Sutter General Plan Exterior Incremental Environmental Noise Impact Standards for Noise Sensitive Uses (dba)**

Residences and Buildings Where People Normally Sleep <sup>a</sup>		Institutional Land Uses with Primarily Daytime and Evening Uses <sup>b</sup>	
Existing L <sub>dn</sub>	Allowable Noise Increment	Existing Peak Hour L <sub>eq</sub>	Allowable Noise Increment
45	8	45	12
50	5	50	9
55	3	55	6
60	2	60	5
65	1	65	3
70	1	70	3
75	0	75	1
80	0	80	0

Source: Federal Transit Administration, Transit Noise Impact and Vibration Assessment, May 2006.

Note: Noise Levels are measured at the property line of the noise-sensitive use.

<sup>a</sup> This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.

<sup>b</sup> This category includes schools, libraries, theaters, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material.

**N 1.3. Interior Noise Standards.** Require new development to mitigate noise impacts to ensure acceptable interior noise levels appropriate to the land use type as shown in Table 3.6-3 (Maximum Allowable Environmental Noise Standards) [see Table 3.8-6 of this EIS/EIR].

**N 1.4. New Stationary Noise Sources.** Require new development to mitigate noise impacts to ensure acceptable interior noise levels appropriate to the land use type as shown in Table 3.6-4 [see Table 3.8-7 of this EIS/EIR].

**N 1.6. Construction Noise.** Require discretionary projects to limit noise-generating construction activities within 1,000 feet of noise-sensitive uses (i.e., residential uses, daycares, schools, convalescent homes, and medical care facilities) to daytime hours between 7:00 a.m. and 6:00 p.m. on weekdays, 8:00 a.m. and 5:00 p.m. on Saturdays, and prohibit construction on Sundays and holidays unless permission for the latter has been applied for and granted by the County.

**N 1.7. Vibration Standards.** Require construction projects and new development anticipated to generate a significant amount of vibration to ensure acceptable interior vibration levels at nearby noise-sensitive uses based on Federal Transit Administration criteria as shown in Table 3.6-5 [see Table 3.8-8 of this EIS/EIR].

**Table 3.8-6. County of Sutter General Plan Maximum Allowable Environmental Noise Standards**

Land Use	Exterior Noise Level Standard for Outdoor Activity Areas <sup>a</sup>	Interior Noise Level Standard	
Residential (Low Density Residential, Duplex, Mobile homes)	60 <sup>d</sup>	45	NA
Residential (Multi Family)	65 <sup>d</sup>	45	NA
Transient Lodging (Models/Hotels)	65 <sup>d</sup>	45	NA
Schools, Libraries, Churches, Hospitals, Nursing Homes, Museums	70	45	NA
Theaters, Auditoriums	70	NA	35
Playgrounds, Neighborhood Parks	70	NA	NA
Gold Courses, Riding Stables, Water Recreation, Cemeteries	70	NA	NA
Office Buildings, Business Commercial and Professional	70	NA	45
Industrial, Manufacturing, Utilities, and Agriculture	70	NA	45

Note: Where a proposed use is not specifically listed on this table, the use shall comply with the noise exposure standards for the nearest similar use as determined by the Community Services Department.

<sup>a</sup> Outdoor activity areas for residential developments are considered to be the back yard patios or decks of single-family residential units, and the patios or common areas where people generally congregate for multi-family development.

Outdoor activity areas for nonresidential developments are considered to be those common areas where people generally congregate, including outdoor seating areas.

Where the location of outdoor activity areas is unknown, the exterior noise standard shall be applied to the property line of the receiving land use.

<sup>b</sup> As determined for a typical worst-case hour during periods of use.

<sup>c</sup> Where it is not possible to reduce noise in outdoor activity areas to 60 dB, L<sub>dn</sub>/CNEL or less using a practical application of the best-available noise reduction measures, an exterior level of up to 65 dB, L<sub>dn</sub>/CNEL may be allowed provided that available exterior noise level reduction measures have been implemented and interior noise levels are in compliance with this table.

<sup>d</sup> Where it is not possible to reduce noise in outdoor activity areas to 65 dB, L<sub>dn</sub>/CNEL or less using a practical application of the best-available noise reduction measures, an exterior level of up to 70 dB, L<sub>dn</sub>/CNEL may be allowed provided that available exterior noise level reduction measures have been implemented and interior noise levels are in compliance with this table.

**Table 3.8-7. County of Sutter General Plan Noise Level Standards from Stationary Sources**

Noise Level Descriptor	Daytime (7:00 a.m. to 10:00 p.m.)	Nighttime (10:00 p.m. to 7:00 a.m.)
Hourly L <sub>eq</sub> , dBA	55	45
Maximum level, dBA	70	65

Note: Noise Levels are measured at the property line of the noise-sensitive use.

**Table 3.8-8. County of Sutter General Plan Groundborne Vibration Impact Criteria for General Assessment**

Land Use Category	Impact Levels (VdB)		
	Frequent Events <sup>a</sup>	Occasional Events <sup>b</sup>	Infrequent Events <sup>c</sup>
Category 1: Buildings where vibration would interfere with interior operations	65 <sup>d</sup>	65 <sup>d</sup>	65 <sup>d</sup>
Category 2: Residences and buildings where people normally sleep	72	75	80
Category 3: Institutional land uses with primarily daytime uses	75	78	83

Source: Federal Transit Administration, Transit Noise Impact and Vibration Assessment, May 2006.

Note: Vibration levels are measured in or near the vibration-sensitive use.

<sup>a</sup> “Frequent Events” is defined as more than 70 vibration events of the same source per day.

<sup>b</sup> “Occasional Events” is defined as between 30 and 70 vibration events of the same source per day.

<sup>c</sup> “Infrequent Events” is defined as fewer than 30 vibration events of the same source per day.

<sup>d</sup> This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels.

## Sutter County Noise Ordinance

Sutter County has not adopted a noise ordinance.

## City of Lincoln General Plan

Excerpted below are the relevant goal and policies from the *City of Lincoln General Plan* that pertain to noise (City of Lincoln 2008).

### Goal

To protect residents from health hazards and annoyance associated with excessive noise levels.

### Policies

**HS-8.1 Sensitive Receptors.** The City will allow the development of new noise-sensitive land uses (which include but are not limited to residential, health care facilities and schools) only in areas exposed to existing or projected levels of noise which satisfy the levels specified in Table 8.1. Noise mitigation measures spaces to levels specified in Table 8.1 [see Table 3.8-9 of this EIS/EIR].

**HS-8.2 Protect Residential Areas.** The City will strive to achieve exterior noise levels for existing and future dwellings in residential areas that do not exceed exterior noise levels of 60 dBA CNEL and interior noise levels of 45 dBA CNEL.

**HS-8.8 Construction Noise.** The City will provide guidelines to developers for reducing potential construction noise impacts on surrounding land uses.

**HS-8.9 Noise Compatibility Guidelines.** The City shall use adopted noise compatibility guidelines to evaluate compatibility of proposed new development and ensure compatibility between residential, commercial and other surrounding land uses (See General Plan Table 8-1, Maximum Allowable Noise Exposure by Land Use [see Table 3.8-9 of this EIS/EIR]).

**HS-8.10 Sound Attenuation Features.** The City shall require sound attenuation features such as walls, berming, and heavy landscaping between commercial and industrial uses and residential uses to reduce noise and vibration. Setback distances may also be used to reduce noise.

Also, implementation measures are identified to help the City implement the goals and policies of its general plan. Health and Safety Implementation Measure 10 in Table 8-2 of the general plan, which is intended to implement policies HS-8.2, HS-8.8, HS-8.9 and HS-8.10, pertains to noise.

The City will prepare guidelines for developers for reducing potential noise impacts (including construction-related noise impacts) on surrounding land uses.

As noted above, under Policy HS-8.1, mitigation is required to satisfy the noise levels specified in *City of Lincoln General Plan* Table 8-1; those levels are shown in Table 3.8-9.

**Table 3.8-9. City of Lincoln Land Use Compatibility Guidelines for Development**

Locations	Normally Acceptable (L <sub>dn</sub> )	Conditionally Acceptable (L <sub>dn</sub> )	Normally Unacceptable (L <sub>dn</sub> )	Unacceptable (L <sub>dn</sub> )
Residential—low density single family, duplex, mobile homes	<60	61–70	71–75	>75
Residential—multiple family, group homes	<60	61–70	71–75	>75
Motels/hotels	<60	61–70	71–80	>80
Schools, libraries, churches, hospitals, extended care facilities	<60	61–70	71–80	>80
Auditoriums, concert halls, amphitheaters	<65	NA	66–70	>70
Sports arenas, outdoor spectator sports	<70	NA	71–75	>75
Playgrounds, neighborhood parks	<70	NA	NA	>70
Golf courses, riding stables, water recreation, cemeteries	<70	NA	71–80	>80
Office buildings, business commercial and professional	<65	66–75	75–81	NA
Industrial, manufacturing, utilities, agriculture	<70	71–80	>81	NA

Source: City of Lincoln 2008:Table 8-1.

Notes:

- Normally Acceptable: Specified land use is satisfactory, based on the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.
- Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed insulation features have been included in the design.
- Normally Unacceptable: New construction or development should generally be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirements must be made and needed noise insulation features included in the design. Outdoor areas must be shielded.
- Unacceptable: New construction or development should not be undertaken.

L<sub>dn</sub> = day-night level.

## City of Lincoln Noise Ordinance

The City of Lincoln's Noise Ordinance (Municipal Code Chapter 9.04) addresses noise control in the city. This chapter of the Municipal Code, however, only addresses noise from sound-emitting devices such as a sound system, loudspeaker, or radio; it does not provide guidance for other activities that would apply to the proposed action and alternatives such as construction equipment.

## 3.8.2 Environmental Setting

### Existing Noise Environment

Covering more than 250,000 acres, the Plan Area is located in Placer County and it comprises a wide variety of land uses.

*Noise-sensitive land uses* are generally defined as locations where people reside or where the presence of unwanted sound could adversely affect the primary intended use of the land. Places where people live, sleep, recreate, worship, and study are generally considered to be sensitive to noise because intrusive noise can be disruptive to these activities.

Noise-sensitive land uses in the Plan Area include residential development, hotels, hospitals, theaters and auditoriums, churches, office buildings, schools, libraries, playgrounds, and neighborhood parks.

There are several primary sources of noise in the Plan Area. Mobile noise sources are those related to transportation and include roadway traffic, railroads, and airports. The most prevalent noise source is roadway traffic, which is a constant source of noise compared to the intermittent sounds generated by railroads and airports. Stationary sources of noise in the area may include aggregate mines, recycling facilities, solid waste transfer stations, agricultural activities, general service commercial and light industrial uses, recreational uses, parks, and school playing fields. Lincoln Regional Airport is the only airport in the Plan Area. High noise levels are generated by the Lincoln Regional Airport only in Hazard Zone A, which is contained within the airport property (Placer County Airport Land Use Commission 2014).

The existing noise environment in the Plan Area can be characterized generally by the area's level of development. The level of development and ambient noise levels tend to be closely correlated. Areas that are not urbanized are relatively quiet, while more urbanized areas are noisier as a result of roadway traffic, industry, and other human activities. Table 3.8-10 summarizes typical ambient noise levels based on level of development.

**Table 3.8-10. Population Density and Associated Ambient Noise Levels**

	$L_{dn}$
Rural	40–50
Small town or quiet suburban residential	50
Normal suburban residential	55
Urban residential	60
Noisy urban residential	65
Very noisy urban residential	70
Downtown, major metropolis	75–80
Area adjoining freeway or near major airport	80–90

Source: Hoover and Keith 2000.

$L_{dn}$  = day-night level.

## Noise Fundamentals

*Noise* is commonly defined as unwanted sound that annoys or disturbs people and potentially causes an adverse psychological or physiological effect on human health. Because noise is an environmental pollutant that can interfere with human activities, evaluation of noise is necessary when considering the environmental impacts of a proposed project.

*Sound* is mechanical energy transmitted by pressure waves over a medium such as air or water. Sound is characterized by various parameters that include the rate of oscillation of sound waves (frequency), the speed of propagation, and the pressure level or energy content (amplitude). In particular, the sound pressure level is the most common descriptor used to characterize the loudness of an ambient (existing) sound level. Although the decibel (dB) scale, a logarithmic scale, is used to quantify sound intensity, it does not accurately describe how sound intensity is perceived by human hearing. The human ear is not equally sensitive to all frequencies in the entire spectrum, so noise measurements are weighted more heavily for frequencies to which humans are sensitive in a process called *A-weighting*, written as dBA and referred to as A-weighted decibels. Table 3.8-11 provides definitions of sound measurements and other terminology used in this section, and Table 3.8-12 summarizes typical A-weighted sound levels for different noise sources.

**Table 3.8-11. Definition of Sound Measurements**

Sound Measurements	Definition
Decibel (dB)	A unitless measure of sound on a logarithmic scale that indicates the squared ratio of sound pressure amplitude to a reference sound pressure amplitude. The reference pressure is 20 micro-pascals.
A-weighted decibel (dBA)	An overall frequency-weighted sound level in decibels that approximates the frequency response of the human ear.
Maximum sound level ( $L_{max}$ )	The maximum sound level measured during the measurement period.
Minimum sound level ( $L_{min}$ )	The minimum sound level measured during the measurement period.
Equivalent sound level ( $L_{eq}$ )	The equivalent steady state sound level that in a stated period of time would contain the same acoustical energy.

Sound Measurements	Definition
Percentile-exceeded sound level ( $L_{xx}$ )	The sound level exceeded “x” percent of a specific time period. $L_{10}$ is the sound level exceeded 10% of the time.
Day-night level ( $L_{dn}$ )	The energy average of the A-weighted sound levels occurring during a 24-hour period, with 10 dB added to the A-weighted sound levels occurring during the period from 10:00 p.m. to 7:00 a.m.
Community noise equivalent level (CNEL)	The energy average of the A-weighted sound levels occurring during a 24-hour period with 5 dB added to the A-weighted sound levels occurring during the period from 7:00 p.m. to 10:00 p.m. and 10 dB added to the A-weighted sound levels occurring during the period from 10:00 p.m. to 7:00 a.m.
Peak particle velocity (peak velocity, or PPV)	A measurement of ground vibration defined as the maximum speed (measured in inches per second) at which a particle in the ground is moving relative to its inactive state. PPV is usually expressed in inches/second.
Frequency: hertz (Hz)	The number of complete pressure fluctuations per second above and below atmospheric pressure.

In general, human sound perception is such that a change in sound level of 1 dB typically cannot be perceived by the human ear, a change of 3 dB is just noticeable, a change of 5 dB is clearly noticeable, and a change of 10 dB is perceived as doubling or halving the sound level.

Different types of measurements are used to characterize the time-varying nature of sound. These measurements include the equivalent sound level ( $L_{eq}$ ), the minimum and maximum sound levels ( $L_{min}$  and  $L_{max}$ ), percentile-exceeded sound levels (such as  $L_{10}$ ,  $L_{20}$ ), the day-night sound level ( $L_{dn}$ ), and the community noise equivalent level (CNEL).  $L_{dn}$  and CNEL values differ by less than 1 dB. As a matter of practice,  $L_{dn}$  and CNEL values are considered to be equivalent and are treated as such in this assessment.

For a point source, such as a stationary compressor or construction equipment, sound attenuates based on geometry at rate of 6 dB per doubling of distance. For a line source such as free-flowing traffic on a freeway, sound attenuates at a rate of 3 dB per doubling of distance (California Department of Transportation 2009). Atmospheric conditions including wind, temperature gradients, and humidity can change how sound propagates over distance and can affect the level of sound received at a given location. The degree to which the ground surface absorbs acoustical energy also affects sound propagation. Sound that travels over an acoustically absorptive surface, such as grass, attenuates at a greater rate than sound that travels over a hard surface, such as pavement. The increased attenuation is typically in the range of 1–2 dB per doubling of distance. Barriers, such as buildings and topography that block the line of sight between a source and receiver, also increase the attenuation of sound over distance.

**Table 3.8-12. Typical A-Weighted Sound Levels**

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

Source: California Department of Transportation 2009.

dBA = A-weighted decibel.

## Vibration Fundamentals

Operation of heavy construction equipment, particularly pile driving and other impulsive devices, such as pavement breakers, creates seismic waves that radiate along the surface of the earth and downward into the earth. These surface waves can be felt as ground vibration. Vibration from operation of this equipment can result in effects ranging from annoyance of people to damage of structures. Varying geology and distance will result in different vibration levels containing different frequencies and displacements. In all cases, vibration amplitudes will decrease with increasing distance.

As seismic waves travel outward from a vibration source, they excite the particles of rock and soil through which they pass and cause them to oscillate. The actual distance that these particles move is usually only a few ten-thousandths to a few thousandths of an inch. The rate or velocity (in inches per second [in/sec]) at which these particles move is the commonly accepted descriptor of the vibration amplitude, referred to as the peak particle velocity (PPV). Table 3.8-13 summarizes typical vibration levels generated by construction equipment (Federal Transit Administration 2006).

**Table 3.8-13. Vibration Source Levels for Construction Equipment**

Equipment	Peak Particle Velocity at 25 Feet
Pile driver (impact)	0.644 to 1.518
Pile drive (sonic)	0.170 to 0.734
Vibratory roller	0.210
Hoe ram	0.089
Large bulldozer	0.089
Caisson drilling	0.089
Loaded trucks	0.076
Jackhammer	0.035
Small bulldozer	0.003

Source: Federal Transit Administration 2006.

Vibration amplitude attenuates (diminishes) over distance and is a complex function of how energy is imparted into the ground and the soil conditions through which the vibration is traveling. The following equation can be used to estimate the vibration level at a given distance for typical soil conditions.  $PPV_{ref}$  is the reference PPV at 25 feet (from Table 3.8-14):

$$PPV = PPV_{ref} (25/Distance)^{1.5}$$

Table 3.8-14 summarizes guideline criteria for vibration annoyance potential suggested by the California Department of Transportation (Caltrans) (California Department of Transportation 2013).

**Table 3.8-14. Guideline Criteria for Vibration Annoyance Potential**

Human Response	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Source: California Department of Transportation 2013.

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls.

Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

PPV = peak particle velocity.

in/sec = inches per second.

Table 3.8-15 summarizes guideline criteria for vibration damage potential suggested by Caltrans (California Department of Transportation 2013).

**Table 3.8-15. Guideline Criteria for Vibration Damage Potential**

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Source: California Department of Transportation 2013.

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls.

Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

PPV = peak particle velocity.

in/sec = inches per second.

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