3.11 Noise and Vibration

The noise and vibration environment in the Caltrain corridor is described to establish the baseline for analyzing changes resulting from construction and operation of the Proposed Project. This discussion focuses on land uses and sensitive receptors along the existing railroad corridor that would be exposed to potential increases in noise and vibration levels that may result from the Proposed Project.

3.11.1 Existing Conditions

3.11.1.1 Regulatory Setting

State

California requires each local government entity to implement a noise element as part of its general plan. The State of California General Plan Guidelines (California Governor's Office of Planning and Research 2003) provides guidelines for evaluating the compatibility of various land uses as a function of community noise exposure. Based on these guidelines, cities along the Caltrain corridor have adopted noise compatibility standards as part of their noise elements. Cities' standards are addressed below.

Local

As described in Chapter 2, *Project Description*, pursuant to SamTrans' enabling legislation (Public Utilities Code Section 103200 et seq.) and the 1991 Interstate Commerce Commission's approval of the JPB acquisition of the Caltrain line, JPB activities within the Caltrain right-of-way (ROW) are exempt from local building and zoning codes and other land use ordinances. Nonetheless, the JPB will cooperate with local government agencies in performing improvements within the Caltrain ROW and will comply with local regulations affecting any of its activities within other jurisdictions.

General Plan Noise Elements

The noise elements in the general plans for all the cities and counties along the Caltrain corridor identify the average noise standard for the Community Noise Equivalent Level (CNEL) to be 65 A-weighted decibels (dBA). This is usually illustrated by 65 dBA CNEL noise contours overlaid over a map of the jurisdiction. These contours consistently follow railroad tracks, freeways, and major connector roads, indicating that these are the major sources of existing noise exposure. Brisbane, South San Francisco, San Bruno, Millbrae, Burlingame, San Carlos, Menlo Park, Palo Alto, Sunnyvale, Santa Clara, and San Jose also indicate that airports contribute to the existing noise levels.

Municipal Codes

The property line noise level restrictions in the municipal codes for the various cities along the Caltrain corridor can be grouped into following four general methods.

- The municipal codes for San Francisco, Brisbane, San Bruno, San Carlos, Redwood City, and Palo Alto regulate the property line noise levels based on the dBA level above local ambient, with the local ambient defined in each city's code.

- South San Francisco, San Mateo, Belmont, North Fair Oaks (San Mateo County), Menlo Park, Atherton, Sunnyvale, and Santa Clara all provide maximum allowable noise levels for daytime and nighttime hours. Some of these jurisdictions further delineate the maximum allowable noise level for each land use type, while others include additional regulations regarding tonal noises.
- The San Jose municipal code specifies maximum allowable noise levels at residential and commercial property lines but does not provide further detail with regard to time periods or local ambient noise levels.
- Millbrae and Burlingame do not include any quantitative noise limits in their municipal codes.

Most of the cities along this corridor limit construction noise to particular time periods during weekday, weekend and holiday daytime hours. Nighttime construction is prohibited. Some of the municipal codes restrict construction noise based on the maximum noise levels allowable at property lines or at a specified distance from construction equipment.

Of all the cities along the Caltrain corridor, only Sunnyvale, Santa Clara, and San Jose specify limits on ground-borne vibration. Santa Clara's municipal code sets the vibration perception threshold at a motion velocity of 0.01 inch/second over the range of 1 to 100 Hertz. This threshold cannot be exceeded at the property lines. Construction activities are exempt from both noise and vibration limits during allowed hours under the Santa Clara municipal code. Sunnyvale and San Jose limit ground vibration at the property line to activity that is imperceptible without instrumentation.

Table 3.11-1 summarizes the local ordinances along the Caltrain corridor.

Table 3.11-1. Summary of Local Noise and Vibration Ordinances

Jurisdiction	Noise/ Vibration Source	Maximum Allowable Levels or Exemption
San Francisco	Construction	7:00 a.m. to 8:00 p.m.: 80 dBA measured at a distance of 100 feet from construction equipment. 8:00 p.m. to 7:00 a.m.: no more than 5 dBA above the ambient at any point outside of the property plane.
	Fixed	Residential Interior Noise: 45 dBA from 10:00 p.m. to 7:00 a.m., 55 dBA from 7:00 a.m. to 10:00 p.m. with windows open except where building ventilation is achieved through mechanical means that allow windows to remain closed.
	General	Not more than 5 dBA above the ambient at any point beyond residential property plane; not more than 8 dBA above the ambient at any point beyond commercial and industrial property plane. Minimum ambient is defined as: 35 dBA for interior residential noise, and 45 dBA in all other locations.
Brisbane	Construction	83 dBA at 25 feet from individual equipment; 86 dBA at any point outside the property plane of the project. Construction permitted weekdays from 7:00 a.m. to 7:00 p.m.; weekends and holidays from 9:00 a.m. to 7:00 p.m.
	General	Not more than 10 dB over ambient for more than 15 minutes per hour, or not more than 20 dB over ambient for more than 3 minutes per hour. Minimum ambient is defined as: 35 dBA for interior residential noise, and 45 dBA in all other locations.

Jurisdiction	Noise/ Vibration Source	Maximum Allowable Levels or Exemption
South San Francisco	Construction	90 dBA at 25 feet from individual equipment; 90 dBA at any point outside the property plane of the project. Construction permitted weekdays from 8:00 a.m. to 8:00 p.m.; Saturdays from 9:00 a.m. to 8:00 p.m.; Sundays and holidays from 10:00 a.m. to 6:00 p.m.
	General	Not more than the noise level standard per land use for more than 30 minutes per hour. Not more than the noise level standard per land use plus 5 dBA for more than 15 minutes per hour. Not more than the noise level standard per land use plus 10 dBA for more than 5 minutes per hour. Not more than the noise level standard per land use plus 15 dBA for more than 1 minute per hour. Not more than the noise level standard per land use or the maximum measured ambient, plus 20 dBA for any period of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels shall be increased in 5 dBA increments above the ambient. Noise level standards for single-family residential land use zones: 50 dBA from 10:00 p.m.to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m. Noise level standards for multi-family residential land use zones: 55 dBA from 10:00 p.m. to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m.
San Bruno	Construction	85 dBA at 100 feet from equipment or project between 7:00 a.m. and 10:00 p.m.; 60 dBA at 100 feet from equipment or project between 10:00 p.m. and 7:00 a.m.
	General	Not more than 10 dBA above the zone ambient base level. Minimum ambient is defined as: 45 dBA from 10:00 p.m. and 7:00 a.m.; 60 dBA from 7:00 a.m. and 10:00 p.m. From 7:00 a.m. to 10:00 p.m., the ambient may be exceeded by 20 dBA for a period of no more than 30 minutes in a 24-hour period.
Millbrae	Construction	Construction permitted weekdays from 7:30 a.m. to 7:00 p.m.; Saturday from 8:00 a.m. to 6:00 p.m.; Sundays and holidays from 9:00 a.m. to 6:00 p.m.
Burlingame	Construction	Construction permitted weekdays from 7:00 a.m. to 7:00 p.m.; Saturday from 9:00 a.m. to 6:00 p.m.; Sundays and holidays from 10:00 a.m. to 6:00 p.m.
	Powered Equipment	Permitted Monday through Saturday from 8:00 a.m. to 7:00 p.m.; Sundays and holidays from 10:00 a.m. to 6:00 p.m.
San Mateo	Construction	90 dBA at 25 feet from individual equipment; 90 dBA at any point outside the property plane of the project. Construction permitted weekdays from 7:00 a.m. to 7:00 p.m.; Saturdays from 8:00 a.m. to 5:00 p.m.; Sundays and holidays from 12:00 p.m.to 4:00 p.m.

Jurisdiction	Noise/ Vibration Source	Maximum Allowable Levels or Exemption
	General	Not more than the noise level standard per land use for more than 30 minutes per hour. Not more than the noise level standard per land use plus 5 dBA for more than 15 minutes per hour. Not more than the noise level standard per land use plus 10 dBA for more than 5 minutes per hour. Not more than the noise level standard per land use plus 15 dBA for more than 1 minute per hour. Not more than the noise level standard per land use or the maximum measured ambient, plus 20 dBA for any period of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient. Noise level standards for single-family residential land use zones: 50 dBA from 10:00 p.m.to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m. Noise level standards for multi-family residential land use zones: 55 dBA from 10:00 p.m.to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m.
Belmont	Construction	Construction permitted weekdays from 8:00 a.m. and 5:00 p.m.; Saturdays from 10:00 a.m. to 5:00 p.m.; prohibited on Sundays and holidays.
	General	Single-family residential zones: 55 dBA nighttime; 65 dBA daytime Daytime defined as weekdays from 7:00 a.m. to 9:00 p.m., and weekends and holidays from 9:00 a.m. to 7:00 p.m. Nighttime defined as any hour outside of daytime hours.
San Carlos	Construction	Construction permitted weekdays from 7:00 a.m. to 6:00 p.m.; weekends and holidays from 9:00 a.m. to 5:00 p.m.
	General	Not more than 10 dBA above ambient at a distance of 49 feet beyond the property line. Minimum allowable ambient is 35 dBA.
Redwood City	Construction	110 dBA at 25 feet from individual equipment; 110 dBA at any point outside the property plane of the project. Construction permitted weekdays from 7:00 a.m. to 8:00 p.m.; prohibited on weekends and holidays.
	General	Not more than 6 dBA above ambient outside the property line from 8:00 p.m. to 8:00 a.m. Minimum ambient is defined as 30 dBA for interior residential noise and 40 dBA in all other locations.

Jurisdiction	Noise/ Vibration Source	Maximum Allowable Levels or Exemption
North Fair Oaks (San Mateo County)	Construction	Construction permitted weekdays from 7:00 a.m. to 6:00 p.m.; Saturdays from 9:00 a.m. to 5:00 p.m.; prohibited on Sundays and holidays.
	General	Exterior noise: Not more than 55 dBA daytime and 50 dBA nighttime for 30 minutes per hour. Not more than 60 dBA daytime and 55 dBA nighttime for 15 minutes per hour. Not more than 65 dBA daytime and 60 dBA nighttime for 5 minutes per hour. Not more than 70 dBA daytime and 65 dBA nighttime for 1 minute per hour. Not more than 75 dBA daytime and 70 dBA nighttime for any length of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient. Interior noise: Not more than 45 dBA daytime and 40 dBA nighttime for 5 minutes per hour. Not more than 50 dBA daytime and 45 dBA nighttime for 1 minute per hour. Not more than 55 dBA daytime and 50 dBA nighttime for any length of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient. Daytime is defined as 7:00 a.m. to 10:00 p.m.; nighttime is 10:00 p.m. to 7:00 a.m.
Atherton	Construction	Construction permitted weekdays from 8:00 a.m. to 5:00 p.m.; prohibited on weekends and holidays.
	General	Not more than 60 dBA from 7:00 a.m. to 10:00 p.m. and 50 dBA from 10:00 p.m.to 7:00 a.m. beyond the property line. If the measured ambient equals or exceeds the noise limit, then the noise limit is 5 dB over ambient.
Menlo Park	Construction	85 dBA at 50 feet from equipment. Construction permitted weekdays between 8:00 a.m. and 6:00 p.m.; prohibited on weekends and holidays.
	General	Not more than 60 dBA from 7:00 a.m. to 10:00 p.m. and 50 dBA from 10:00 p.m. to 7:00 a.m. beyond the property line.
Palo Alto	Construction	110 dBA at 25 feet from individual equipment; 110 dBA at any point outside the property plane of the project. Construction permitted weekdays from 8:00 a.m. to 6:00 p.m.; Saturdays from 9:00 a.m. to 6:00 p.m.; prohibited Sundays and holidays.
	General	Not more than 6 dBA above ambient beyond residential property plane; not more than 8 dBA above ambient beyond commercial or industrial property plane. Minimum ambient is defined as 30 dBA for interior residential noise and 40 dBA in all other locations.
Mountain View	Construction	Construction permitted weekdays from 7:00 a.m. to 6:00 p.m.; prohibited weekends and holidays.
	Stationary	Not more than 55 dBA from 7:00 a.m. to 10:00 p.m.; not more than 50 dBA from 10:00 p.m. to 7:00 a.m. Levels as measured at any location on any receiving residential property.
Sunnyvale	Construction	Construction permitted weekdays from 7:00 a.m. to 6:00 p.m.; Saturdays from 8:00 a.m. to 5:00 p.m.; prohibited on Sundays and national holidays.
	Vibration	Ground vibration not to be perceptible at any point on the property line of the premises without the use of special measuring instrument.

Jurisdiction	Noise/ Vibration Source	Maximum Allowable Levels or Exemption
	General	Not more than 75 dBA at any point on the property line of the premises upon which the noise or sound is generated or produced; not more than 50 dBA during nighttime or 60 dBA during daytime hours at any point on adjacent residentially zoned property. If the noise occurs during nighttime hours and the enforcing officer has determined that the noise involves a steady, audible tone such as a whine, screech or hum, or is a staccato or intermittent noise (e.g., hammering) or includes music or speech, the allowable noise or sound level shall not exceed 45 dBA.
Santa Clara	Construction	Construction permitted weekdays from 7:00 a.m. to 6:00 p.m.; Saturdays from 9:00 a.m. to 6:00 p.m.; prohibited Sundays and holidays. Construction activities are exempt from both noise and vibration limits during allowed hours.
	Vibration	Not to be above the vibration perception threshold of an individual at the closest property line point to the vibration source on the affected property. Vibration perception threshold defined as a motion velocity of 0.01 inch/second over the range of 1 to 100 Hertz.
	Fixed	Single-family residential zone: 50 dBA from 10:00 p.m. to 7:00 a.m.; 55 dBA from 7:00 a.m. to 10:00 p.m. Multi-family residential zone: 50 dBA from 10:00 p.m. to 7:00 a.m.; 55 dBA from 7:00 a.m. to 10:00 p.m. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient.
San Jose	Construction	Construction activities within 500 feet of a residential unit are limited to 7:00 a.m. to 7:00 p.m.
	Vibration	Ground vibration not to be perceptible without the use instruments at the property line of the site.
	General	Not more than 55 dBA at residential property lines; not more than 60 dBA at commercial property lines

3.11.1.2 Environmental Setting

Fundamentals of Environmental Noise and Vibration

Noise and Vibration Terminology

A brief description of noise and vibration concepts and terminology used in this assessment is provided below.

- Sound. A vibratory disturbance transmitted by pressure waves through a medium such as air or water and capable of being detected by a receiving mechanism, such as the human ear or a microphone.
- Noise. Sound that is loud, unpleasant, unexpected, or otherwise undesirable.
- Decibel (dB). A unitless measure of sound on a logarithmic scale, which 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. The dBA scale is the most widely used for environmental noise assessments.
- Maximum Sound Levels (L_{max}). The maximum sound level measured during the measurement period.
- Minimum Sound Levels (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. The 1-hour A-weighted equivalent sound level (L_{eq} 1h) is the energy average of A-weighted sound levels occurring during a 1-hour period.
- 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 between 10 p.m. and 7 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 sound levels occurring during the period from 7 p.m. to 10 p.m. and 10 dB added to the sound levels occurring during the period from 10 p.m. to 7 a.m.
- Vibration Velocity Level (or Vibration Decibel Level, VdB). The root mean square velocity amplitude for measured ground motion expressed in VdB.
- Peak Particle Velocity (PPV). A measurement of ground vibration defined as the maximum speed at which a particle in the ground is moving, expressed in inches per second (in/sec).

Overview of Sound and Noise

Noise is typically described as unwanted sound. Sound is caused by transmission of mechanical energy that propagates as waves of alternating pressure through a medium (fluids, solids, or gases such as the air) to a hearing organ, such as a human ear. Sound (or noise) is commonly discussed in terms of a source, a receiver, and the propagation path between the two. Figure 3.11-1 illustrates a typical source-path-receiver scenario for airborne sound from rail transit. Several factors affect the quality of sound as perceived by the human ear. Sound can be further described in terms of intensity, pitch, and time variation.

The intensity of a sound is determined by the fluctuation in air pressure above and below the atmospheric pressure at equilibrium by sound waves. Sound intensity is usually expressed in terms of the sound pressure level (L_p) in decibel (dB) units. Decibels are logarithmic values of the ratio of the pressure produced by the sound wave to a reference pressure, calculated as:

$$L_p = 20 \times \log_{10}(p/p_{ref}), \text{ dB}$$

where “p” is the root-mean-square (RMS) pressure and “p_{ref}” is the reference pressure[1].

Decibels are used instead of actual pressure units to account for the extremely large range of sound pressure values that the human ear is capable of perceiving. For example, a train horn noise of 100

[1] The standard reference sound pressure is 20 micro-Pascal as indicated in ANSI S1.8-1969, *Preferred Reference Quantities for Acoustical Levels*.

dB has about 5,600 times greater pressure than a very low sound of 35 dB typically found in a rural environment.

Sound attenuates as a function of the distance between the source and the receiver due to geometric spreading. Geometric spreading loss is due to energy dissipation into three dimensions as sound travels through the air and the wave energy is spread out over an increasingly large area. For point sources, such as stationary equipment or other closely grouped sources, the sound level attenuates at a rate of 6 dB per doubling of distance. For line sources, the sound level will attenuate at 3 dB per doubling of distance. The time-averaged sound level from train vehicles passing along a track will attenuate at a rate of 3 dB per doubling of distance because of the linear nature of the moving source when averaged over time.

In addition to geometric spreading due to distance, sound levels are further attenuated due to ground effects, shielding by structures, or atmospheric absorption. Other atmospheric conditions, such as wind and temperature gradients, can influence the direction of the sound waves as they travel through the air. Atmospheric effects are not normally included in the modeling of rail transit noise because the effects are generally significant only at long distances beyond the potential noise impact areas for rail transit corridors.

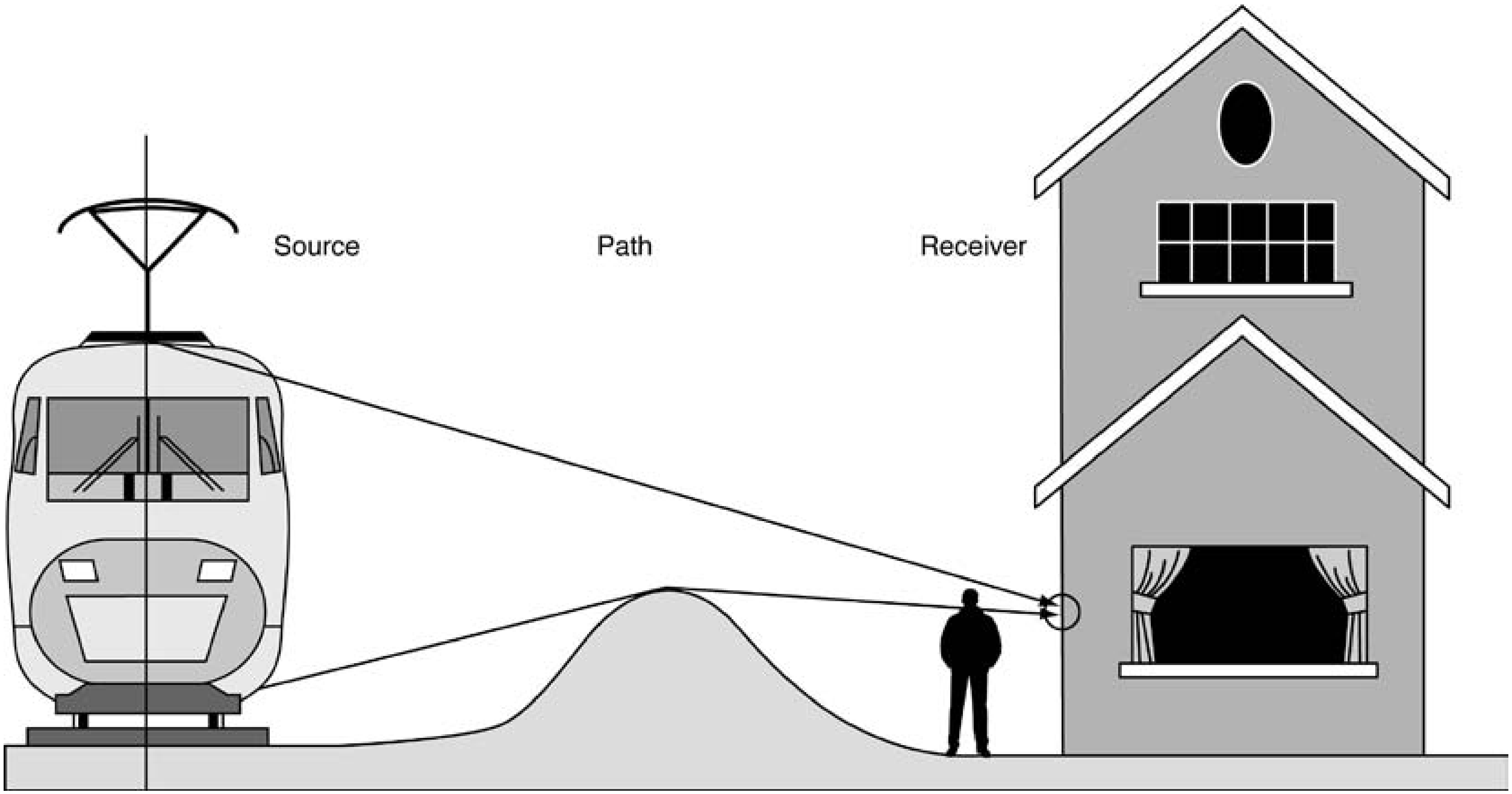
The pitch describes the character and frequency content of noise. It is expressed in terms of the rate of fluctuation of the air pressure in cycles per second or Hertz (Hz). The average human ear is sensitive to noise frequencies between 20 Hz and 20,000 Hz. However, the human hearing system does not respond equally to all frequencies, and it is more sensitive to midband frequencies (e.g., 500 to 2,000 Hz). Thus, the A-weighting system de-emphasizes the low and very high frequency components of the sound in a manner similar to the response of the average human ear. The A-weighted sound level (dBA) is commonly used to quantify environmental noise because it correlates well with human response and is expressed in terms of a single number. Figure 3.11-2 provides a comparison of noise levels of transit and non-transit sources. This figure also provides typical noise levels found in urban settings.

Environmental noise commonly varies with time. There are several descriptors to characterize environmental noise according to their duration. The equivalent noise level (Leq) is the logarithmic (or energy) summation over a period of interest, and it is widely used as a single-number descriptor of environmental noise. Common usages of the Leq are the Day-Night Sound Level (Ldn) and community noise equivalent level (CNEL). Many studies have shown that the Ldn is well-correlated with human annoyance for community noise. The noise metrics CNEL and Ldn are typically equal or differ by no more than 1 decibel. The Ldn descriptor will be used in this report to assess 24-hour noise, except where CNEL is used in local ordinances.

Overview of Ground-Borne Noise and Vibration

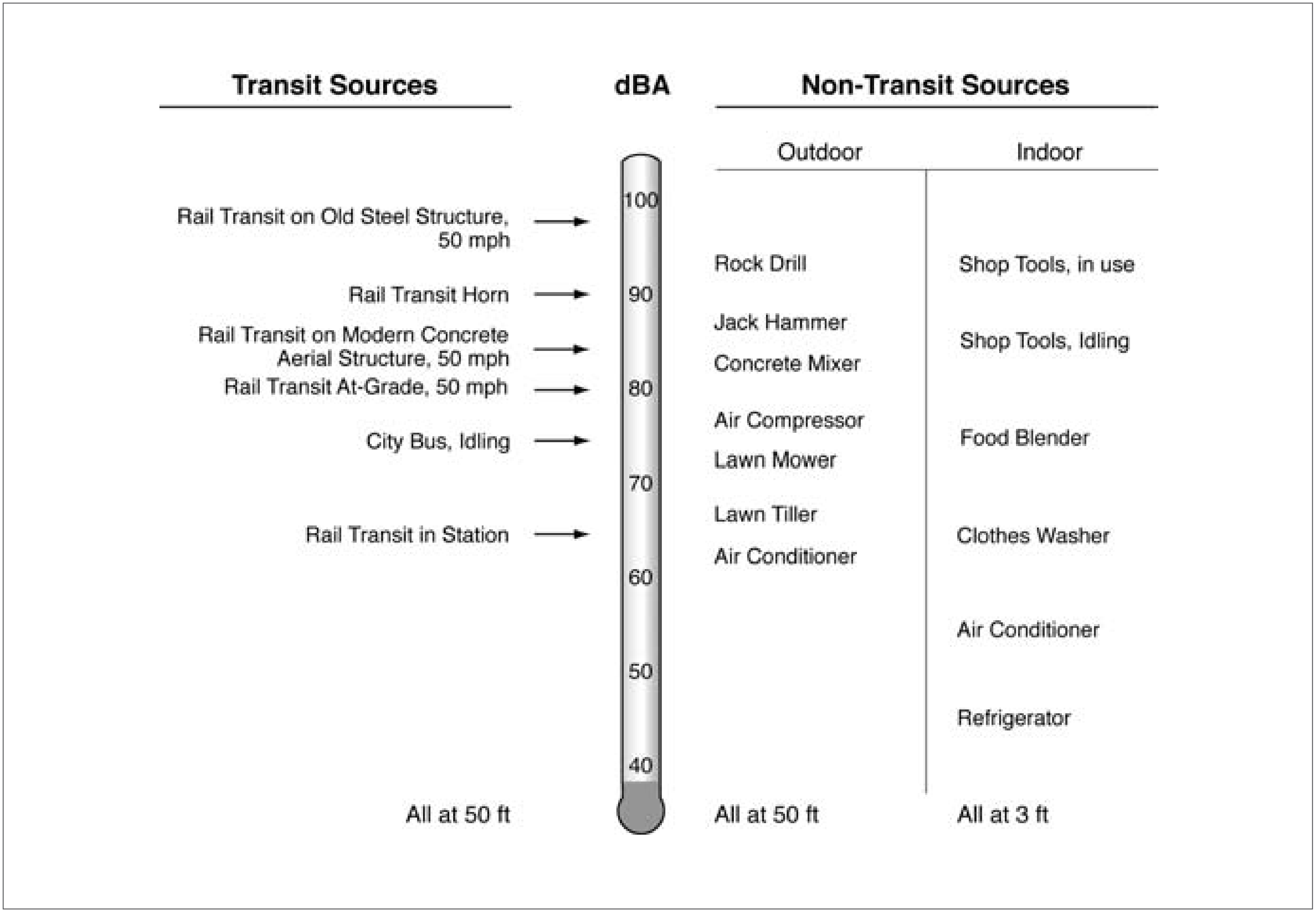
Ground vibration is an oscillatory motion of the soil with respect to the equilibrium position and can be quantified in terms of displacement, velocity, or acceleration. Vibration can be described by its peak or RMS amplitudes. The RMS amplitude is useful for assessing human annoyance, while peak vibration is most often used for assessing the potential for damage to building structures. Construction vibration is assessed in terms of peak velocity, or peak particle velocity (PPV).

Although vibration velocity can be quantified in units of inches per second, it is common to use the velocity level to quantify vibration to cover the wide range of magnitudes that can be encountered. The vibration is expressed in terms of the velocity level (L_v) in decibel units, defined as:



Source: Federal Railroad Administration 2012.

Figure 3.11-1
Source-Path-Receiver Framework for Airborne Wayside Noise
Peninsula Corridor Electrification Project



Source: Federal Transit Administration 2006.

Figure 3.11-2
Typical A-Weighted Sound Levels from Transit and Non-Transit Sources
Peninsula Corridor Electrification Project

$$L_v = 20 \times \log_{10}(v/v_{ref}), \text{VdB}$$

where "v" is the RMS velocity amplitude and "v_{ref}" is the reference velocity amplitude[2].

Thus, the descriptor used in this report to assess ground-borne vibration for human annoyance is the L_v in decibels or VdB. Vibration is a function of the frequency of motion measured in cycles/second or Hz. Ground vibration of concern for transportation sources generally spans from 4 Hz to 60 Hz. The overall vibration is the combined energy of ground motion at all frequencies, and this overall vibration level is used in this analysis.

Vibration attenuates as a function of the distance between the source and the receiver due to geometric spreading and inherent damping in the soil that absorbs energy of the ground motion. Ground-borne vibration from rail transit systems is caused by dynamic forces at the wheel/rail interface. It is influenced by many factors, which include the rail and wheel roughness, out-of-round wheel conditions, the mass and stiffness of the rail vehicle truck, the mass and stiffness characteristics of the track support system, and the local soil conditions.

Vibration caused by the transit structure, such as at-grade ballast and tie track, radiates energy into the adjacent soil in the form of different types of waves[3] that propagate through the various soil and rock strata to the foundation of nearby buildings. Buildings respond differently to ground vibration depending on the type of foundation, the mass of the building, and the building interaction with the soil. Once inside the building, vibration propagates throughout the building with some attenuation with distance from the foundation, but often with amplification due to floor resonances. The basic concepts for ground vibration generated by a rail system are illustrated in Figure 3.11-3.

Figure 3.11-4 illustrates the typical levels of human response and, at much higher levels, the structural response to ground-borne vibration. The figure shows that the threshold of human perception is about 65 VdB, while the threshold for "cosmetic" structural damage is about 100 VdB (re: 1 micro-in/sec). However, the latter threshold, building damage, is directly related to the condition of the structure. It is very rare that transportation-generated ground vibration approaches building damage levels.

Ground-borne noise is a secondary phenomenon of ground-borne vibration. When a building structure vibrates, noise is radiated into the interior of the building. Typically, this is a low frequency sound that would be perceived as a low rumble. The magnitude of the sound depends on the frequency characteristic of the vibration and the manner in which the room surfaces in the building radiate sound. Ground-borne noise is quantified by the A-weighted sound level inside the building.

Existing Ambient Noise

The study area included the Caltrain ROW and the adjacent areas in which noise sensitive receptors may be locations. Noise sensitive receptors in the study area include residential areas, schools, and

[2] The standard reference quantity for vibration velocity used by FTA is 1×10^{-6} inches/second, or 1 micro-inch/second.

[3] These waves include shear (also known as S, secondary or transverse) in which the ground moves perpendicularly with respect to the direction of vibration movement, and Rayleigh (also known as ground roll) surface waves which move primarily along the surface of the ground, similar in appearance to ripples on the water surface.

hospitals. Noise sensitive receptors are located at distances that are as close as 40 feet from the Caltrain ROW

The existing ambient noise in the Caltrain corridor primarily comes from noise from the Caltrain rail and freight rail service, BART, traffic on main highways and major arterials, and from aircraft flyover noise while aircraft land at and take off from nearby airports, specifically, San Francisco International Airport (SFO), San Carlos Airport, Palo Alto Airport, and Mineta San Jose International Airport.

In areas of the corridor that have grade crossings, the existing ambient noise is influenced to a large degree by Caltrain and freight train warning horn noise. Horn noise can be heard at great distances from the rail alignment, depending on geographical characteristics, meteorological conditions and other factors. However, the area over which train horn noise generally has an impact is normally limited to 0.25-mile in each direction from the grade crossing.

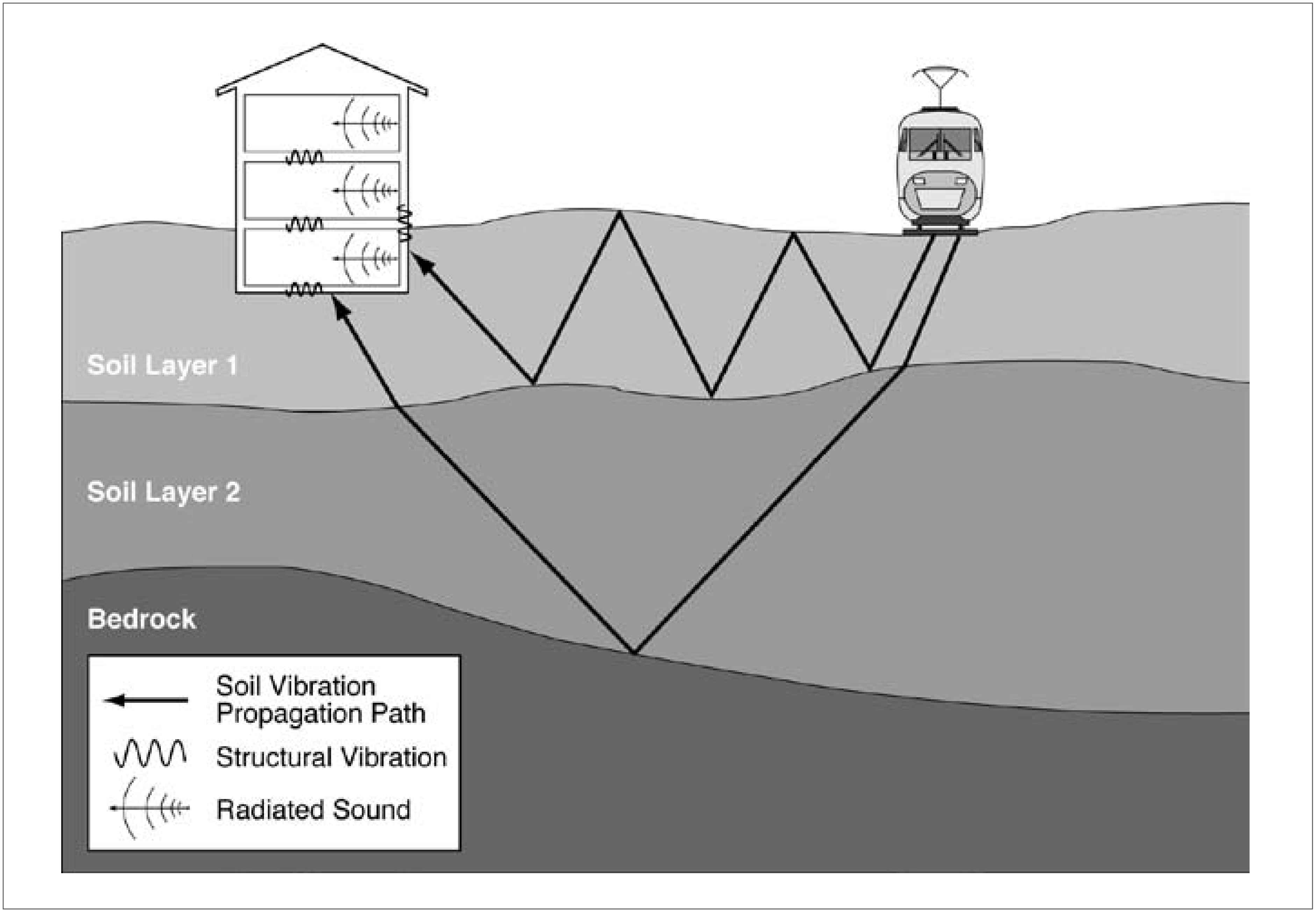
Field Measurements

To characterize the existing ambient noise along the Caltrain alignment, Wilson, Ihrig and Associates (WIA) conducted long-term noise measurements from May 17, 2013 to May 27, 2013 at 12 sites and updated the 2001 and 2002 measurement data conducted for the prior Project EIR/EA for Caltrain Electrification (JPB 2009). The 2013 noise measurement results are summarized in Table 3.11-2.

In addition, WIA previously conducted an extensive noise survey along the Caltrain alignment for the California high-speed rail (HSR) project (Wilson, Ihrig and Associates 2010). The survey included long-term noise measurements of 1 to 3 days at 35 sites from October 16, 2009 to December 2, 2009 and at additional 19 locations from March 4, 2010 to March 12, 2010. These measurements were taken within the Caltrain corridor and are relatively recent, and, thus, are suitable for this analysis. The measurement results for the HSR project are summarized in Table 3.11-3.

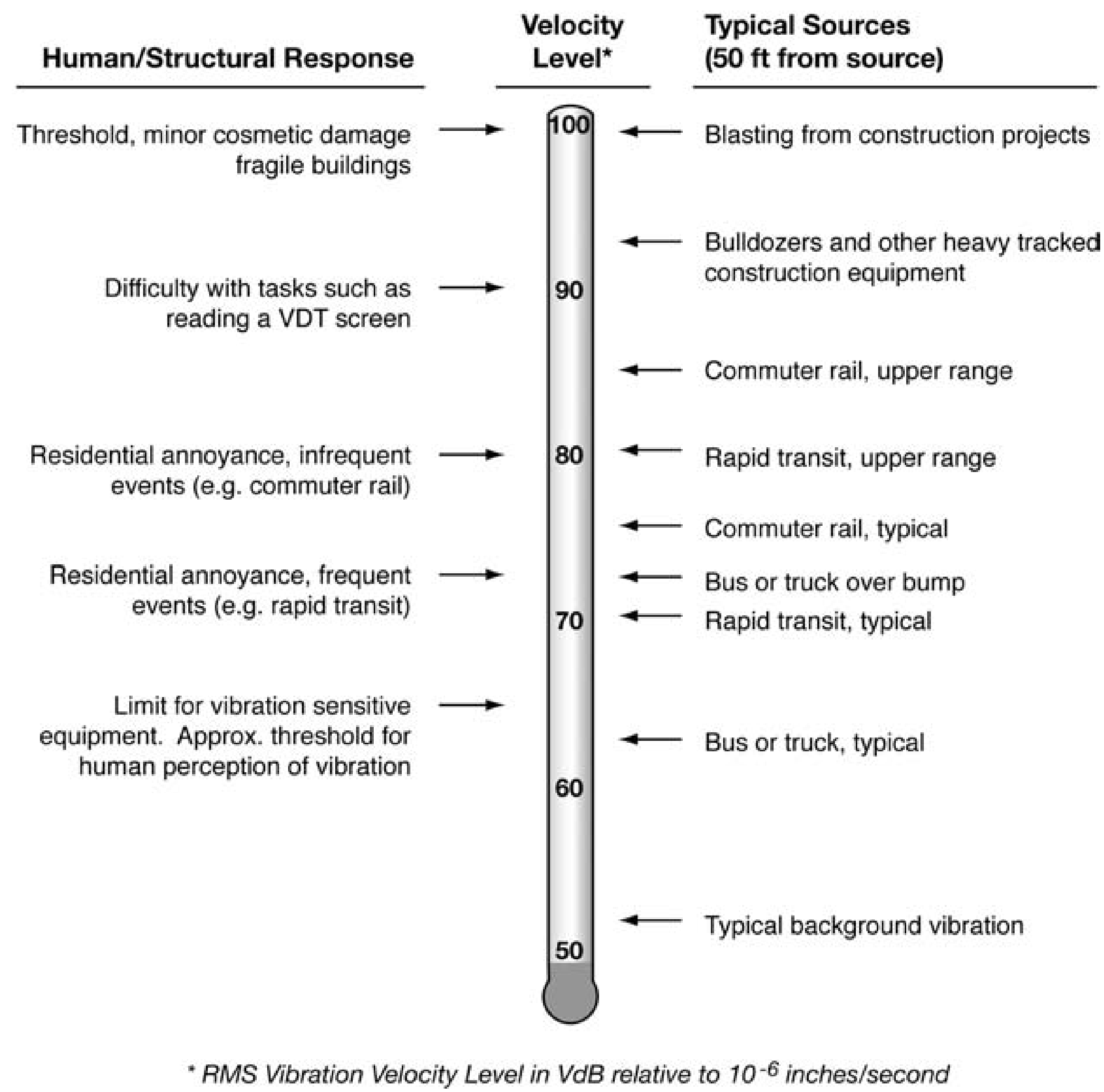
The long-term noise measurements collected the ambient noise levels for consecutive 1-hour intervals. The L_{max}, L_{min}, and L_{eq} were obtained for each 1-hour interval. The L_{eq} levels were used to calculate the L_{dn} over each 24-hour period measured. The L_{dn} describes the energy averaged noise exposure over a 24-hour period and it is the noise metric used for residential land uses. The hourly L_{eq} is based on the daytime hour with the loudest L_{eq}. This hour is generally referred to as the peak hour, which could occur at different times of the day depending on whether the noise source is from train operations or automobile traffic. The L_{eq} is used as the metric for evaluating noise impacts on institutional land uses with primarily daytime use.

The results of the existing ambient noise surveys are discussed in the following section. Tables 3.11-2 and 3.11-3 show the noise measurement results for the 2013 and 2009–2010 noise surveys, respectively. Figure 3.11-5 depicts measurement locations.



Source: Federal Railroad Administration 2012.

Figure 3.11-3
Propagation of Ground-Borne Vibration into Buildings
Peninsula Corridor Electrification Project



Source: Federal Transit Administration 2006.

Figure 3.11-4
Typical Levels of Ground-Borne Vibration
Peninsula Corridor Electrification Project

Table 3.11-2. Summary of 2013 Ambient Noise Measurement Locations and Noise Levels

County	Site No.	Address	Land Use	Distance[a] (feet)	Date Surveyed	Average L_{eq}[b] (dBA)	Average L_{dn}[c] (dBA)
San Mateo	R5[d]	1289 Herman Street, San Bruno	Residential	85	5/17/13 – 5/24/13	78	78
	R7[d]	847 Huntington Avenue, San Bruno	Residential	100	5/17/13 – 5/24/13	75	74
	R12	20 Hillcrest Boulevard, Millbrae	Residential	244	5/17/13 – 5/27/13	65	63
	R14	1457 California Drive, Burlingame	Residential	155	5/17/13 – 5/27/13	72	71
	R18[e]	142 N. Railroad Avenue, San Mateo	Residential	40	5/17/13 – 5/27/13	76	74
	R22	102 Blossom Circle, San Mateo	Residential	128	5/17/13 – 5/27/13	71	70
	R27	198 Buckingham Avenue, Redwood City	Residential	50–70	5/17/13 – 5/25/13	72	71
Santa Clara	R34	Peers Park, Palo Alto	Residential	40	5/17/13 – 5/25/13	73	71
	R36[d]	4201 Park Boulevard, Palo Alto	Residential	35	5/17/13 – 5/25/13	81	80
	R44[e]	3585 Agate Street, Santa Clara	Residential	130	5/17/13 – 5/27/13	69	69
	R48[d]	782 Auzerais Avenue, San Jose	Residential	45	5/17/13 – 5/27/13	83	82
	R49	748 Illinois Avenue, San Jose	Residential	50	5/17/13 – 5/27/13	71	71

[a] Approximate distance from near track.

[b] Arithmetic average of weekday peak hour L_{eq} levels for 5 days: Monday (5/20/13) through Friday (5/24/13).

[c] Arithmetic average of weekday L_{dn} levels for 5 days: Monday (5/20/13) through Friday (5/24/13).

[d] R5, R7, R36 and R48 are within 0.25 mile of at-grade crossings.

[e] R18 and R44 are near stations.

Source: Wilson, Ihrig and Associates 2013.

1 **Table 3.11-3. Summary of 2009-2010 Ambient Noise Measurement Locations and Noise Levels**

County	Site No.	Address	Land Use	Distance[a] (feet)	Date Surveyed	Average L_{eq}[b] (dBA)	Average L_{dn}[c] (dBA)
San Francisco	N34[d, e]	431 Pennsylvania Avenue, San Francisco	Residential	160	11/06/09 – 11/10/09	71	65
	N35[e]	1174 22nd Street, San Francisco	Residential	75	11/30/09 – 12/02/09	74	74
	N33[d]	48 Reddy Street, San Francisco	Residential	170	11/06/09 – 11/10/09	64	64
	N55[d]	88 Kalmanovitz, San Francisco	Residential	165	06/14/10 – 06/15/10	62	64
	N32	48 Gould Street, San Francisco	Residential	135	06/14/10 – 06/15/10	69	68
	N31[e]	327 Tunnel Avenue, San Francisco	Residential / Church	70	11/06/09 – 11/10/09	72	71
San Mateo	N30	42 San Francisco Avenue, Brisbane	Residential	410	11/06/09 – 11/10/09	77	75
	N29	50 Joy Avenue, Brisbane	Residential	930	11/03/09 – 11/05/09	71	76
	N54	1300 Veterans Boulevard, South San Francisco	Hotel	100	03/09/10 – 03/10/10	72	77
	N28[d]	242 Village Way, South San Francisco	Residential	400	11/03/09 – 11/05/09	79	77
	N27[f]	1209 Herman Street, San Bruno	Residential	80	11/03/09 – 11/05/09	75	76
	N53[f]	576 First Avenue, San Bruno	Residential	80	03/09/10 – 03/12/10	69	75
	N26[e]	265 San Luis Avenue, San Bruno	Residential	180	11/03/09 – 11/05/09	68	68
	N52	1036 San Antonio Avenue, Millbrae	School	115	03/09/10 – 03/12/10	64	70
	N25[f]	254 Monterey Street, Millbrae	Residential	150	11/03/09 – 11/05/09	71	71
	N51[e]	150 Serra Avenue, Millbrae	Hospital	70	03/09/10 – 03/12/10	68	73
	N50	1710 California Drive, Burlingame	Hospital / Residential	140	03/09/10 – 03/12/10	63	68
	N49[e, f]	966 California Drive, Burlingame	School	145	03/09/10 – 03/12/10	71	74
	N22[e]	815 Carolan Avenue, Burlingame	Residential	145	10/30/09 – 11/02/09	74	71
	N21[e, f]	396 Catalpa Street, San Mateo	Residential	50	10/30/09 – 11/02/09	71	69
	N20	1416 South Railroad Ave, San Mateo	Residential	95	10/30/09 – 11/02/09	71	67

County	Site No.	Address	Land Use	Distance[a] (feet)	Date Surveyed	Average L_{eq}[b] (dBA)	Average L_{dn}[c] (dBA)
San Mateo (Cont)	N19	8 Antioch Drive, San Mateo	Residential	90	10/28/09 – 10/29/09	73	73
	N18[d, e]	792 Old Country Road, Belmont	Residential	120	10/28/09 – 10/29/09	74	73
	N17[e]	1088 Sylvan Drive, San Carlos	Residential	85	10/28/09 – 10/29/09	69	70
	N48	1552 West el Camino Real, San Carlos	Hotel	175	03/09/10 – 03/12/10	70	73
	N16[f]	1840 Stafford Street, San Carlos	Residential	80	10/28/09 – 10/29/09	75	73
	N15[e, f]	100-198 Winklebleck Street, Redwood City	Commercial	245	10/28/09 – 10/29/09	69	69
	N47[f]	631 Pennsylvania Ave, Redwood City	Residential	40	03/09/10 – 03/12/10	73	77
	N14	200 Berkshire Avenue, Redwood City	Residential	40 – 55	10/23/09 – 10/27/09	70	72
	N13[f]	1601 Stone Pine Lane, Menlo Park	Residential	35	10/23/09 – 10/27/09	76	70
	N46[e, f]	1128 Merrill Street, Menlo Park	Commercial	105	03/09/10 – 03/12/10	66	72
	N45[f]	638 Alma Street, Menlo Park	Park	130	03/05/10 – 03/08/10	65	68
	N12	248 Alma Street, Menlo Park	Residential	135	10/23/09 – 10/27/09	71	66
	N44[f]	118 West El Camino Real, Menlo Park	Hotel	60	03/05/10 – 03/08/10	66	70
Santa Clara	N43	Lucas Lane and Encina Avenue, Palo Alto	Hospital	35	03/05/10 – 03/08/10	67	72
	N42	Lucas Lane and Embarcadero Road, Palo Alto	School	35	03/05/10 – 03/08/10	70	74
	N11[d, f]	1528 Mariposa Avenue, Palo Alto	Residential	180	10/23/09 – 10/27/09	62	61
	N10	3040 Alma Street, Palo Alto	Residential	120	10/23/09 – 10/27/09	78	77
	N41[d, f]	4116 Park Boulevard, Palo Alto	Residential	190	03/05/10 – 03/08/10	57	62
	N40[e]	4243 Alma Street, Palo Alto	Church	125	03/09/10 – 03/12/10	72	75
	N9[f]	2358 Central Expressway, Mountain View	Residential	135	10/20/09 – 10/21/09	76	75

County	Site No.	Address	Land Use	Distance[a] (feet)	Date Surveyed	Average L_{eq}[b] (dBA)	Average L_{dn}[c] (dBA)
Santa Clara (Cont)	N8[e, f]	112 Horizon Avenue, Mountain View	Residential	285	10/20/09 – 10/21/09	71	71
	N39	Central Expressway and Whisman Station Drive, Mountain View	Residential	185	03/05/10 – 03/08/10	69	71
	N7[d, f]	981 Asilomar Terrace, Sunnyvale	Residential	90	10/20/09 – 10/21/09	69	66
	N6	110 Waverly Street, Sunnyvale	Residential	100	10/20/09 – 10/21/09	71	70
	N38[e, f]	111 West Evelyn Avenue, Sunnyvale	Commercial	85	03/05/10 – 03/08/10	72	76
	N5	Evelyn Terrace, Santa Clara	Residential	35 – 50	10/16/09 – 10/19/09	72	72
	N4[d]	2790 Agate Drive, Santa Clara	Residential	160 – 175	10/16/09 – 10/19/09	64	63
	N37	2400 Walsh Avenue, Santa Clara	School	220	03/05/10 – 03/08/10	60	64
	N3[d]	2079 Main Street, Santa Clara	Residential	140	10/16/09 – 10/19/09	64	63
	N2	1315 De Altura Commons, San Jose	Residential	95 – 115	10/16/09 – 10/19/09	67	65
	N36[e]	726 Emory Street, San Jose	School	430 – 450	03/05/10 – 03/08/10	61	64
	N1[e]	102 Laurel Grove Lane, San Jose.	Residential	125	10/20/09 – 10/21/09	70	72

[a] Approximate distance from near track. Range of distance shown where there are more than 2 tracks.
[b] Arithmetic average of weekday peak hour L_{eq} levels (2 days).
[c] Arithmetic average of weekday L_{dn} levels (2 days).
[d] N34, N33, N55, N28, N18, N11, N41, N7 (partially), N4, and N3 acoustically shielded from direct Caltrain noise exposure.
[e] N34, N35, N31, N26, N51, N49, N21, N18, N17, N15, N46, N40, N8, N38, N36, and N1 near stations.
[f] N27, N53, N25, N49, N22, N21, N16, N15, N47, N13, N46, N45, N44, N11, N41, N9, N8, N7, and N38 within 0.25 mile of at-grade crossings.
Source: Wilson, Ihrig and Associates 2010.

Existing Noise Levels

San Francisco

Existing noise levels were characterized at six locations in the vicinity of the Caltrain corridor as part of the 2009–2010 survey: N34, N35, N33, N55, N32, and N31 for the HSR project. The ambient condition corresponds to that of an urban setting. Sources of ambient noise are Caltrain trains, freight trains, vehicles on I-280 and U.S. 101, and local motor vehicle traffic. The average L_{dn} ranged from 64 dBA to 74 dBA depending on the location. The peak hour L_{eq} levels ranged from 62 dBA to 74 dBA.

At location N33, the peak hour L_{eq} was relatively low at 64 dBA primarily due to the existing intervening structures between the Caltrain ROW and homes that provides noise shielding and the distance from main arterials or freeways. A similar situation was observed for receptors near N55 because of the shielding provided by storage buildings located next to the rail alignment.

No noise measurements were conducted during 2013 in San Francisco.

San Mateo County

Noise levels were measured near four receptor sites in 2013 from San Bruno to Burlingame: R5, R7, R12, and R14. The average L_{dn} noise levels ranged from 63 dBA to 78 dBA. The peak hour L_{eq} levels ranged from 65 dBA and 78 dBA. Relatively lower levels (63 dBA L_{dn} and 65 dBA peak hour L_{eq}) were obtained at location R12, which is approximately 245 feet west of the southbound Caltrain track and situated behind the first row of homes along Hemlock Avenue.

From San Mateo to Redwood City, noise levels were measured near three receptor sites in 2013: R18, R22, and R27. The average L_{dn} noise levels ranged from 70 dBA to 74 dBA and the peak hour L_{eq} levels ranged from 71 dBA to 76 dBA.

Noise measurements were obtained at 28 locations within San Mateo County as part of the 2009–2010 survey: N30, N29, N54, N28, N27, N53, N26, N52, N25, N51, N50, N49, N22, N21, N20, N19, N18, N17, N48, N16, N15, N47, N14, N13, N46, N45, N12, and N44. The average L_{dn} varied from 66 dBA to 77 dBA depending on location, distance from the alignment, proximity to grade crossings and other noise sources. Peak hour L_{eq} levels ranged from 64 dBA to 79 dBA.

N54 and N28 are near U.S. 101 in South San Francisco and is where the highest L_{dn} level of 77 dBA was recorded. Similarly, 77 dBA L_{dn} level was measured at location N47. The higher noise levels at N47 are attributed to the proximity of the location to the Chestnut Street at-grade rail crossing and, therefore, to train horn and roadway noise at this location.

Airport noise from SFO is also a dominant contributor to the existing ambient noise environment in areas of South San Francisco, San Bruno, and Millbrae, particularly in the areas within the flight path of aircraft departing from runways 28L and 28R (heading northwest). According to the SFO noise contour map contained in the *San Bruno General Plan* (City of San Bruno 2009), noise sensitive receptors located within the 65 dBA CNEL contour (near the airport and flight path) are currently exposed to noise levels from railroad and other sources that exceed 65 dBA CNEL. For example, measurements taken at N27 and N53 resulted in L_{dn} levels of 76 dBA and 75 dBA, respectively. The noise metrics CNEL and L_{dn} are typically equal or differ by no more than 1 dB. Receptors located in Millbrae and within the Caltrain corridor are located outside the 65 dB CNEL contour, but within the area that is exposed to noise from SFO operations between 55 and 60 dB CNEL.

Santa Clara County

Noise levels were measured near five receptor sites in 2013 from Palo Alto to San Jose: R34, R36, R44, R48, and R49. The average L_{dn} noise level ranged from 69 dBA to 82 dBA and peak hour L_{eq} noise levels ranged from 69 to 83 dBA. R36 and R48 are near at-grade rail crossings and the noise levels in excess of 80 dBA for both the L_{dn} and peak hour L_{eq} are attributed to the influence of noise from train warning horns and crossing bells.

Noise measurements were obtained at nineteen locations within Santa Clara County as part of the 2009–2010 survey: N43, N42, N11, N10, N41, N40, N9, N8, N39, N7, N6, N38, N5, N4, N37, N3, N2, N36, and N1. The average L_{dn} varied from 61 dBA to 77 dBA depending on location, distance from the alignment, proximity to at-grade crossings and other noise sources. Peak hour L_{eq} levels ranged from 60 dBA to 78 dBA. The average L_{dn} levels obtained at N11 and N41 were 61 dBA and 62 dBA, respectively. The average L_{dn} obtained at both N4 and N3 was 63 dBA. N11, N41, N4, and N3 measurement locations are representative of the existing ambient noise for single-family residences located on the western side of the Caltrain alignment. However, because noise measurements were obtained in front of the homes (whereas Caltrain noise affects the back of homes) adjustments to the measured noise level are applied in this analysis to determine the noise exposure at the back of the properties.

Existing Ambient Vibration

The existing ambient vibration in the corridor is largely the result of vibration from the Caltrain rail and freight rail service, and, to a much lesser extent, from traffic on nearby streets. Currently, freight trains operate approximately between 8 p.m. and 5 a.m[4]. with very limited frequency. The effect of these infrequent freight operations on the ambient vibration is relatively insignificant in comparison with the effect of 92 Caltrain trains per day serving the corridor.

Field Measurements

To address the existing ambient vibration levels in the Caltrain corridor, WIA conducted measurements of the prevailing ground-borne vibration at numerous locations along the corridor. Measurements of the existing vibration levels were performed at nine sites along the Caltrain alignment. The nine chosen sites are roughly the same sites where vibration measurements were performed for the prior Caltrain electrification Project EIR/EA in 2001 and 2002 (JPB 2009). Because Caltrain trains are the dominant source of ground vibration, the vibration survey focused on obtaining ground vibration during Caltrain passbys at a typical setback distance between sensitive receptors and the nearest track. Measurements of at least 12 Caltrain train passbys were recorded at different locations. For each site, train vibration was measured at various distances from the rail alignment. Table 3.11-4 summarizes vibration measurement locations and ground-borne vibration levels at theses measurement locations.

In addition, WIA previously conducted an extensive vibration survey along the Caltrain alignment for the HSR project (Wilson, Ihrig and Associates 2010). The 2010 vibration survey included measurements at 22 sites along the Caltrain alignment from October 2009 to March 2010. At each site, measurements of at least three Caltrain train passbys were recorded at two varying distances from the rail alignment. The results of this survey are summarized in Table 3.11-5. Figure 3.11-5 depicts measurement locations.

Results of the ambient vibration survey provide not only an indicator of the existing overall vibration levels throughout the Caltrain corridor. Also, because the vibration source (Caltrain) is similar throughout the corridor, the results also indicate the degree of variability in soil vibration characteristics along the alignment. The results of the existing ambient vibration surveys are discussed in the following section.

[4] Occasionally, freight trains may operate during off-peak hours in the middle of the day, but routine operations are between 8 p.m. and 5 a.m. at present.

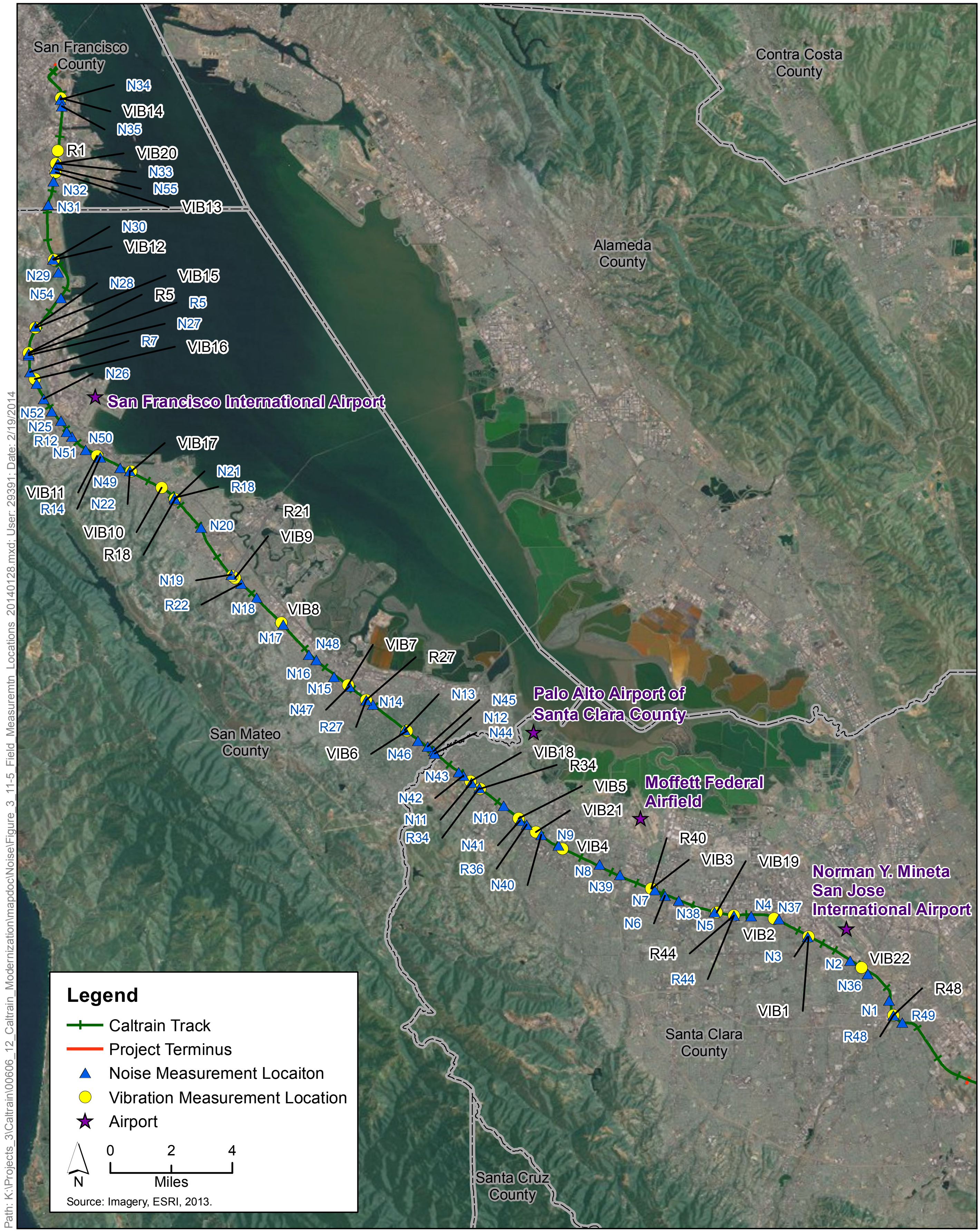


Figure 3.11-5
Overview Map of All Field Measurement Locations
Peninsula Corridor Electrification Project

Table 3.11-4. Summary of 2013 Vibration Measurement Locations and Ground-Borne Vibration Levels

County	Site No.	Address	Date	Distance from outermost track centerline[a] (feet)	Vibration Velocity[b] (VdB)	Source[c]	Train speed (mph)
San Francisco	R1	1831 Palou Avenue, San Francisco	5/30/13	0[d]	68	Caltrain	63–71
				14	71	Caltrain	61–79
				35	71	Caltrain	63–73
				49	73	Caltrain	61–79
				75	71	Caltrain	63–73
				89	72	Caltrain	61–79
				150	71	Caltrain	61–73
				164	72	Caltrain	61–79
San Mateo	R5	1289 Herman Street, San Bruno	5/23/13	40	75	Caltrain	56–77
				55	74	Caltrain	57–65
				100	70	Caltrain	56–77
				115	71	Caltrain	57–65
				150	65	Caltrain	56–77
				165	68	Caltrain	57–65
				200	65	Caltrain	56–77
				215	65	Caltrain	57–65
	R18	140 N. Railroad Avenue, San Mateo	5/24/13	35	83 79	Caltrain	75–77 35–48
				50	76-77 73 67	Caltrain Caltrain BB only	75–77 25 24–25
				55	73 71	Caltrain	76 35–48
				70	70 66 62	Caltrain Caltrain BB only	75 25 24–25
				100	70 64	Caltrain	75–77 35–48
				115	67 62 58	Caltrain Caltrain BB only	75 25 24–25
				200	60-61 52	Caltrain	75–77 35–48
				215	58 50 49	Caltrain Caltrain BB only	75 25 24–25
San Mateo (Cont)	R21	2 Antioch Drive, San Mateo	5/28/13	35	80 78 72	Caltrain Caltrain BB only	74–76 42–54 50–55
				49	77 74 70	Caltrain Caltrain BB only	70 40–45 41–45
				75	74 70 67	Caltrain Caltrain BB only	74–76 42–54 50–55

County	Site No.	Address	Date	Distance from outermost track centerline[a] (feet)	Vibration Velocity[b] (VdB)	Source[c]	Train speed (mph)
				89	67 66 61	Caltrain Caltrain BB only	70 40–45 41–45
				150	61 58 57	Caltrain Caltrain BB only	74–76 42–54 50–55
				164	61 56 54	Caltrain Caltrain BB only	70 40–42 41–45
				200	60 54 54	Caltrain Caltrain BB only	74–76 42–54 50–55
				214	58 52 52	Caltrain Caltrain BB only	70 40–42 41–45
	R27	198 Buckingham Avenue, Redwood City	5/24/13	23	83 80	Caltrain	73–79 60–65
				52	77	Caltrain	73–79
				53	74 71	Caltrain	73–79 60–65
				82	71	Caltrain	73–79
				93	68 65	Caltrain	73–79 60–65
				122	67	Caltrain	73–79
				193	60 57	Caltrain	73–79 60–65
				222	59	Caltrain	73–79
Santa Clara	R34	Peers Park, Palo Alto	5/30/13	28	77 76 73	Caltrain	72 41–48 58
				42	77 72	Caltrain	72 32–36
				53	74 73 72	Caltrain	72 41–48 58
				67	73 66	Caltrain	72 32–36
				103	66 65 63	Caltrain	72 58 41

County	Site No.	Address	Date	Distance from outermost track centerline[a] (feet)	Vibration Velocity[b] (VdB)	Source[c]	Train speed (mph)
Santa Clara (Cont)				117	67 60	Caltrain	72 32
				203	63 62 60	Caltrain	58 72 41
				217	56	Caltrain	32
	R40	125 N Mary Avenue, Sunnyvale	6/5/13	50	77 74 73	Caltrain Caltrain BB only	77–80 51–56 69–75
				65	74	Caltrain	65–70
				100	72 70 67	Caltrain BB only Caltrain	77–80 6975 51-56
				115	70 69	BB only Caltrain	75 65–70
				150	70 68 63	Caltrain BB only Caltrain	77–80 69–75 51–56
				165	69 67	BB only Caltrain	75 65–70
				200	68 67 62	Caltrain BB only Caltrain	77–80 69–75 51–56
				215	68 65	BB only Caltrain	75 65–70
	R44	3529 Agate Street, Santa Clara	5/28/13	27	82	Caltrain	79
				41	79	Caltrain	74–81
				53	79	Caltrain	74–81
				63	77	Caltrain	77–82
				85	75	Caltrain	78–82
				111	73	Caltrain	74–81
				133	73	Caltrain	75–82
				185	67	Caltrain	74–82
	R48	782 Auzerais Avenue, San Jose	5/29/13	25	89	Caltrain	25–39
				39	80 68	Caltrain BB only	15–25 14–20
				50	76	Caltrain	25–39
				64	71 62	Caltrain BB only	15–25 14–20
				100	69	Caltrain	25–39
				114	65 58	Caltrain BB only	15–25 14–20
				200	61	Caltrain	25–39
				214	58	Caltrain	15–25

[a] Approximate horizontal distance to the outermost respective track centerline for each group of passbys.
[b] Vibration levels with respect to 1 μ-inch/sec.
[c] "Caltrain" is non-Baby Bullet and Baby Bullet trains; "BB only" is only Baby Bullet trains
[d] Location is over the top of one of the San Francisco tunnels.
Source: WIA 2013.

Table 3.11-5. Summary of 2009-2010 Vibration Measurement Locations and Ground-Borne Vibration Levels

County	Site No.	Address	Date	Distance from outermost track centerline[a] (feet)	Vibration Velocity[b] (VdB)	Source
San Francisco	VIB14	391 Pennsylvania Avenue, San Francisco	11/24/09	120	52	Caltrain
				220	48	Caltrain
	VIB20	Diana Street, San Francisco	2/24/10	105 to 155	62–67	Caltrain
	VIB13	1700 Egbert Avenue, San Francisco	11/03/09	140	74	Caltrain
				240	63	Caltrain
San Mateo	VIB12	29 San Francisco Avenue, Brisbane	11/03/09	300	43	Caltrain
				400	38	Caltrain
	VIB15	257 Village Way, South San Francisco	11/24/09	275	41	Caltrain
				325	40	Caltrain
	VIB16	228 Pine Street, San Bruno	11/24/09	100	74	Caltrain
				150	68	Caltrain
	VIB11	1101 Oxford Road, Burlingame	10/30/09	100	69	Caltrain
				150	64	Caltrain
	VIB17	1051 Park Avenue, Burlingame	11/24/09	150	61	Caltrain
				200	58	Caltrain
	VIB10	360–398 Villa Terrace, San Mateo	10/02/09	50	75	Caltrain
				100	67	Caltrain
	VIB9	1 East 40th Avenue, San Mateo	10/27/09	80	72	Caltrain
				160	61	Caltrain
	VIB8	1090 Riverton Drive, San Carlos	10/27/09	100	58	Caltrain
				200	54	Caltrain
	VIB7	307 Beech Street, Redwood City	10/27/09	50	75	Caltrain
				150	64	Caltrain
	VIB6	418 Encinal Avenue, Menlo Park	10/23/09	50	70	Caltrain
				100	66	Caltrain
Santa Clara	VIB18	96 Churchill Avenue, Palo Alto	11/25/09	50	74	Caltrain
				100	68	Caltrain
	VIB5	100–139 West Meadow Drive, Palo Alto	10/23/09	70	69	Caltrain
				140	50	Caltrain
	VIB21	240 Monroe Drive, Mountain View	3/08/10	100 to 115	70	Caltrain
				100	75 to 81	Freight
	VIB4	40 South Rengstorff Avenue, Mountain View	10/23/09	50	77	Caltrain
				100	70	Caltrain
	VIB3	200–216 North Mary Avenue, Sunnyvale	10/20/09	62	78	Caltrain
				132	70	Caltrain
	VIB19	West Evelyn Terrace, Sunnyvale	12/02/09	45	80	Caltrain
				110	70	Caltrain
	VIB2	2419–2429 South Drive, Santa Clara	10/20/09	140	72	Caltrain
				180	69	Caltrain
	VIB1	2075 Main Street, Santa Clara	10/20/09	80	78	Caltrain
				125	73	Caltrain
	VIB22	855 McKendrie Street, San Jose	3/10/10	70 to 195	70 to 77	Caltrain
				83 to 258	68 to 77	Amtrak
				100 to 270	64 to 73	Freight

Note:
[a] Approximate horizontal distance to the respective track for each group of passbys.
[b] Vibration levels with respect to 1 μ-inch/sec.
Source: WIA 2010.

Existing Vibration Levels

San Francisco

Vibration levels in this section were measured in 2013 near Caltrain receptor site R1, a location near the north portal of Tunnel No. 3 between Oakdale Avenue and Palou Avenue. Ground vibration level during Caltrain passbys was measured up to 73 VdB at a distance of approximately 50 feet from track centerline. Vibration levels did not exhibit much attenuation with distance, a distinctive feature of the data set from R1 that may be due to effects of the tunnel structure. Passbys vibration level measured 72 VdB at a distance of 164 feet. Observed speeds were up to 79 mph.

For measurements taken previously for the HSR studies, Caltrain vibration levels were measured at the following sites:

- HST VIB20: 62–67 VdB at 105–155 feet. The site is near R2 on the opposite side of the alignment by the south portal of tunnel No. 3.
- HST VIB13: 74 VdB at 140 feet. The site is in an open cut area between R2 and R3.

San Mateo County

In San Bruno, vibration levels were measured in 2013 near receptor site R5, along Herman Street at the intersection of Tanforan Avenue. Ground vibration during near track (southbound) Caltrain passbys measured up to 75 VdB at a distance of approximately 40 feet from the near track centerline and 70 VdB at 100 feet. Far track (northbound) trains produced comparatively higher vibration levels, presumably due to the presence of a crossover near and opposite the measurement site. Far track trains measured 74 VdB at 55 feet and 71 VdB at 115 feet. Observed speeds were up to 77 mph for near track (southbound) trains and up to 65 mph for far track (northbound) trains.

For the HSR project, Caltrain vibration levels were measured at the following HSR sites:

- HST VIB16: 74 VdB at 100 feet and 68 VdB at 150 feet. The site is south of R5 at 228 Pine Street in San Bruno and is closest to R8 on the northbound side of the at-grade alignment near the corner of 1st Avenue and Pine Street.
- HST VIB11: 69 VdB at 100 feet and 64 VdB at 150 feet. The site is near the intersection of Oxford Road and California Drive in Burlingame, on the southbound side of the at-grade alignment and close to R14.
- HST VIB17: 61 VdB at 150 feet and 58 VdB at 200 feet. The location is near the intersection of Park Avenue and Carolan Avenue in Burlingame, on the northbound side of the at-grade alignment.
- HST VIB10: 75 VdB at 50 feet and 67 VdB at 100 feet. The location abuts the tracks on the northbound side.

In San Mateo, vibration levels were measured in 2013 near receptor site R18, at 140 N. Railroad Avenue. Ground vibration during Caltrain passbys measured up to 83 VdB at a distance of approximately 35 feet from track centerline; up to 77 VdB at 50 feet; and up to 70 VdB at 100 feet. Observed speeds were up to 77 mph for these events. Vibration levels were also measured near receptor site R21 at 2 Antioch Drive. Ground vibration during Caltrain passbys measured up to 80 VdB at 35 feet for observed speeds up to 76 mph and up to 77 VdB at 50 feet for observed speeds of 70 mph.

For the HSR project, Caltrain vibration levels were measured at the following HSR sites:

- HST VIB9: 72 VdB at 80 feet and 61 VdB at 160 feet.
- HST VIB8: 58 VdB at 100 feet and 54 VdB at 200 feet.
- HST VIB7: 75 VdB at 50 feet and 64 VdB at 150 feet.

In Redwood City, vibration levels were measured in 2013 near receptor site R27, at 198 Buckingham Avenue. The location is on the southbound side of the alignment opposite four active tracks at-grade. Ground vibration from Caltrain passbys measured up to 83 VdB at approximately 25 feet from track centerline; up to 77 VdB at approximately 50 feet; and up to 68 VdB at 93 feet. Observed speeds for these passbys were up to 79 mph.

For the HSR project, Caltrain passby vibration levels measured 70 VdB at 50 feet and 66 VdB at 100 feet at HSR VIB6 located at 418 Encinal Avenue in Menlo Park. The site is near and just south of the receptor site R30 and similarly on the northbound side of the alignment.

Santa Clara County

In Palo Alto, vibration levels were measured in 2013 at receptor site R34 at Peers Park. Ground vibration from Caltrain passbys measured up to 77 VdB at 28 feet, up to 74 VdB at 53 feet and up to 66 VdB at 103 feet. Observed speeds for these events were in the low 70 mph.

For the HSR project, Caltrain vibration levels were measured at the following HSR sites:

- HST VIB18: 74 VdB at 50 feet and 68 VdB at 100 feet. The location is in Palo Alto, about three blocks north of R34 and similarly on the southbound side of the alignment.
- HST VIB5: 69 VdB at 70 feet and 50 VdB at 140 feet. The location is in Palo Alto, north of and relatively close to R36 and similarly on the southbound side of the alignment.
- HST VIB21: 70 VdB at 100 feet. The location is in Mountain View, south of and relatively close to R36 and similarly on the southbound side of the alignment.
- HST VIB4: 77 VdB at 50 feet and 70 VdB at 100 feet. The location is in Mountain View, near R34 though on the southbound side of the alignment.
- HST VIB3: 78 VdB at 62 feet and 70 VdB at 132 feet. The location is in Sunnyvale at R40 and also on the northbound side of the alignment.

In Sunnyvale, vibration levels were measured in 2013 at receptor site R40 at 125 N. Mary Avenue. Ground vibration from Caltrain passbys measured up to 77 VdB at 50 feet, up to 72 VdB at 100 feet, up to 70 VdB at 150 feet, and up to 68 VdB at 200 feet. Observed speeds for these events were up to 79 mph. For the HSR project, Caltrain passby vibration levels measured 80 VdB at 45 feet and 70 VdB at 100 feet at HST VIB19. The location is roughly equidistance between receptor sites R43 and R44 and opposite four active tracks.

In Santa Clara, vibration levels were measured in 2013 at receptor site R44 at 3529 Agate Street. Ground vibration from Caltrain passbys measured up to 82 VdB at 27 feet, 79 VdB at 53 feet, 75 VdB at 85 feet, and 73 VdB at 133 feet. Observed speeds were up to 82 mph. For the HSR project, Caltrain vibration levels were measured at the following HSR sites:

- HST VIB2: 72 VdB at 140 feet and 69 VdB at 180 feet. The location is in Santa Clara between R45 and R46.

- HST VIB1: 78 VdB at 80 feet and 73 VdB at 125 feet. The location is in Santa Clara, near and just south of R47.
- HST VIB22: 77 VdB at 70 feet and 70 VdB at 195 feet. The location is in San Jose between R47 and R48.

In San Jose, vibration levels were measured at receptor site R48 at 782 Auzerais Avenue. Ground vibration from Caltrain passbys measured up to 89 VdB at 25 feet, 76 VdB at 50 feet, and 69 VdB at 100 feet. Observed speeds were only up to 39 mph.

3.11.2 Impact Analysis

Activities associated with construction and operation of the Proposed Project that would cause noise and vibration impacts are described in this section, along with mitigation measures to address significant impacts.

3.11.2.1 Methods for Analysis

Noise Analysis

Existing Noise Exposures

To determine the potential noise level increase from the Proposed Project, existing noise exposures at noise sensitive receptors along the Caltrain corridor were developed to separate noise from Caltrain operations, freight train operations, and non-railroad ambient sources. The noise exposures resulting from Proposed Project operations were then calculated by adding the noise level from proposed future train operations to the existing non-railroad ambient noise level. Table 3.11-6 summarizes the existing noise exposures from Caltrain, freight, and non-railroad ambient sources at representative analysis sites. The methods for determining existing ambient noise levels for these sources are described below.

Adjustments to the Measured Ambient Noise Levels

Existing ambient noise levels were established for each representative site using the nearest representative measurement either from Table 3.11-2 or Table 3.11-3. The measured noise levels were adjusted for distance, acoustical shielding, and proximity to other noise sources where the conditions of the measurement location differed from the conditions of the receptor position for each representative site. For example, at locations where noise measurements were obtained in front of the homes and Caltrain is directly exposed to the back of homes, the data were adjusted to determine the noise exposure at the back of the properties. The noise surveys ranged over multiple days. The average L_{dn} values were used, except in some cases where the minimum or maximum measured L_{dn} values were more consistent with the noise model. Appendix C includes the discussions of the adjustments to the measured noise levels and how each of the existing ambient noise levels were established for each representative site.

Table 3.11-6. Existing Caltrain/Freight/Non-Railroad Ambient Noise at Representative Sites

Receptor Site No.	Side of Alignment	Land Use	Distance to Receptor (feet)	Measurement Site ID	Distance to Measurement Site (feet)	Adjusted Total Ambient Noise Exposure at Receptor[a] L_{dn} (dBA)	Caltrain Diesel Locomotive Train Noise[b] L_{dn} (dBA)	Freight Train Noise L_{dn} (dBA)	Residual Noise Exposure from Non-railroad Sources[c] L_{dn} (dBA)
1	W	MFR	110	N32	135	69	63	65	65
2	E	SFR	80	N33	170	70	65	65	66
3	E	SFR	90	N32	135	70	64	66	66
4	E	SFR	120	N31	70	69	66	65	60
5	W	SFR	110	R05	85	76	71	73	69
6	E	MFR	50	R07	100	77	74	73	67
7	W	SFR	120	R07	100	74	70	71	64
8	E	SFR	100	N53	80	74	71	70	64
9	W	SFR	150	N53	80	72	69	68	62
10	W	SFR	170	N26	180	67	60	62	64
11	E	MFR	160	N25	150	71	66	66	67
12	W	SFR	90	R12	244	72	68	69	61
13	W	SFR	150	N50	140	68	61	63	65
14	W	SFR	160	R14	155	70	66	64	66
15	W	SFR	190	N22	145	70	64	66	66
16	E	SFR	160	N22	145	71	66	66	67
17	W	SFR	40	R18	40	76	73	73	60
18	E	SFR	70	R18	40	72	69	68	56
19	W	MFR	110	N47	40	73	68	68	69
20	W	SFR	85	N20	95	67	64	62	60
21	E	SFR	100	N19	90	72	68	68	65
22	E	MFR	120	R22	128	70	65	64	67
23	E	MFR	120	N18	120	73	68	68	69
24	E	SFR	100	N17	85	70	67	66	60
25	E	SFR	90	N16	80	73	70	70	61
26	E	SFR	50	N47	40	76	73	72	66
27	W	MFR	110	R27	70	69	65	65	62

Receptor Site No.	Side of Alignment	Land Use	Distance to Receptor (feet)	Measurement Site ID	Distance to Measurement Site (feet)	Adjusted Total Ambient Noise Exposure at Receptor[a] L_{dn} (dBA)	Caltrain Diesel Locomotive Train Noise[b] L_{dn} (dBA)	Freight Train Noise L_{dn} (dBA)	Residual Noise Exposure from Non-railroad Sources[c] L_{dn} (dBA)
28	E	SFR	50	N14	55	72	68	68	65
29	W	SFR	60	N13	45	70	68	66	51
30	E	SFR	65	N13	45	70	68	66	51
31	E	MFR	175	N45	130	67	60	60	65
32	W	MFR	100	N44	60	68	65	64	60
33	E	SFR	120	N42	35	69	65	63	65
34	W	SFR	40	R34	40	72	70	67	62
35	E	MFR	160	N10	120	76	70	70	73
36	W	SFR	50	R36	35	78	74	75	68
37	E	SFR	150	N9	135	75	68	70	71
38	W	MFR	110	N8	285	73	69	69	66
39	E	SFR	150	N39	185	72	61	61	71
40	E	SFR	75	N7	90	68	65	63	60
41	E	MFR	80	N7	90	70	66	66	61
42	E	SFR	80	N6	100	71	67	65	66
43	W	MFR	75	N6	100	71	65	65	68
44	W	MFR	85	R44	130	71	66	66	67
45	W	SFR	110	N4	160	68	62	63	64
46	W	SFR	95	N37	220	68	64	62	64
47	W	SFR	95	N3	140	68	64	62	64
48	W	SFR	60	R48	45	81	77	78	65
49	E	SFR	50	R49	50	71	68	67	61

Note:
[a] Total ambient noise exposure is based on representative noise measurement data.
[b] Noise from existing Caltrain diesel-locomotive trains as determined by FTA model.
[c] Noise from existing diesel-locomotive trains was removed from total ambient noise level by decibel subtraction (energy basis).
SFR = single-family residence.
MFR = multi-family residence.
Source: WIA 2013.

Existing Caltrain Operations

Existing Caltrain diesel trains were modeled using sound exposure level (SEL) references for diesel locomotives and commuter rail cars provided in the FTA guidelines (Federal Transit Administration 2006). The calculations assume each Caltrain train consists of one locomotive and five passenger cars at the existing service level of 92 trains per day (and 5 trains per peak hour per direction) and maximum train speeds up to 79 mph. The FTA model levels were compared to measurements conducted in 2013, and the results confirmed the FTA model values.

The noise model assumed flat terrain and acoustically "soft" (i.e. absorptive) ground conditions at locations where terrain consisted mostly of railroad ROW, yards, and other non-paved surfaces. The ground factor (G) values for the distance attenuation calculations were 0.6 for noise sources located lower on the train, and 0.7 for sources located higher on the train. Where intervening terrain is mostly roadways or parking lots, then a ground factor of zero was used.

The horn noise prediction model is based on a reference level of 96 dBA L_{max} at 100 feet. The model takes into account the receptor distance from the grade crossing and the track and adjusts the SEL to account for horn usage (non-continuous horn blowing). It was assumed that horn usage is less when approaching stations than grade crossings. At receptor sites within 0.25 mile of grade crossings, a horn usage factor of 0.3 was assumed. At locations within 0.25 mile of stations, a horn usage factor of 0.15 was assumed. Further, based on the existing noise measurement results, modified horn usage factors were used, ranging from 0.04 to 0.7, to adjust the horn noise model to the measured noise values. At a few locations, a 2 dBA adjustment was applied to account for the effect of horn noise reflecting off buildings close to the railroad ROW.

Existing Freight Train Operations

The freight trains normally operate between 8 p.m. and 5 a.m.[5] The noise measurement results show clear peaks in the hourly noise levels between 10 p.m. and 5 a.m., and these peaks were attributed to freight activity. The influence of freight activity on L_{dn} levels was investigated by comparing the measured L_{dn} levels (including all hours) with equivalent "non-freight" L_{dn} levels (excluding data between 10 p.m. and 5 a.m.). The "non-freight" L_{dn} levels are 1 to 4 dBA lower than the measured L_{dn} levels, depending on location, and 2 dBA lower on average. This suggests that freight activity has the effect of increasing the total L_{dn} levels by 1 to 4 dBA, and that the freight noise level is generally within 2 dBA (+ or –) of the Caltrain noise level. In situations where non-rail noise sources dominate, the freight noise contribution is much less.

[5] Freight operates in the JPB-owned Caltrain corridor under a Trackage Rights Agreement (TRA) between UPRR and the JPB. This TRA provides that between midnight and 5 a.m., at least one main track will always be in service for freight. In addition, the TRA requires the JPB to provide the ability to operate freight service on the corridor whenever there is at least 30 minutes headway between passenger trains. Between 10 a.m. and 3 p.m., the TRA requires the JPB to provide at least one 30-minute headway window for freight service capable of operating at commuter service speeds. In practice today, freight commonly runs between 8 p.m. and 5 a.m., with occasional daytime service. Freight service hours are not limited by the TRA on the UP-owned MT-1 track between CP Coast and CP Lick (Santa Clara to south of Tamien Station).

Non-Railroad Ambient Noise Estimates

Once the effects of Caltrain and freight trains were determined, the remaining noise level represents the existing noise exposure due to all other noise sources (residual). The existing noise contributions calculated for Caltrain operations and estimated for existing freight activity, as discussed above, were mathematically subtracted from the total existing noise level established for each site.

The non-railroad ambient noise levels along the Caltrain corridor are typically between 60 and 70 dBA. Non-railroad ambient noise levels less than 60 dBA were in "quiet" residential areas with backyards abutting the right of way and no large roadways or other noise sources contributing. Non-railroad ambient noise levels above 70 dBA indicate sites exposed to major non-rail noise sources, such as large arterial roads and highways or airplane traffic.

Proposed Train Operations

The proposed project would replace approximately 75 percent of the locomotive and passenger car fleet for San Francisco to San Jose service with EMU technology with a catenary system in 2019. The EMU trains were assumed to be six cars long, with three motor cars (powered cars) and three non-powered trailer cars. The Proposed Project assumes maximum train speeds would not change; however, there would be a greater number of total trains per day. The analysis also assumes EMU cars would be roughly the same length as the existing Caltrain rail cars.

The FTA guidelines give no specific reference SEL for EMU trains. The Federal Railroad Administration (FRA) guidance (FRA 2012) includes more recent data on train systems, including data on high-speed and very high-speed steel-wheeled EMU trains. The high-speed category refers to trains less than 150 mph where aerodynamic noise sources are not a significant factor. The FRA reference levels at 50 feet for the high-speed EMU train (with a length of 634 feet) are 86 dBA SEL for propulsion noise and 91 dBA SEL for wheel-rail noise from a train travelling at a speed of 90 mph (which is faster than the maximum for the Proposed Project, which would be 79 mph). Train length and speed adjustments were applied to the FRA SEL values to normalize to the FTA reference SEL conditions (i.e.,1 car at 50 mph). With the adjustments, the equivalent reference SELs are 80.2 dBA at 50 feet for a single power car running at 50 mph and 77.2 dBA at 50 feet for a single non-powered car running at 50 mph. Specific adjustment factors and procedures are discussed in Appendix C.

It was assumed that 100 percent of the trains running from San Francisco to San Jose would use EMU technology with a catenary system in 2040, with the same configuration and parameters discussed above.[6] From Gilroy to San Jose, the same diesel train configuration would continue as it does today with six trains per day (three trains per direction per average weekday day).

Train Horns and Crossing Bells

Train horns and crossing bells are major noise sources associated with train operations. Trains sound their horns before roadway crossings and when approaching a passenger station. The

[6] The PCEP only has funding for 75 percent replacement of diesel service between San Francisco and San Jose. Over time, Caltrain plans to replace diesels with EMUs such that by 2040 it is a reasonable assumption that 100 percent of service would be with EMUs. In addition, when high-speed rail service is "blended" with Caltrain service (presently assumed to be sometime between 2026 and 2029), all Caltrain service from San Francisco to San Jose would need to with EMUs, so full electrification may occur long before 2040.

location and number of roadway crossings and stations would not be changed as a result of the Proposed Project.

The horn noise prediction model and horn usage factors are described above under the *Existing Caltrain Operations*. The number of train operations would slightly increase for the proposed operations. The effect of increasing the total number of daytime trains (7 a.m. to 10 p.m.) from 77 to 98 trains would equate to 0.9 dB relative increase in the daytime equivalent noise level (L_{eq}). The effect of increasing the total number of nighttime trains (10 p.m. to 7 a.m.) from 15 to 16 (or peak hour trains from 5 to 6) would equate to 0.8 dB relative increase in the nighttime L_{eq}.

Special Track Work

Special track work includes turnouts and crossovers. Airborne noise from train passage over special track work contributes to wayside noise and can increase the wayside noise level with the introduction of an impulsive source noise. It is assumed the location and number of turnouts and crossovers would not be changed as a result of the Proposed Project.

L_{eq} noise levels due to special track work would slightly increase due to the increased number of trains (similar to the train horns and crossing bells discussed above). However, special track work is not expected to have any substantial effect on the total noise level and, therefore, is not considered in this analysis.

Curving Noise (Wheel Squeal)

Wheel squeal occurs on curves with small radii where the tendency to squeal increases as the curve radius become smaller. For curves with radius greater than 1,000 feet, no wheel squeal should occur. For curves with a smaller radius, wheel squeal may or may not occur depending on several factors, including bogie/wheel dynamics, lubrication, rail gage and wear, and whether the wheels are resilient wheels, among other things. Two types of curving noise exist; one is conventional wheel squeal produced by un-damped solid steel wheels, and the other is flanging noise. Wheel squeal is most likely produced by the low rail leading wheel. Flanging noise may occur with damped wheels and resilient wheels, as well as solid steel wheels. Flanging noise is usually associated with high rail leading wheel flanging.

It is assumed track curves would not change as a result of the Proposed Project. Therefore, there would be no potential for increase in wheel squeal, which is not included in this analysis.

Ancillary Facilities

The area of study for the ancillary facilities was selected based on the screening distances recommended by FTA. Specifically, for power substations the screening distance for a condition of unobstructed sound path between source and receiver is 250 feet. Where intervening buildings obstruct the sound path from the substation to the receptor, the screening distance is 125 feet.

The FTA reference SEL for substations is 99 dBA at 50 feet, which equates to an L_{dn} of 74 dBA at the same reference distance (assuming 24-hour continuous usage). These FTA reference values for SEL and L_{dn} were used to calculate the total project noise levels at noise sensitive receivers within the screening distances from each electrical facility site.

Train Station

No substantial changes to the existing stations would occur as part of the Proposed Project.

However, there would be an increase in passenger activity at stations due to the proposed increased rail service that would result in increased automobile traffic in the immediate vicinity of the station itself. The increased Caltrain service would occur primarily during peak hours, which is a less sensitive time for noise. Roadways near Caltrain stations already experience automobile traffic noise due to passenger train riders traveling to and from the stations and from train noise with a peak of activity in the time before and after train arrival.

Although traffic would increase around stations due to the Proposed Project, the level of traffic noise is not expected to substantially increase above the current noise along roadways near Caltrain stations. In addition, as discussed in Section 3.14, *Transportation and Traffic*, the project would result in a substantial reduction in regional vehicle miles travelled and, thus, overall lower traffic noise regionally.

Construction

As noted in the 2008 noise and vibration study (Parsons 2008), construction noise varies greatly depending on the construction process, type, and condition of the equipment used, and layout of the construction site. Many of these factors are traditionally left to the contractor's discretion, which makes it difficult to accurately estimate levels of construction noise. Overall, construction noise levels are governed primarily by the noisiest pieces of equipment. The engine, which is usually diesel, is the dominant noise source for most construction equipment. The actual sequence of construction tasks and their respective time durations would vary, depending on the tasks and the local conditions. Because of ROW constraints, some tasks such as railroad traffic detouring and utility relocations might be undertaken more than once.

Joint use of the corridor for construction and operation of trains would place major logistical constraints on both. On the construction side, operation would restrict working room and working hours, and interruptions from passing trains would reduce efficiencies. On the train operation side, the joint use of the corridor would require single-tracking, service interruptions, speed restrictions, and work zone enforcement.

The FTA method and noise data were used to determine construction noise exposure for each piece of equipment. The noise data include the maximum noise level (L_{max}) of construction equipment operating at full power at a reference distance of 50 feet and the usage factors for the equipment. The usage factor is the percentage of time each piece of construction equipment is typically operated at full power over the specified time period 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 over 50% of the time is 3 dB less than the L_{max} value.

The 2008 study estimated the 8-hour L_{eq} levels for the construction equipment at 50 and 100 feet based on respective usage factors. The usage factors account for the total time during an 8-hour day and were estimated based on experience with other similar construction projects. Table 3.11-7 (reproduced from the 2008 study) summarizes typical L_{max} of the construction equipment at 50 feet and the corresponding 8-hour L_{eq} levels at 50 and 100 feet. The usage factors have not been changed from the 2008 analysis. Note that the noise levels in Table 3.11-7 are typical values, and there can be wide fluctuations in the noise emissions of similar equipment based factors such as the operating condition of the equipment and the technique used by the equipment operator.

The following three construction activities have been identified for the purpose of determining construction noise exposure (each activity includes a number of different phases):

- Overhead Contact System Installation.
- Overbridge Protection Barriers Installation.
- Substations, Switching, and Paralleling Stations Construction.

Each stage would involve multiple activities that could create high noise levels. The noise levels for major pieces of construction equipment within a given stage are shown in Table 3.11-7. Total construction noise exposure was determined by first calculating the noise exposure for each piece of equipment, and then combining the noise exposures for all equipment to be used during a construction stage. The equipment noise levels within a particular stage were combined together to obtain a total noise exposure for each stage (listed as bolded entries in Table 3.11-7). Noise levels of different stages were not combined because the different stages would not occur at the same time in a given area.

Table 3.11-7. Typical Construction Equipment Noise Emission Levels

Equipment	Maximum Noise Level L_{max}, dBA, 50 feet from Source	Equipment Usage Factor	Total 8-Hour L_{eq} Exposure, dBA, at Various Distances[a]	
			50 feet	100 feet
Overhead Contact System Installation				
Foundation Installation without Casing			**76**	**70**
Auger/drill rigs	73	67	82	76
Concrete truck	70	64	79	73
Telescoping boom bucket trucks	62	56	71	65
Front loader	66	60	75	69
Dump truck	54	48	63	57
Generator to vibrate the concrete	65	59	74	68
Foundation Installation with Casing			**77**	**70**
Auger/drill rigs	70	64	79	73
Concrete truck	67	61	76	70
Telescoping boom bucket trucks	65	59	74	68
Front Loader	66	60	75	69
Vibratory hammer	73	67	82	76
Dump truck	54	48	63	57
Generator to vibrate the concrete	65	59	74	68
OCS Pole Installation			**73**	**67**
Diesel construction train (stationary)	58	52	58	52
Diesel construction train (in transit)	45	39	45	39
Telescoping boom bucket trucks	69	63	69	63
Generator (nighttime lighting)	70	64	70	64
OCS Wiring			**74**	**68**
Diesel construction train (stationary)	60	54	60	54
Diesel construction train (in transit)	56	50	56	50
Telescoping boom bucket trucks	71	65	71	65
Generator (nighttime lighting)	72	66	72	66

Equipment	Maximum Noise Level L_{max}, dBA, 50 feet from Source	Equipment Usage Factor	Total 8-Hour L_{eq} Exposure, dBA, at Various Distances[a] 50 feet	100 feet
Overbridge Protection Barriers				
Installation of Barriers to Roadway Bridges			**81**	**75**
Pneumatic drill (in concrete)	85	0.30	80	74
Utility truck (with crane)	81	0.30	76	70
Flatbed truck	78	0.10	68	62
Substation, Switching, and Paralleling Stations				
Ground Clearing Stage – one site only			**83**	**77**
Dozer	85	0.50	82	76
Front loader	80	0.30	75	69
Dump truck	71	0.25	65	59
Compactor	81	0.25	75	69
Ground Grade			**81**	**75**
Backhoe	80	0.30	75	69
Hammer to drive rods (small vibrator)	86	0.25	80	74
Concrete Foundations			**84**	**78**
Flatbed truck	78	0.10	68	62
Wood saw to construct forms	88	0.25	82	76
Concrete truck	82	0.25	76	70
Utility truck (with crane)	81	0.30	76	70
Generator to vibrate the concrete	82	0.15	74	68
Electrical Equipment Installation			**83**	**77**
Flatbed truck	78	0.15	70	64
Forklift	80	0.27	74	69
Large crane	85	0.50	82	76

[a] Distances are measured from the center of the noise producing activities associated with the construction phase.

Source: Parsons 2008.

Vibration Analysis

Train Operations

To assess the potential for vibration impact of the Proposed Project, WIA evaluated factors that would have the potential to increase vibration levels. Factors that would potentially cause changes to the wayside vibration levels are vehicle vibration characteristics, train speed, distance between receptor and track centerline, and track structure type.

The factors would remain the same with the Proposed Project as under the existing condition with the one exception that the EMU vehicle may have different vibration characteristics than the existing locomotive powered trains. Therefore, for any given receptor, all factors remain the same with the exception of the EMU vehicle.

The vibration characteristics attributable to the change in vehicle would be a function of truck (bogie) design, unsprung mass of the vehicle, type of primary suspension, wheel type, and other factors. These details would be reviewed during final design for comparison with the existing Caltrain vehicles to confirm the vibration analysis assumptions. This analysis assumes that the unsprung weight of the future EMU vehicle would not substantially exceed that of the existing Caltrain gallery car.

Construction

Two types of construction vibration impacts were analyzed: (1) human annoyance, and (2) building damage. Human annoyance occurs when construction vibration rises significantly above the threshold of human perception for extended periods of time. Building damage can be cosmetic or structural. Fragile buildings such as historical structures or ancient ruins are generally more susceptible to damage from ground vibration. Normal buildings that are not particularly fragile would not experience any cosmetic damage (e.g., plaster cracks) at distances beyond 20 feet based on topical construction equipment vibration levels. This distance can vary substantially depending on the soil composition and underground geological layer between vibration source and receiver. In addition, not all buildings respond similarly to vibration generated by construction equipment. The potential for vibration annoyance and building damage was analyzed for major vibration-producing construction equipment that would be used for the Proposed Project. The vibration levels produced by construction equipment are estimated using FTA vibration data and from field measurements, as shown in Table 3.11-8.

Table 3.11-8. Vibration Source Levels for Construction Equipment

Equipment	PPV[a] at 25 ft (in/sec)	Approximate Velocity Level[b] at 25 ft (VdB)
Large bulldozer	0.089	87
Loaded trucks	0.076	86
Small bulldozer	0.003	58
Auger/drill rigs	0.089	87
Vibratory hammer	0.07[c]	85[c]
Vibratory compactor/roller	0.55[d]	103[d]

[a] Peak particle ground velocity measured at 25 feet unless noted otherwise.
[b] Route mean square amplitude ground velocity in decibels (VdB) referenced to 1 micro-inch/second.
[c] Measured at 88 feet by Parsons.
[d] Measured at 15 feet by Parsons.
Source: Federal Transit Administration 2006; Parsons 2008.

3.11.2.2 Thresholds of Significance

The Proposed Project would be considered to have a significant impact if it would result in any of the conditions listed below.

- Expose persons to or generate noise levels in excess of FTA thresholds.
- Expose persons to or generate groundborne vibration or groundborne noise levels in excess of FTA thresholds.

- Be located within an airport land use plan area, or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport and expose people residing or working in the project area to excessive noise levels.
- Be located in the vicinity of a private airstrip and expose people residing or working in the project area to excessive noise levels.

The Proposed Project is a surface transit project and would not permanently locate people to reside or work in the project area. Therefore, aircraft noise is not analyzed further.

The FTA noise and vibration criteria used to identify the significant impacts of the project during operation and construction are discussed in sections below. Although local jurisdictions have their own noise and vibration standards (as discussed above), these criteria are generally designed to assess the impacts of land use development projects. The FTA noise and vibration criteria are specifically designed to assess the impacts of rail projects and provide a uniform set of criteria to apply to the entire 52-mile project corridor, instead of varying the criteria of individual jurisdictions. This approach allows for a more consistent basis by which to identify where the Proposed Project would have significant impacts.

FTA Noise Criteria

Operation Noise Criteria

The FTA guidelines provide impact assessment procedures and criteria for noise (FTA 2006). The impact criteria are based on maintaining a noise environment considered acceptable for land uses where noise may have an effect on sensitive receptors. Land use also factors into the determination of impact; industrial uses are assumed to not have sensitive receptors and therefore are not considered, while places where people sleep or where quiet is an integral component of the land use (i.e., Categories 1 and 2) get an additional 5 dB protection beyond other land uses containing sensitive receptors. Descriptions of the three land use categories that are subject to noise criteria are shown in Table 3.11-9. The noise exposure is measured in terms of L_{dn} for residential land uses and in terms of $L_{eq}(h)$ for other land uses as defined in the table.

The FTA noise impact criteria are based on comparison of the existing outdoor noise levels with the future outdoor noise levels from the Proposed Project in combination with the existing noise. The impact criteria for increases in project noise exposure are presented in Figures 3.11-6 and 3.11-7. Noise level increases are categorized as *no impact*, *moderate impact*, or *severe impact*, where the two levels of noise impact are characterized as explained below.

Moderate impact: In this range of noise impact, the change in cumulative noise level is noticeable to most people, but may not be sufficient to cause strong, adverse reactions from the community. In this transitional range, other project-specific factors must be considered to determine the magnitude of impact and the need for mitigation. Factors to consider are the number of noise-sensitive sites that are affected and the existing level of noise exposure. If existing noise exposure is greater than L_{dn} 65 dBA, then there would be a stronger need for mitigation.

Severe impact: Project-generated noise in the severe impact range can be expected to cause a significant percentage of people to be highly annoyed by the new noise levels and represents the most compelling need for mitigation. Noise mitigation will normally be specified for sensitive receptors where a severe impact occurs unless there are truly extenuating circumstances that prevent implementation of mitigation.

Table 3.11-9. Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric, dBA	Description of Land Use Category
1	Outdoor L_{eq} (h)[a]	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor L_{eq} (h)[a]	Institutional land uses with primarily daytime and evening use. This category includes land uses where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material, such as schools, libraries and churches. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios, and concert halls fall into this category. Places for meditation or study associated with cemeteries, monuments, and museums, and certain historical sites, parks, and recreational facilities are also included.

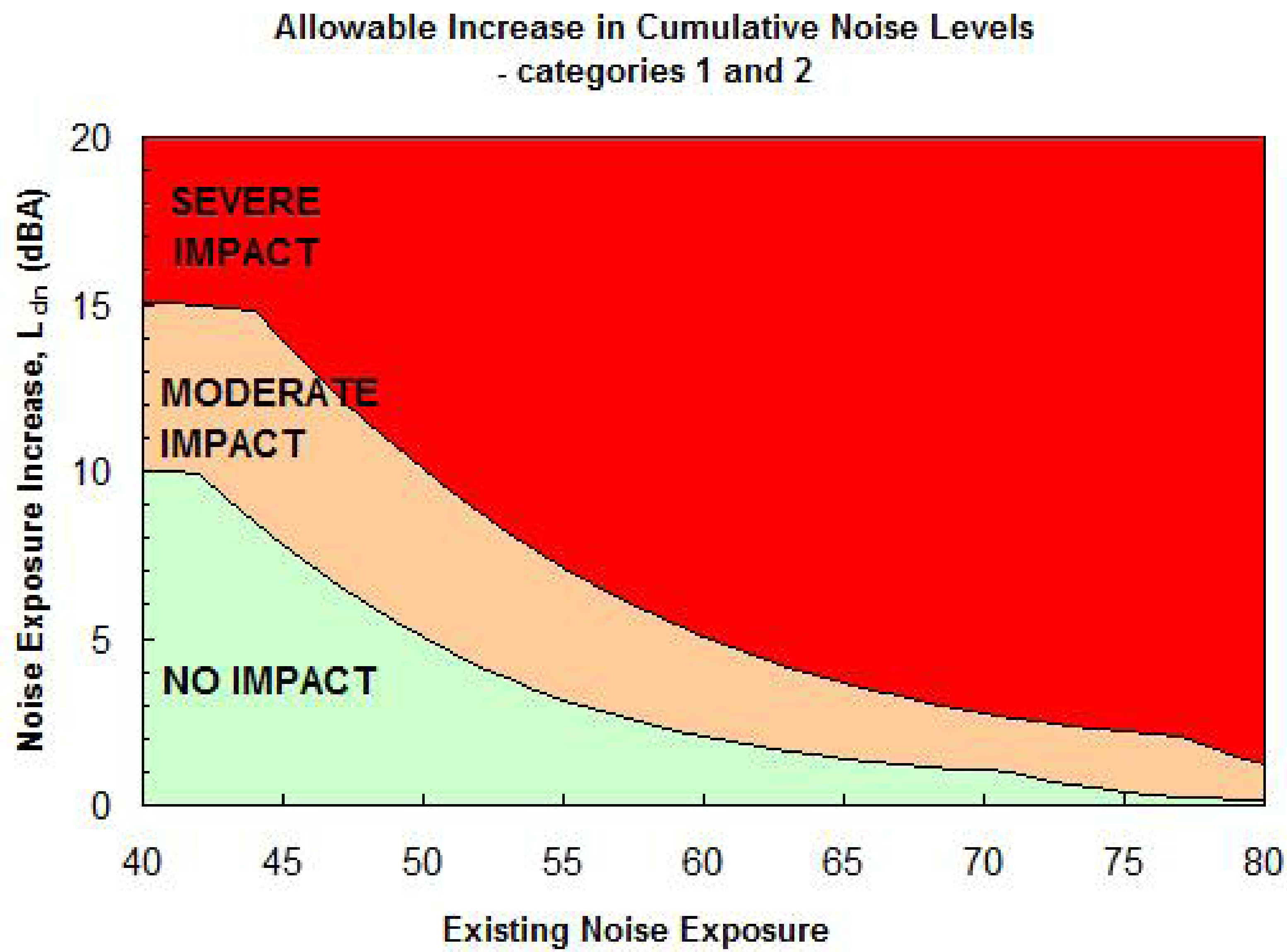
[a] L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.
Source: FTA 2006.

The thresholds for these three levels of impact, as indicated in Figures 3.11-6 and 3.11-7, are based on the projected increase of the existing ambient noise level associated with operation of the Proposed Project. The thresholds also may be used to evaluate the Proposed Project in combination with other new planned projects to determine cumulative impacts.

The process of determining impact severity begins with a determination of land use with reference to the land use categories defined in Table 3.11-9. Once the land use category has been determined, an appropriate noise metric is selected to determine the projected noise level and the severity of impact. The next steps are to determine the existing exterior noise exposure for each receptor or group of similar receptors, and then to determine the total noise exposure associated with the Proposed Project combined with the existing ambient noise level and, in the case of a cumulative noise analysis, other projects. The severity of impact is then determined using the thresholds depicted in Figures 3.11-6 and 3.11-7.

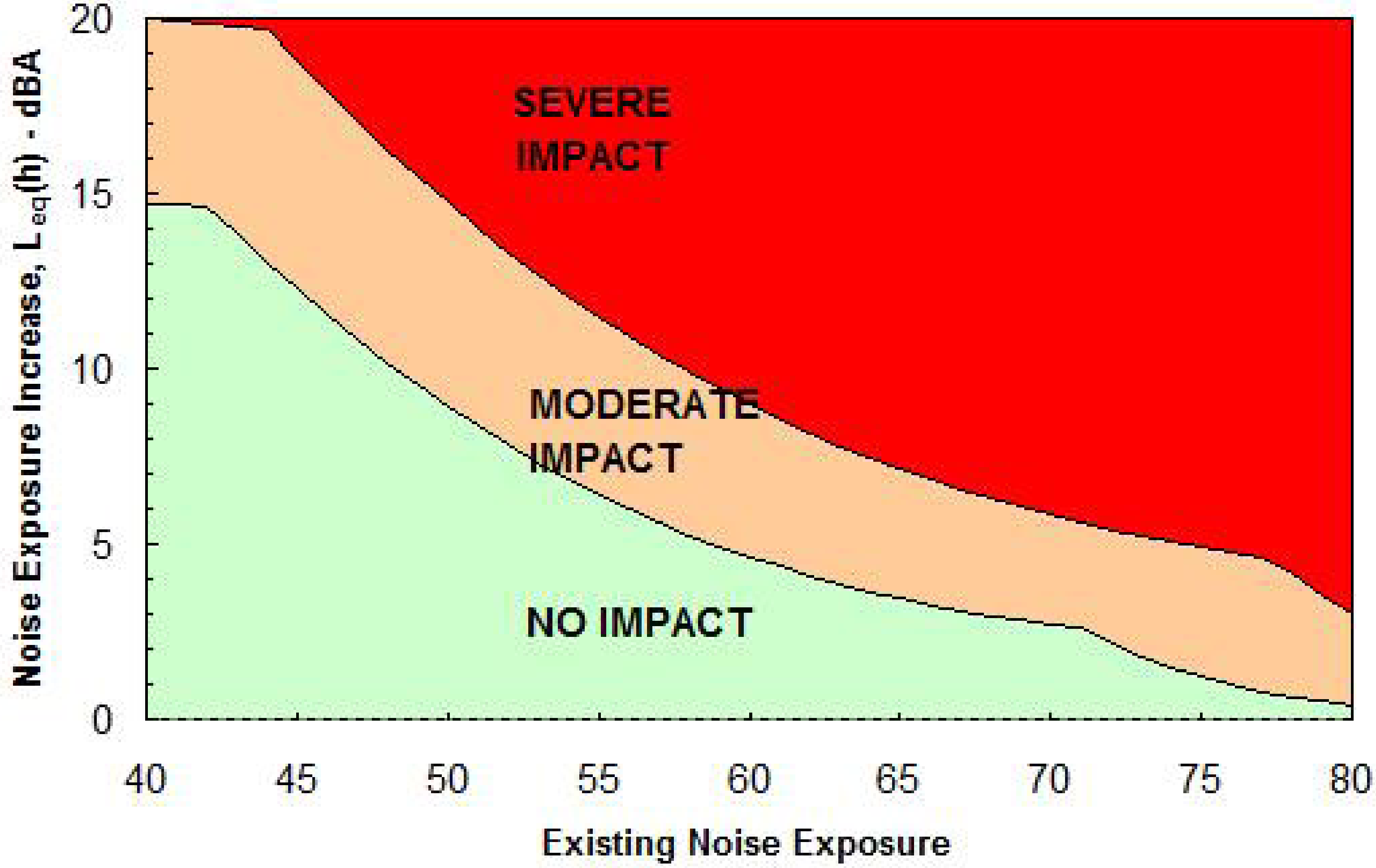
A hypothetical example would be a residential property that has an existing L_{dn} exposure of 60 dBA. The noise exposure resulting from the Proposed Project, regional growth, and other planned projects could result in an L_{dn} exposure of 65 dBA. Adding (on a logarithmic basis) an L_{dn} of 65 dBA to the existing noise level would result in a total L_{dn} exposure of 66 dBA. This represents a potential increase of 6 dBA over the existing noise level. Using Figure 3.11-6 a line would be drawn vertically at 60 dBA and another line drawn horizontally at 6 dBA from left-hand axis. The intersection of these two lines determines the severity of impact. In this example, the resulting noise increase would be considered a severe impact on the residential property.

The FTA criteria can also be presented in terms of absolute levels for evaluating noise from the transit project alone. However, the absolute criteria is only applicable to new transit sources where the existing noise levels generated by existing transit systems, roadway, and other sources will not



Source: Federal Transit Administration 2006.

Figure 3.11-6
Noise Impact Thresholds for FTA Category 1 and 2
Peninsula Corridor Electrification Project



Source: Federal Transit Administration 2006.

Figure 3.11-7
Noise Impact Thresholds for FTA Category 3
Peninsula Corridor Electrification Project

change as a result of the project. The absolute criteria assume the project noise can be added to the existing noise to calculate a new total noise level. If the existing noise was dominated by a source that changed due to the project, it would be incorrect to add the project noise to the existing noise. Therefore, the relative form of the noise criteria must be used for projects involving proposed changes to an existing transit system.

Stationary Source Criteria

The noise criteria for stationary sources, such as traction power substations, switching stations, and paralleling stations, were established by the FTA methods described above. The noise from these facilities is evaluated as part of the entire project noise, and the impact is based on comparing the project noise with the existing conditions. Most local codes within the Caltrain corridor limit noise levels from continuous operations (such as those generated from stationary sources) to the same as the existing ambient. In some cases, codes allow a 5 to 10 dBA increase above the existing ambient background, which would result in an net increase of 3 to 6 dBA over the existing ambient condition. For existing noise environments on the order of 65 to 70 L_{dn}, the FTA noise criteria for land use category 1 and 2 typically defines a moderate noise impact as a noise increase of approximately 1 to 2 dBA and a severe impact as a noise increase of at least 3 dBA, which is consistent with or more restrictive than local codes.

Construction Noise Criteria

The FTA construction noise criteria were used for identifying construction noise impacts, as presented in Table 3.11-10. The criteria are based on the L_{eq} level from all equipment operating during a given 8-hour period. Noise impacts for long-term construction projects, with daily variations in construction activities, are based on a 30-day average L_{dn} or L_{eq}.

Noise levels generated by construction equipment would vary depending on several factors including the type of equipment, the condition of the equipment, and the specific operation being performed. Furthermore, noise levels within a given time period will vary depending on the combined quantities of equipment being used and the length of time that each piece of equipment is operated. The L_{eq} metric is useful for evaluating noise for entire phases of construction because it can represent combined noise levels generated by all equipment and take into account the temporal nature of the construction operations.

Table 3.11-10. FTA Construction Noise Assessments Criteria

	8-hour L_{eq} (dBA)		
Land Use	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)	Daily Noise Level (dBA) 30-day Average
Residential	80	70	75 (L_{dn})[a]
Commercial	85	85	80 (24-hour L_{eq})
Industrial	90	90	85 (24-hour L_{eq})

[a] In urban areas with very high ambient noise levels (L_{dn} > 65 dB), L_{dn} from construction operations should not exceed existing ambient + 10 dB.

Source: Federal Transit Administration 2006.

The local noise ordinances for the cities and counties along the Caltrain corridor generally limit construction noise to particular time periods during weekday, weekend, and holiday daytime hours. Nighttime construction work is generally prohibited, but some jurisdictions allow for a variance.

Some of the municipal codes specify the maximum noise levels allowable at property lines or at a specified distance from construction equipment. In jurisdictions with construction noise level limits, the allowable maximum noise levels at property lines range from 86 to 110 dBA. Because the local codes specify construction noise limits in terms of maximum levels, and noise is not assessed using an energy-averaged sound level, it is difficult to compare local noise limits directly to the FTA criteria. If one assumes that all the construction equipment that would be used for the Proposed Project generates 86 dBA continuously over an 8-hour period, the corresponding L_{eq} value would also be 86 dBA L_{eq}. Typically, the energy averaged noise level would be less, because each piece of equipment is operated non-continuously, and therefore generates its specific maximum noise level for only a portion of every hour and a portion of every workday.

FTA Vibration Criteria

The FTA guidance document (FTA 2006) is used to evaluate vibration impacts from Caltrain operations and construction. The evaluation of vibration impacts can be divided into two categories: (1) human annoyance, and (2) building damage. As described below, the human annoyance criteria are used to evaluate vibration impacts resulting from Proposed Project operations, and the building damage criteria are used to evaluate vibration impacts resulting from construction activities.

Operation Vibration Criteria

Vibration impacts are based on the receptor land use category and how frequent the vibration events would occur. The impact level also depends on the type of analysis being conducted (i.e., ground-borne vibration or ground-borne noise).

The FTA guidance document provides ground-borne vibration criteria to assess the human response to different frequencies of ground-borne vibration events from a new project, as shown in Table 3.11-11. In addition, the guideline provides criteria for special buildings that are very sensitive to ground-borne vibration generated from a new project. The impact criteria for these special buildings are shown in Table 3.11-12.

Because the Proposed Project would involve an existing operational railroad corridor, the vibration impact of Proposed Project operation is determined by comparing the potential increase in vibration levels with the existing condition.

The FTA guidance document provides impact criteria for increases in vibrations levels as a result of a rail project based on the use of an existing rail corridor. The Proposed Project is considered a "heavily-used rail corridor," which is defined as a corridor with more than 12 trains per day. For a heavily-used rail corridor, a significant impact would occur if the existing train vibration already exceeds the criteria given in Tables 3.11-11 and 3.11-12 and the Proposed Project would result in a significant increase in the vibration events (defined as doubling the number of existing events), or if the Proposed Project would result in an increase of existing vibration level by 3 VdB or more. As shown in *Existing Ambient Vibration* and Tables 3.11-4 and 3.11-5 in Section 3.11.1.2, existing vibration levels exceed the criteria in Tables 3.11-11 and 3.11-12. Therefore, the criteria of a 3 VdB increase or a doubling of existing train vibration events are applied for determining a significant impact.

Ground-borne noise impacts are evaluated for only subway projects or in the cases where a special use building has been isolated for noise but not vibration. Because the existing conditions include vibration from surface commuter and freight railroad activities, no further discussion of ground-borne noise is considered in this analysis.

Table 3.11-11. Ground-Borne Vibration Impact Criteria for Human Annoyance

	Ground-Borne Vibration Impact Levels (VdB relative to 1 micro-inch/sec)		
Land Use Category	Frequent Events[a]	Occasional Events[b]	Infrequent Events[c]
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 VdB[4]	65 VdB[d]	65 VdB[d]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB

[a] Frequent is defined as more than 70 vibration events of the same source per day.
[b] Occasional is defined as between 30 and 70 vibration events of the same source per day.
[c] Infrequent is defined as fewer than 30 vibration events of the same source per day.
[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
Source: FTA 2006.

Table 3.11-12. Ground-Borne Vibration Impact Criteria for Special Buildings

	Ground-Borne Vibration Impact Levels (VdB relative to 1 micro-inch/sec)	
Type of Building or Room	Frequent Events[a]	Occasional or Infrequent Events[b]
Concert Halls	65 VdB	65 VdB
TV Studios	65 VdB	65 VdB
Recording Studios	65 VdB	65 VdB
Auditoriums	72 VdB	80 VdB
Theaters	72 VdB	80 VdB

[a] Frequent is defined as more than 70 vibration events per day.
[b] Occasional or infrequent is defined as fewer than 70 vibration events per day.
Source: FTA 2006

Construction Vibration Criteria

Normally, vibration resulting from a train passby would not cause building damage. However, damage to fragile historic buildings located near the ROW can be a concern if vibration levels approach or exceed 90 VdB. As documented under *Existing Ambient Vibration*, vibration from existing passenger and freight operations on the Caltrain corridor do not reach this level.

Construction activities can result in varying degrees of ground vibration, depending on the equipment and method employed and proximity to receptors. The vibration associated with typical transit construction is not likely to damage building structures, but it could cause cosmetic building damage under unusual circumstances.

Vibrations generated by surface transportation and construction activities are mainly in the form of surface or Raleigh waves. Studies have shown that the vertical component of transportation-generated vibrations is the strongest, and that PPV correlates best with building damage and complaints. Table 3.11-13 summarizes the construction vibration limits shown in FTA guidelines for structures located near the ROW of a transit project.

Table 3.11-13. Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate L_v[a]
I. Reinforced-concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

[a] RMS velocity in decibels (VdB) relative to 1 micro-inch per second
Source: FTA 2006.

3.11.2.3 Impacts and Mitigation Measures

Impact NOI-1a	Expose sensitive receptors to substantial increase in noise levels during construction
Level of Impact	Significant
Mitigation Measures	NOI-1a: Implement Construction Noise Control Plan
Level of Impact after Mitigation	Significant and unavoidable

Noise exposures for all equipment being used in each construction stage were combined together to determine the total noise impact, as shown in Table 3.11-7.

To assess impacts on noise sensitive receptors, a calculation was performed to determine the distances from the construction activities where an 80-dBA exposure would occur over an 8-hour period[7]. The 80-dBA exposure level represents the noise limit for daytime construction at residential land uses. The significance criteria described in Table 3.11-10 for different land uses (residential, commercial, industrial) would apply as well as the different (and lower) criteria for nighttime work. The 80-dBA level was used for the purposes of identifying where daytime impacts would occur on residential receptors only. Impacts at nighttime are considered separately below.

Table 3.11-14 summarizes the distances at which sensitive residential receptors could be potentially exposed to substantial increases in construction noise during daytime. As shown in Table 3.11-6, noise sensitive receptors along the project corridor are located as close as 35 feet from the near track. Impact areas would typically extend beyond this distance.

[7] Construction activities will generally be limited to an 8-hour workday, however there may be periods in which construction activities may require work for periods longer than a typical 8-hour workday.

Table 3.11-14. Exposure to Construction Noise

Construction Stage	Distance to L_{eq} of 80 dBA Based on 8-Hours/Day of Exposure to Construction Noise[a] (feet)
Overhead Contact System Installation	
Foundation installation without casing	30
Foundation installation with casing	35
OCS pole installation	25
OCS wiring	30
Overbridge Protection Barriers	
Installation of barriers to roadway bridges	60
Traction Power Substations, Switching Station, and Paralleling Stations	
Ground Clearing Stage – one site only	75
Ground grade	55
Concrete foundations	80
Electrical equipment installation	70

Note:

[a] Distances are measured from the center of the noise producing activities associated with the construction phase. Construction activities will generally be limited to an 8-hour workday, however there may be periods in which construction activities may require work for periods longer than a typical 8-hour workday.

Source: Parsons 2008.

Noise sensitive land uses adjacent to construction lay-down or staging areas could also experience construction noise impacts. These are areas where construction equipment and materials are stored and accessed during the construction period. At the time of this study, specific locations and details of the lay-down areas were unknown. If lay-down areas are selected within 90 feet of a residential area, noise impacts could result.

Because commercial and industrial land uses are less sensitive to noise, daytime construction impacts would likely only occur when construction is immediately adjacent to commercial land uses. Daytime impacts are not likely to occur on adjacent industrial land uses.

Nighttime construction near residential uses would have larger impacts than daytime construction would have. The distance to the 70 dBA residential nighttime criteria would be less than shown in Table 3.11-14. The number of residences affected by nighttime construction would be greater than the number of residences impacted by daytime construction noise with the same noise level.

Although the measures specified in Mitigation Measure NOI-1a would generally reduce the construction noise levels, the measures would not necessarily guarantee that sensitive residential receptors would not be exposed to noise levels exceeding the 80 dBA limit during the day or the 70 dBA limit at night. In specific, given the active railroad, it is probable that construction near some residential areas will have to be conducted at night to avoid disruption of passenger rail operations and to complete the project on schedule. Furthermore, at TPFs, a temporary sound wall may be effective, but in many cases (such as OCS pole installation) the nature of the construction work makes use of such sound walls infeasible.

Construction-related noise would be short-term and would cease after the construction is completed. Still, even with mitigation, the impact of temporary construction-related noise on nearby noise sensitive receptors would remain a significant and unavoidable impact, in particular where heavy construction would occur immediately adjacent to residences and where construction would occur at night near residences.

Mitigation Measure NOI-1a: Implement Construction Noise Control Plan

A noise control plan that incorporates, at a minimum, the following best practices into the construction scope of work and specifications to reduce the impact of temporary construction-related noise on nearby noise sensitive receptors shall be prepared and implemented.

- An active community liaison program shall be established. The community liaison program will keep residents informed about construction plans so residents may plan around noise or vibration impacts and will provide a conduit for residents to express any concerns or complaints.
- Contractors shall be required to use newer equipment fitted with the manufacturers' recommended noise abatement measures, such as mufflers, engine covers, and engine vibration isolators intact and operational. Newer equipment will generally be quieter in operation than older equipment. All construction equipment shall be inspected at periodic intervals to ensure proper maintenance and presence of noise control devices (e.g., mufflers and shrouding). Electric or "quiet" equipment shall be used for generators, compressors, and other construction equipment where feasible.
- Contractors shall employ construction methods or equipment that will provide the lowest level of noise and ground vibration impact near residences and consider alternative methods that are suitable for the soil condition. The contractor shall be required to select construction processes and techniques that create the lowest noise levels.
- Truck loading, unloading, and hauling operations shall be conducted so that noise and vibration are kept to a minimum by carefully selecting routes to avoid going through residential neighborhoods to the greatest possible extent.
- Ingress and egress to and from the staging area shall be on collector streets or higher street designations (preferred), and through routes for trucks will be designed to the extent feasible to minimize the frequency of backup alarm sound.
- Idling equipment shall be turned off whenever feasible.
- When practicable, temporary noise barriers will be used to protect sensitive receptors against excessive noise from construction activities. Partial enclosures around continuously operating equipment or temporary barriers along construction boundaries will be considered.
- Construction activities within residential areas will be minimized during evening, nighttime, weekend, and holiday periods to the extent feasible.
- Noise and vibration monitoring shall be conducted to verify compliance with the noise limits. Independent monitoring should be performed to check compliance in particularly sensitive areas. Contractors will be required to modify and/or reschedule their construction activities if monitoring determines that maximum limits are exceeded at residential land uses.

Impact NOI-1b	Expose sensitive receptors to substantial increase in noise levels from Proposed Project operations
Level of Impact	Significant
Mitigation Measures	NOI-1b: Conduct site-specific acoustical analysis of ancillary facilities based on the final mechanical equipment and site design and implement noise control treatments where required
Level of Impact after Mitigation	Less than significant

Train Operations

Operational noise impact from proposed EMU train operations is evaluated based on the FTA guidelines and noise impact criteria described in Section 3.11.2.2, *Thresholds of Significance*. The FTA noise impact criteria are based on comparison of the existing outdoor noise levels and the future outdoor noise levels from the Proposed Project operations in combination with the existing ambient noise. The existing ambient noise levels at representative analysis sites are described in Section 3.11.2.1, Methods for Analysis, and summarized in Table 3.11-6. These noise levels include existing Caltrain, freight rail, other tenant railroads and non-railroad ambient noise sources. The projected future train noise levels resulting from the Proposed Project were added to the existing ambient noise level to calculate a total future noise level and determine the Proposed Project's noise increase. The applicable FTA impact criteria, as shown in Figures 3.11-6 and 3.11-7, were determined for each receptor based on the total existing noise level calculated for each site.

Operational train noise impacts would include both a decrease in train noise, because EMUs are quieter than corresponding diesel locomotives, and an increase in train noise, primarily during peak hours due to the Proposed Project's increase in Caltrain service. Operational train noise projections and impacts at each of the representative sites are presented in Table 3.11-15 and can be summarized as follows:

- In 33 study locations, the positive effect of quieter EMUs would outweigh the influence of increased horn noise based on comparing No Project with Proposed Project conditions.
- At eight locations, the adverse effects of increased horn noise would outweigh the positive effect of quieter EMUs, and future noise levels under the Proposed Project would be slightly higher than existing noise levels but less than the FTA thresholds.
- At eight locations, the positive effect of quieter EMUs would be offset by the increase in horn noise such that noise conditions would not change.

As shown in Table 3.11-15, there are no study locations where noise increase would exceed the FTA moderate impact or severe impact level. Therefore, Proposed Project operations would have a less-than-significant impact along the Caltrain corridor.

As discussed in Section 4.1, *Cumulative Impacts*, due to future cumulative train service increases along the corridor, future cumulative train operational noise level increases would be greater than the project-level increases discussed in this section and are considered significant. See Section 4.1 for discussion of cumulative impacts.

1 **Table 3.11-15. Noise Levels and Impacts from Train Operation**

					Existing	Proposed Project Operation		FTA Impact Criteria		
Receptor Site No	Side of Alignment	Land Use[a]	Distance to Receptor (feet)	Measurement Site ID	Total Ambient Noise Exposure at Receptor[b] L_{dn} (dBA)	Total Ambient Noise Exposure at Receptor[c] L_{dn} (dBA)	Increase (Proposed minus Existing) Noise (dBA)	Moderate (dBA)	Severe (dBA)	Exceed Criteria
1	W	MFR	110	N32	69	69	-0.2	1.1	2.9	No
2	E	SFR	80	N33	70	70	-0.2	1.0	2.8	No
3	E	SFR	90	N32	70	70	-0.2	1.0	2.8	No
4	E	SFR	120	N31	69	69	0.0	1.1	2.9	No
5	W	SFR	110	R05	76	75	-0.5	0.3	2.1	No
6[d]	E	MFR	50	R07	77	75	-2.3	0.3	2.0	No
7[d]	W	SFR	120	R07	74	72	-1.6	0.5	2.3	No
8[d]	E	SFR	100	N53	74	72	-2.3	0.5	2.3	No
9[d]	W	SFR	150	N53	72	70	-2.4	0.8	2.5	No
10	W	SFR	170	N26	67	67	-0.1	1.2	3.2	No
11	E	MFR	160	N25	71	71	0.1	1.0	2.6	No
12	W	SFR	90	R12	72	72	0.0	0.8	2.5	No
13	W	SFR	150	N50	68	68	-0.1	1.2	3.1	No
14	W	SFR	160	R14	70	70	0.1	1.0	2.8	No
15	W	SFR	190	N22	70	70	0.0	1.0	2.8	No
16	E	SFR	160	N22	71	71	0.1	1.0	2.6	No
17	W	SFR	40	R18	76	76	0.0	0.3	2.1	No
18	E	SFR	70	R18	72	72	0.0	0.8	2.5	No
19	W	MFR	110	N47	73	73	0.1	0.6	2.4	No
20	W	SFR	85	N20	67	67	-0.4	1.2	3.2	No
21	E	SFR	100	N19	72	72	-0.1	0.8	2.5	No
22	E	MFR	120	R22	70	70	-0.2	1.0	2.8	No
23	E	MFR	120	N18	73	73	0.0	0.6	2.4	No
24	E	SFR	100	N17	70	70	0.0	1.0	2.8	No
25	E	SFR	90	N16	73	73	0.1	0.6	2.4	No
26	E	SFR	50	N47	76	76	0.1	0.3	2.1	No
27	W	MFR	110	R27	69	69	-0.3	1.1	2.9	No
28	E	SFR	50	N14	72	72	-0.3	0.8	2.5	No
29	W	SFR	60	N13	70	70	-0.2	1.0	2.8	No
30	E	SFR	65	N13	70	70	-0.2	1.0	2.8	No
31	E	MFR	175	N45	67	67	-0.1	1.2	3.2	No
32	W	MFR	100	N44	68	68	-0.2	1.2	3.1	No
33	E	SFR	120	N42	69	69	-0.3	1.1	2.9	No
34	W	SFR	40	R34	72	72	-0.4	0.8	2.5	No
35	E	MFR	160	N10	76	76	-0.4	0.3	2.1	No
36	W	SFR	50	R36	78	78	0.1	0.2	1.8	No
37	E	SFR	150	N9	75	75	-0.3	0.4	2.2	No
38	W	MFR	110	N8	73	73	-0.3	0.6	2.4	No
39	E	SFR	150	N39	72	72	-0.1	0.8	2.5	No
40	E	SFR	75	N7	68	68	-0.4	1.2	3.1	No

					Existing	Proposed Project Operation		FTA Impact Criteria		
Receptor Site No	Side of Alignment	Land Use[a]	Distance to Receptor (feet)	Measurement Site ID	Total Ambient Noise Exposure at Receptor[b] L_{dn} (dBA)	Total Ambient Noise Exposure at Receptor[c] L_{dn} (dBA)	Increase (Proposed minus Existing) Noise (dBA)	Moderate (dBA)	Severe (dBA)	Exceed Criteria
41	E	MFR	80	N7	70	70	-0.2	1.0	2.8	No
42	E	SFR	80	N6	71	71	-0.1	1.0	2.6	No
43	W	MFR	75	N6	71	71	-0.2	1.0	2.6	No
44	W	MFR	85	R44	71	72	0.6	1.0	2.6	No
45	W	SFR	110	N4	68	68	-0.2	1.2	3.1	No
46	W	SFR	95	N37	68	68	-0.3	1.2	3.1	No
47	W	SFR	95	N3	68	68	-0.3	1.2	3.1	No
48	W	SFR	60	R48	81	81	0.0	0.1	1.0	No
49	E	SFR	50	R49	71	70	-0.8	1.0	2.6	No

Notes:

[a] SFR: Single-Family Residence; MFR: Multi-Family Residence

[b] Existing total noise exposure is based on representative noise measurement data, as prescribed for Table 3.11-6.

[c] Proposed total noise exposure is the result of combining future Caltrain noise with existing non-railroad noise and freight train noise, as prescribed for Table 3.11-6.

[d] R6 and R7 are near San Bruno Avenue grade crossing in San Bruno. R8 and R9 are near Angus Avenue. The San Bruno Grade Separation project will eliminate the at-grade crossings at San Bruno, San Mateo and Angus Avenues and, thus, the need for routine horn soundings at this location will be less than under existing conditions. Train operators will still sound train horns when there are safety reasons for doing so, but without the at-grade crossings there will not be a need to sound at the crossings themselves, which will be an improvement over existing conditions.

Source: WIA 2013.

Traction Power Facilities

In addition to the noise generated by the proposed Caltrain passenger rail operations, the electrical traction power substations and facilities (ancillary facilities) would generate stationary noise. Noise sensitive receptors that may be potentially impacted by these new stationary noise sources were identified using the screening distance of 250 feet. As explained in Section 3.11.2.1, *Methods for Analysis*, FTA reference levels were used to calculate the total project noise level at the receptors identified within the screening distance.

Operational noise levels were calculated in order to predict the total Proposed Project noise levels with the ambient noise at the receptors, accounting for both changes resulting from EMU train operations (where TPFs are located near the Caltrain ROW) and the new ancillary facility stationary noise sources. The noise impact predictions for ancillary facilities are shown in Table 3.11-16. Noise impacts would depend on facility layout. This analysis is conservative because distances were calculated using the outer footprint of that facility that is the minimum distance to the nearest sensitive receptor, even though the actual distance from the noise generating sources to the sensitive receptor would be greater in many cases. The noise analysis results indicate that the operation of the following ancillary facilities would result in an increase in ambient noise levels exceeding FTA moderate impact criteria at noise sensitive receptors only at the following facility

- **TPS1 Option 3**: Traction Power Supply Substation TPS1 Option 3 is located on vacant land adjacent to commercial property on West Harris Avenue in South San Francisco. The Motel 6, at 111 Mitchell Avenue, South San Francisco, is within 125 feet. The projected noise increase would be 1.2 dBA, at a distance of 70 feet, exceeding the FTA Moderate Impact threshold.

Table 3.11-16. Noise Levels and Impacts from Ancillary Facility Operation

Facility[a]	Receptor Address[b]	Land Use[c]	Receptor Distance to Ancillary Facility (feet)	Receptor Distance to Caltrain Near Track (feet)	Existing Total Noise Exposure[d] (Ldn, dBA)	With Project: Freight + All Other Ambient Noise (Ldn, dBA)	With Project: Project Train Noise[e] (Ldn, dBA)	With Project: Substation Noise (Ldn, dBA)	With Project: Total Noise Exposure[f] (Ldn, dBA)	With Project: Increase (Ldn, dBA)	FTA Impact Criteria: Moderate (Noise Exposure Increase)	FTA Impact Criteria: Severe (Noise Exposure Increase)	Impact Type (number of impacts)[g]
PS1	211 Pennsylvania Street, San Francisco	MFR	120	255	69	69	55	62	70	0.8	1.1	2.9	--
PS2	110 Blanken Ave. / 233 Tunnel Ave., San Francisco	MFR / SFR	150	120	69	66	66	60	70	0.5	1.1	2.9	--
	2189 Bayshore Blvd., San Francisco	SFR	180	150	68	67	58	59	68	0.3	1.2	3.1	--
	100 Lathrop Avenue, San Francisco	SFR	240	120	69	66	66	56	69	0.2	1.1	2.9	--
TPS1-Opt.1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS1-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS1-Opt. 3	111 Mitchel Avenue, San Francisco	Hotel	70	1400	72	72	44	67	73	1.2	0.8	2.5	MI (1)
PS3	1283 California Drive, San Francisco	SFR	120	165	73	71	66	62	73	-0.1	0.6	2.4	--
PS4-Opt. 1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
PS4-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
SWS1	2690 Westmoreland Ave., Redwood City	SFR	180	110	69	67	62	59	68	-0.7	1.1	2.9	--
PS5-Opt. 2	2617 Alma Street, Palo Alto	MFR	180	160	76	75	66	59	75	-0.7	0.3	2.1	--
PS5-Opt. 1	102 Greenmeadow Way, Palo Alto	SFR	100	140	74	73	67	64	74	0.4	0.5	2.3	--
	256 Monroe Dr., Palo Alto	SFR	130	100	75	74	69	62	75	0.2	0.4	2.2	--

						With Project					FTA Impact Criteria		
Facility[a]	Receptor Address[b]	Land Use[c]	Receptor Distance to Ancillary Facility	Receptor Distance to Caltrain Near Track	Existing Total Noise Exposure[d]	Freight + All Other Ambient Noise	Project Train Noise[e]	Substation Noise	Total Noise Exposure[f]	Increase	Moderate	Severe	Impact Type (number of impacts)[g]
			feet	feet	Ldn, dBA						Noise Exposure Increase		
PS6-Opt. 2	105 N Taaffe Street, Sunnyvale	SFR	100	80	71	68	67	64	72	0.6	1.0	2.6	--
PS6-Opt. 1	100 N Murphy Ave, Sunnyvale	SFR	70	110	75	73	68	67	75	0.1	0.4	2.2	--
TPS2-Opt. 1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS2-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS2-Opt. 3	[none]	--	--	--	--	--	--	--	--	--	--	--	--
PS7	[none]	--	--	--	--	--	--	--	--	--	--	--	--

[a] PS: Paralleling Station; TPS: Traction Power Supply Substation; SWS: Switching Station

[b] Use of [none] indicates no noise sensitive receivers within 250 feet of the facility.

[c] SFR: Single-Family Residence; MFR: Multi-Family Residence

[d] Existing Total Noise Exposure is based on representative noise measurement data as discussed in Appendix C.

[e] Project Train Noise levels shown are for year 2020 schedule.

[f] Future Total Noise Exposure is result of combining substation noise with future total noise levels (i.e., ambient + Project train noise + Freight train noise) calculated for the receptor based on methodology discussed in Appendix C.

[g] SI: Severe Impact; MI: Moderate Impact; Indicated in parentheses is the total number of similarly exposed land uses within the screening distance that are impacted. Based on FTA criteria.

Source: WIA 2014 (Appendix C).

Because the operation of one of ancillary facilities would cause an increase in ambient noise levels that exceed the FTA moderate impact criteria, operational noise impact from ancillary facilities is considered a significant impact. With the implementation of Mitigation Measure NOI-1b, impacts related to the one TPF facility (TPS1, Option 3) would be reduced to a less-than-significant level.

Mitigation Measure NOI-1b: Conduct site-specific acoustical analysis of ancillary facilities based on the final mechanical equipment and site design and implement noise control treatments where required

A qualified acoustical consultant shall review final mechanical equipment and site design and calculate expected exterior noise levels at adjacent noise sensitive receptors to limit the substation noise at the TPS1, Option 3 site if selected for a substation site. If TPS1, Option 1 or TPS1, Option 2 sites are selected instead, then this mitigation will not be required.

A moderate noise impact has been identified at TPS1 Option 3 based on the FTA methodology and reference data. If the projected noise contribution from the substation is reduced by at least 2.8 dBA the impact will be eliminated. A performance criterion which limits the substation noise to a maximum noise level of 60 dBA at 50 feet, or no more than 63 dBA Ldn at the closest nearby noise sensitive receptor (111 Mitchel Avenue) would be sufficient to eliminate the moderate noise impact.

TPS1, Option 3 noise levels shall comply with IEEE national standards and guidelines for electrical power facilities. Station layouts and specific noise control measures will be developed during the design phase to minimize noise impacts resulting from the TPFs. Such noise control measures may include the following:

- Locate electrical noise-generating equipment farther away from the property lines of noise sensitive sites, if at all possible.
- Consider the use of special enclosures for all transformers to mitigate the associated low frequency noise impacts.
- Reduce potential noise impacts from the ventilation system for switchgear by using acoustical louvers, line duct silencers, and hoods on the vent openings, and/or by locating vents at the side of the building that is not facing residences.

Impact NOI-2a	Expose sensitive receptors to substantial increase in ground-borne vibration levels during construction.
Level of Impact	Significant
Mitigation Measure	NOI-2a: Implement Construction Vibration Control Plan
Level of Impact after Mitigation	Less than significant

Two types of construction vibration impact were analyzed: 1) Human annoyance and 2) building damage. Human annoyance occurs when construction vibration rises significantly above the threshold of human perception for extended periods of time. Building damage can be cosmetic or structural. Ordinary buildings that are not particularly fragile would not experience any cosmetic damage (e.g., plaster cracks) at distances beyond 30 feet. This distance can vary substantially depending on the soil composition and underground geological layer between vibration source and receiver. In addition, not all buildings respond similarly to vibration generated by construction equipment. The potential for vibration annoyance and building damage was analyzed for major vibration-producing construction equipment that would be used for the Proposed Project.

To assess vibration impacts, calculations were performed to determine the distances at which vibration impacts would occur according to the criteria discussed in Section 3.11.2.2, *Thresholds of Significance*, and the FTA procedures. The distances shown in Table 3.11-17 are the maximum distances at which short-term construction vibration impacts may occur. As shown in Table 3.11-6, some sensitive receptors are located as close as 35 feet from the near track and could be exposed to elevated vibration levels from various construction activities within the existing Caltrain ROW. Damage to wood framed buildings (those most susceptible to vibration damage) could occur if construction equipment were to operate within the distances shown in Table 3.11-17.

It is expected that ground-borne vibration from construction activities would cause only intermittent localized disturbance along the rail corridor. Although processes such as earth moving with bulldozers or the use of vibratory compaction rollers can create annoying vibration, there should be only isolated cases where it is necessary to use this type of equipment in close proximity to residential buildings.

Table 3.11-17. Construction Equipment Vibration Impact Distances

Equipment	Distance to Vibration Annoyance[a] in feet	Distance to Vibration Potential Building Damage[b] in feet
Large bulldozer	45	<10
Loaded trucks	40	<10
Small bulldozer	--	<10
Auger/drill rigs	45	<10
Vibratory hammer	130	25
Vibratory compactor/roller	85	15

[a] This is the distance at which the RMS amplitude velocity level is 80 VdB or less at the inside of the building structure (see Section 3.11.2.2). When propagating from the ground surface to the building structure foundation, there is a vibratory coupling loss of approximately 5 dB; however, this loss is offset by the building amplification in light-frame construction. Thus, no additional adjustments are applied.

[b] This is the distance at which the peak particle velocity is 0.50 inch/sec or less.

Source: Parsons 2008.

Given that the closest structures are less than 25 feet from the Caltrain ROW, it is possible that construction activities involving vibratory hammer or vibratory compactor/roller operations occurring at the edge of or slightly outside of the current ROW could result in vibration damage. If vibratory pile piling is conducted less than 25 feet from buildings or vibratory rolling/compacting conducted less than 15 feet from buildings, then damage from construction vibration may occur which would be a significant impact. Other sources of construction vibration are not expected to generate high enough vibration levels for damage to occur. A particular area of concern would be pile driving near historic station structures along the Caltrain ROW. With implementation of Mitigation Measure NOI-2a, vibration impacts would be avoided or minimized; if building damage occurs due to construction then repairs would be made or compensation provided. With implementation of Mitigation Measure NOI-2a, impacts resulting from construction vibration structural damage would be less than significant.

Residents and other sensitive receptors are also located within the annoyance distances in Table 3.11-17 and, thus, could be significantly annoyed due to construction vibration. The effect would be more acute with equipment with high vibration potential, such as vibratory hammers or vibratory compactor/rollers. With implementation of Mitigation Measure NOI-2a, impacts resulting from construction vibration annoyance would be less than significant.

Mitigation Measure NOI-2a: Implement Construction Vibration Control Plan

A Construction Vibration Control Plan that includes, at a minimum, the following procedures to minimize the potential for building damage from construction vibration shall be prepared:

- Where feasible, avoid placing OCS poles within 25 feet of structures or use alternative construction methods for pile driving (such as augurs) to minimize potential vibration damage.

- Where vibratory compacting/rolling is proposed within 15 feet of structures, utilize alternative equipment (such as non-vibratory rollers) to minimize potential vibration damage.
- Where pile driving is proposed within 50 feet of structures or vibratory compacting/rolling within 25 feet, preconstruction surveys shall be conducted to document the existing condition of buildings in case damage is reported during or after construction.
- Damaged buildings due to project construction shall be repaired or compensation paid.

The Construction Vibration Control Plan shall also include, at a minimum, the following procedures to minimize the potential for annoyance from construction vibration:

- When possible, limit the use of construction equipment that creates high vibration levels near residential structures.
- Require vibration monitoring during vibration-intensive activities.
- Where feasible, plan the hours of vibration-intensive equipment, such as vibratory pile drivers or vibratory rollers, so that impacts on residents are minimal (e.g., weekdays during daytime hours only, when as many residents as possible are away from home).

Impact NOI-2b	Expose sensitive receptors to substantial increase in ground-borne vibration levels from Proposed Project operation
Level of Impact	Less than significant

As presented in Table 3.11-4, existing vibration levels for Caltrain's diesel service at 50 feet from the outermost track vary from 72 to 80 VdB, depending on local site conditions and speed. As presented in Table 3.11-5, existing vibration levels for freight at 100 feet from the outermost track vary from 73 to 81 VdB. These existing levels exceed FTA annoyance thresholds of 72 VdB for immediately adjacent residences and of 75 VdB for immediately adjacent institutional buildings, but these levels do not approach structural damage thresholds.

As discussed above, the impact criteria for vibration are an increase of existing vibration levels by at least 3 VdB or a doubling of existing train vibration events.

To assess the potential for vibration impact of the Proposed Project, factors that would have the potential to increase vibration levels were reviewed. Factors that would potentially cause changes to the wayside vibration levels include vehicle vibration characteristics, train speed, distance between receptor and track centerline, and track structure type. The factors above would remain the same as existing conditions with the one exception that the EMU vehicles may have different vibration characteristics than the existing locomotive powered trains. Therefore, for any given receptor, all factors would remain the same with the exception of the EMU vehicle.

Using FTA vibration reference levels (FTA 2006) for rapid transit trains (which FTA guidance recommends for electric commuter trains), vibration levels with Caltrain EMUs could be 73 Vdb at 50 feet from the outermost track at 50 mph. Adjusting to the 79 mph speed, the vibration levels for the new Caltrain EMUs could be 77 VdB. This level is within the range of existing vibration levels along the Caltrain corridor noted above.

Although the exact unsprung weight of the EMU vehicles isn't known at this time, it would not be significantly greater than the weight of the existing Caltrain vehicles. Therefore, the EMU vehicles would not result in greater vibration levels than the existing train consists. Furthermore, because there would be no diesel locomotives associated with EMU trains, vibration caused by existing locomotives would be reduced.

The Proposed Project would add 22 trains per day to the San Francisco to San Jose Diridon segment and 8 trains per day to the San Jose Diridon to Tamien segment, which would not result in a doubling of existing train vibration events.

New traction power facilities would not generate significant vibrations.

Thus, operational vibration impacts would be less than significant.