

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.

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

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

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

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

20 **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	<p>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.</p> <p>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.</p>
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

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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.

- 1 • A-Weighted Decibel (dBA). An overall frequency-weighted sound level in decibels that
2 approximates the frequency response of the human ear. The dBA scale is the most widely used
3 for environmental noise assessments.
- 4 • Maximum Sound Levels (L_{max}). The maximum sound level measured during the measurement
5 period.
- 6 • Minimum Sound Levels (L_{min}). The minimum sound level measured during the measurement
7 period.
- 8 • Equivalent Sound Level (L_{eq}). The equivalent steady state sound level that in a stated period of
9 time would contain the same acoustical energy. The 1-hour A-weighted equivalent sound level
10 (L_{eq} 1h) is the energy average of A-weighted sound levels occurring during a 1-hour period.
- 11 • Day-Night Level (L_{dn}). The energy average of the A-weighted sound levels occurring during a 24-
12 hour period, with 10 dB added to the A-weighted sound levels occurring between 10 p.m. and 7
13 a.m.
- 14 • Community Noise Equivalent Level (CNEL). The energy average of the A-weighted sound levels
15 occurring during a 24-hour period, with 5 dB added to the sound levels occurring during the
16 period from 7 p.m. to 10 p.m. and 10 dB added to the sound levels occurring during the period
17 from 10 p.m. to 7 a.m.
- 18 • Vibration Velocity Level (or Vibration Decibel Level, VdB). The root mean square velocity
19 amplitude for measured ground motion expressed in VdB.
- 20 • Peak Particle Velocity (PPV). A measurement of ground vibration defined as the maximum speed
21 at which a particle in the ground is moving, expressed in inches per second (in/sec).

22 **Overview of Sound and Noise**

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

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

$$34 \quad L_p = 20 \times \log_{10}(p/p_{ref}), \text{ dB}$$

35 where “p” is the root-mean-square (RMS) pressure and “ p_{ref} ” is the reference pressure¹.

36 Decibels are used instead of actual pressure units to account for the extremely large range of sound
37 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*.

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

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

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

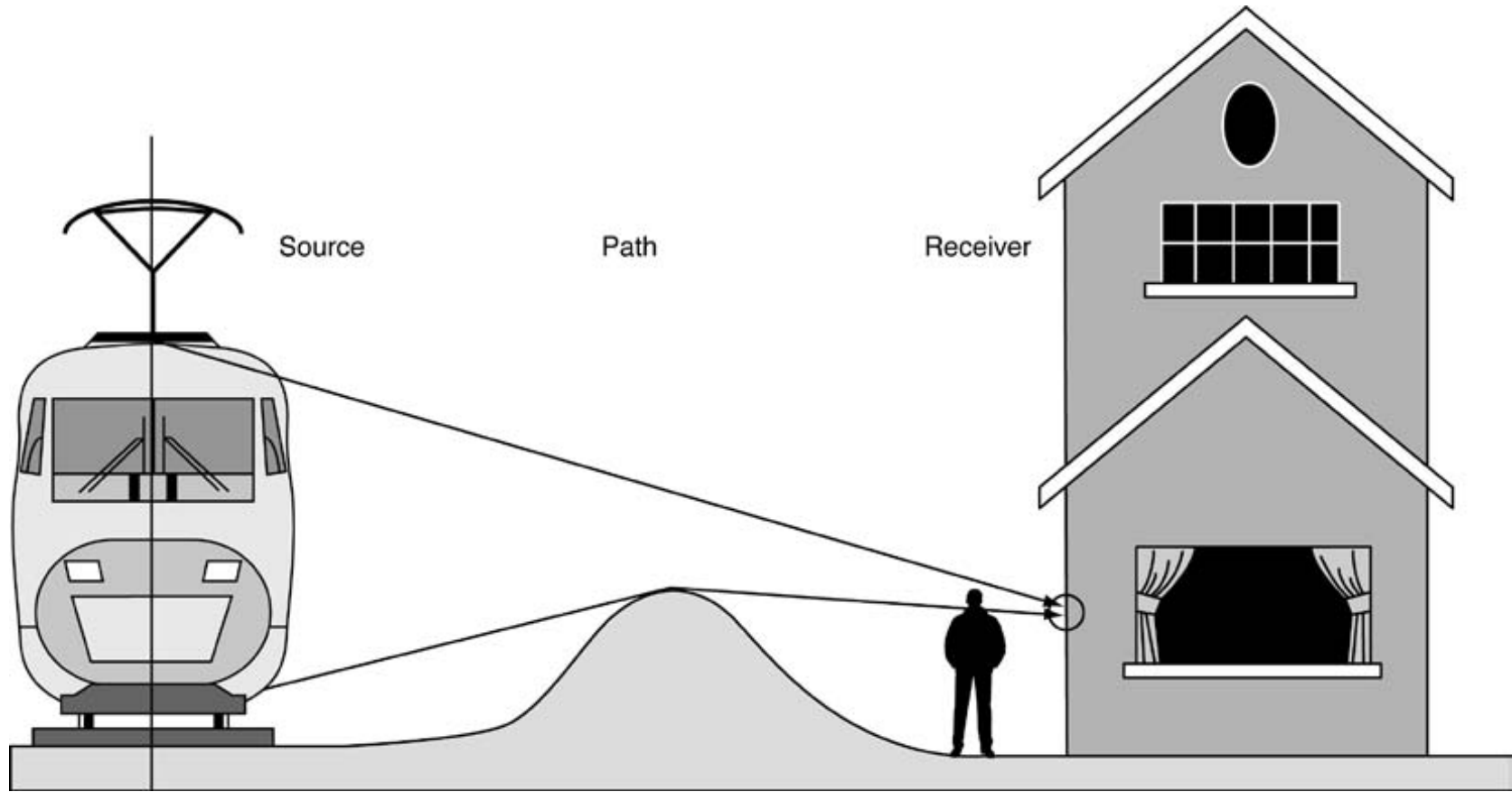
17 The pitch describes the character and frequency content of noise. It is expressed in terms of the rate
18 of fluctuation of the air pressure in cycles per second or Hertz (Hz). The average human ear is
19 sensitive to noise frequencies between 20 Hz and 20,000 Hz. However, the human hearing system
20 does not respond equally to all frequencies, and it is more sensitive to midband frequencies (e.g.,
21 500 to 2,000 Hz). Thus, the A-weighting system de-emphasizes the low and very high frequency
22 components of the sound in a manner similar to the response of the average human ear. The A-
23 weighted sound level (dBA) is commonly used to quantify environmental noise because it correlates
24 well with human response and is expressed in terms of a single number. Figure 3.11-2 provides a
25 comparison of noise levels of transit and non-transit sources. This figure also provides typical noise
26 levels found in urban settings.

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

35 **Overview of Ground-Borne Noise and Vibration**

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

41 Although vibration velocity can be quantified in units of inches per second, it is common to use the
42 velocity level to quantify vibration to cover the wide range of magnitudes that can be encountered.
43 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

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

2 where “v” is the RMS velocity amplitude and “v_{ref}” is the reference velocity amplitude².

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

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

14 Vibration caused by the transit structure, such as at-grade ballast and tie track, radiates energy into
15 the adjacent soil in the form of different types of waves³ that propagate through the various soil and
16 rock strata to the foundation of nearby buildings. Buildings respond differently to ground vibration
17 depending on the type of foundation, the mass of the building, and the building interaction with the
18 soil. Once inside the building, vibration propagates throughout the building with some attenuation
19 with distance from the foundation, but often with amplification due to floor resonances. The basic
20 concepts for ground vibration generated by a rail system are illustrated in Figure 3.11-3.

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

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

33 **Existing Ambient Noise**

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

² The standard reference quantity for vibration velocity used by FTA is 1 x 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.

1 schools, and hospitals. Noise sensitive receptors are located at distances that are as close as 40 feet
2 from the Caltrain ROW

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

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

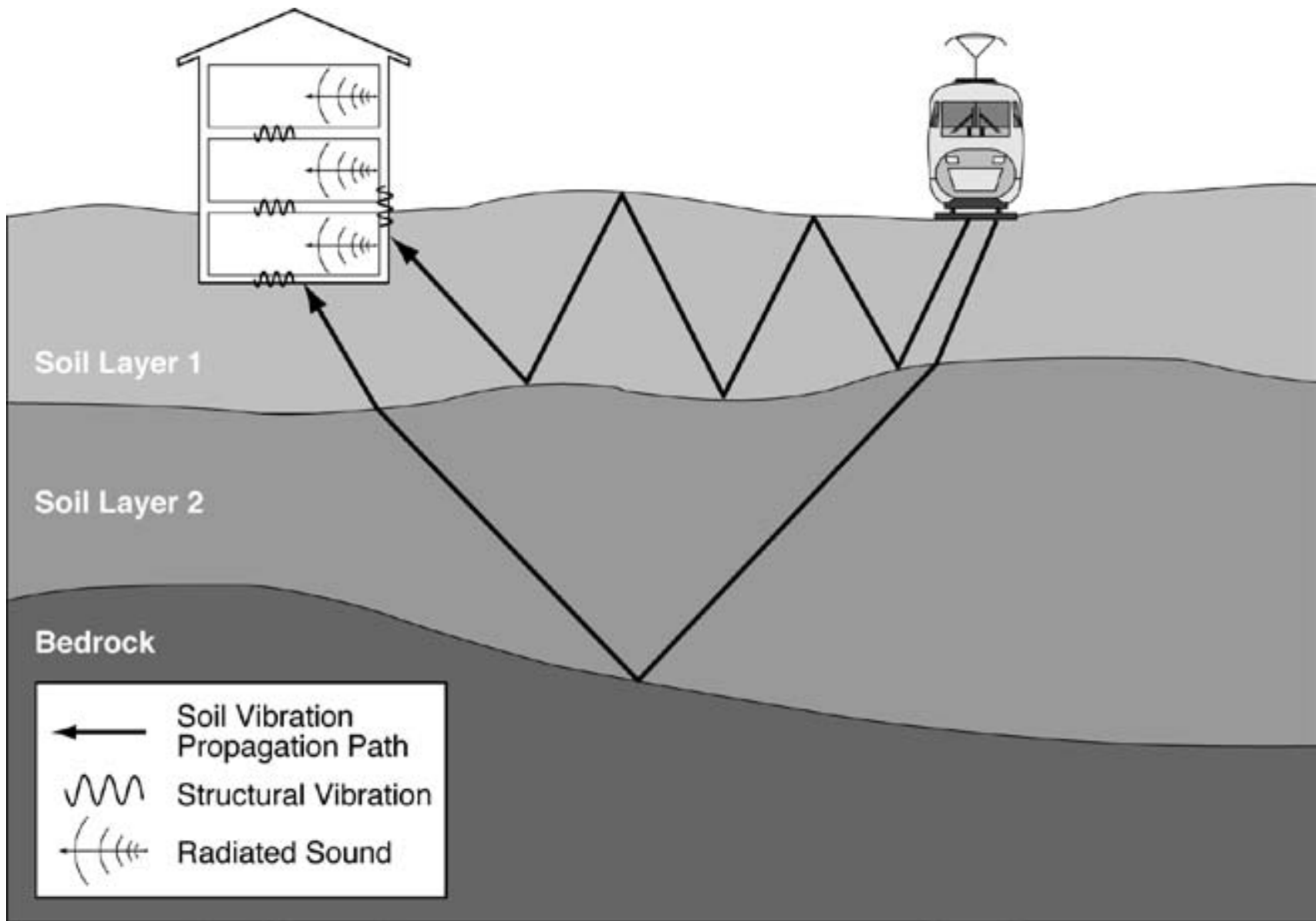
13 **Field Measurements**

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

18 In addition, WIA previously conducted an extensive noise survey along the Caltrain alignment for
19 the California high-speed rail (HSR) project (Wilson, Ihrig and Associates 2010). The survey
20 included long-term noise measurements of 1 to 3 days at 35 sites from October 16, 2009 to
21 December 2, 2009 and at additional 19 locations from March 4, 2010 to March 12, 2010. These
22 measurements were taken within the Caltrain corridor and are relatively recent, and, thus, are
23 suitable for this analysis. The measurement results for the HSR project are summarized in Table
24 3.11-3.

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

33 The results of the existing ambient noise surveys are discussed in the following section. Tables 3.11-
34 2 and 3.11-3 show the noise measurement results for the 2013 and 2009–2010 noise surveys,
35 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

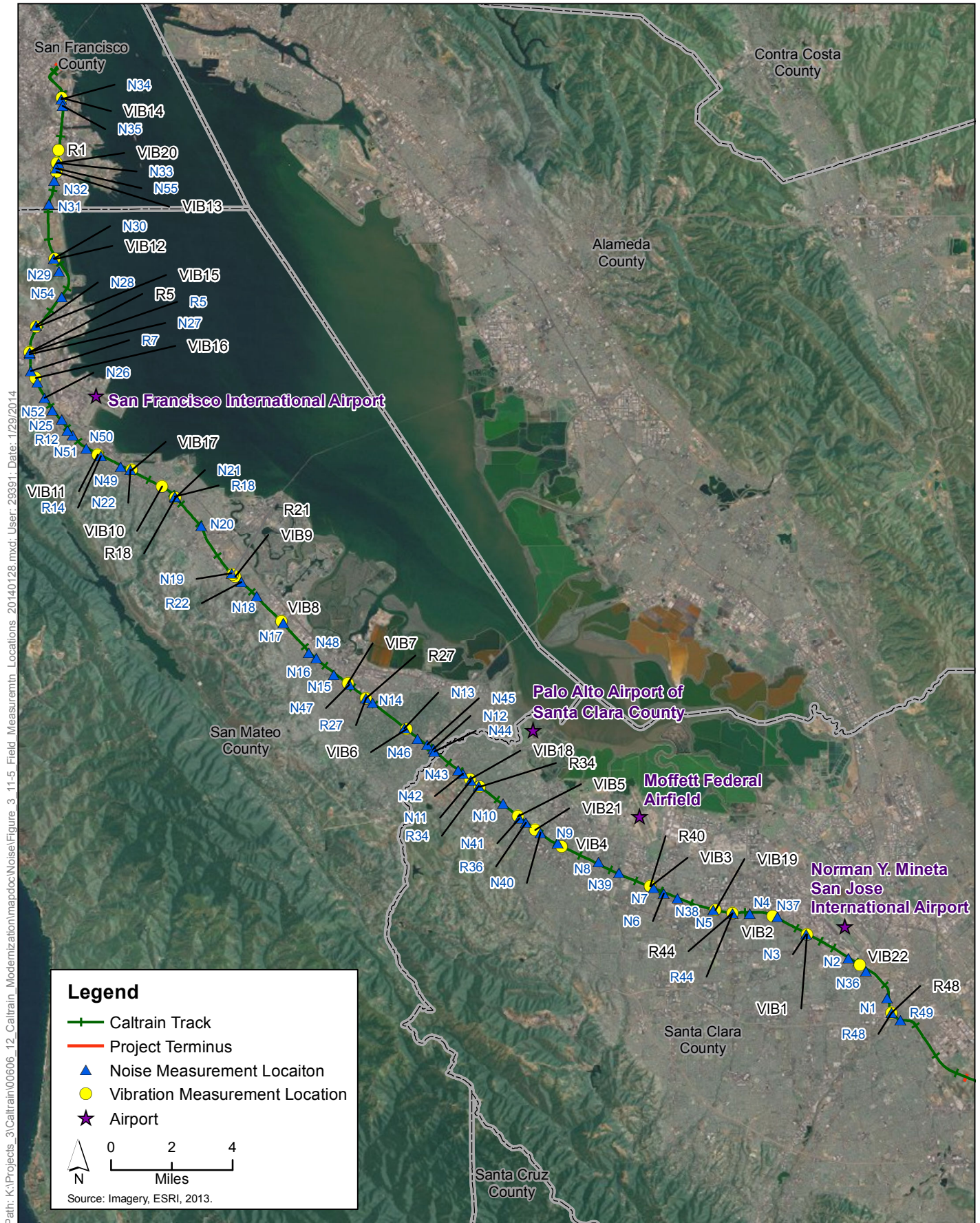


Figure 3.11-5
Overview Map of All Field Measurement Locations
 Peninsula Corridor Electrification Project

1 **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.

2

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.

1

2 **Existing Noise Levels**

3 **San Francisco**

4 Existing noise levels were characterized at six locations in the vicinity of the Caltrain corridor as
 5 part of the 2009–2010 survey: N34, N35, N33, N55, N32, and N31 for the HSR project. The ambient
 6 condition corresponds to that of an urban setting. Sources of ambient noise are Caltrain trains,
 7 freight trains, vehicles on I-280 and U.S. 101, and local motor vehicle traffic. The average L_{dn} ranged
 8 from 64 dBA to 74 dBA depending on the location. The peak hour L_{eq} levels ranged from 62 dBA to
 9 74 dBA.

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

5 No noise measurements were conducted during 2013 in San Francisco.

6 ***San Mateo County***

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

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

15 Noise measurements were obtained at 28 locations within San Mateo County as part of the 2009–
16 2010 survey: N30, N29, N54, N28, N27, N53, N26, N52, N25, N51, N50, N49, N22, N21, N20, N19,
17 N18, N17, N48, N16, N15, N47, N14, N13, N46, N45, N12, and N44. The average L_{dn} varied from 66
18 dBA to 77 dBA depending on location, distance from the alignment, proximity to grade crossings and
19 other noise sources. Peak hour L_{eq} levels ranged from 64 dBA to 79 dBA.

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

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

34 ***Santa Clara County***

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

40 Noise measurements were obtained at nineteen locations within Santa Clara County as part of the
41 2009–2010 survey: N43, N42, N11, N10, N41, N40, N9, N8, N39, N7, N6, N38, N5, N4, N37, N3, N2,

1 N36, and N1. The average L_{dn} varied from 61 dBA to 77 dBA depending on location, distance from
2 the alignment, proximity to at-grade crossings and other noise sources. Peak hour L_{eq} levels ranged
3 from 60 dBA to 78 dBA. The average L_{dn} levels obtained at N11 and N41 were 61 dBA and 62 dBA,
4 respectively. The average L_{dn} obtained at both N4 and N3 was 63 dBA. N11, N41, N4, and N3
5 measurement locations are representative of the existing ambient noise for single-family residences
6 located on the western side of the Caltrain alignment. However, because noise measurements were
7 obtained in front of the homes (whereas Caltrain noise affects the back of homes) adjustments to the
8 measured noise level are applied in this analysis to determine the noise exposure at the back of the
9 properties.

10 **Existing Ambient Vibration**

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

16 **Field Measurements**

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

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

34 Results of the ambient vibration survey provide not only an indicator of the existing overall
35 vibration levels throughout the Caltrain corridor. Also, because the vibration source (Caltrain) is
36 similar throughout the corridor, the results also indicate the degree of variability in soil vibration
37 characteristics along the alignment. The results of the existing ambient vibration surveys are
38 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 usually between 8 p.m. and 5 a.m. at present.

1 **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
	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)
San Mateo (Cont)				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
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 69-75 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
	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.

1 **Table 3.11-5. Summary of 2009-2010 Vibration Measurement Locations and Ground-Borne Vibration**
2 **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.

1 Existing Vibration Levels

2 *San Francisco*

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

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

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

14 *San Mateo County*

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

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

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

34 In San Mateo, vibration levels were measured in 2013 near receptor site R18, at 140 N. Railroad
35 Avenue. Ground vibration during Caltrain passbys measured up to 83 VdB at a distance of
36 approximately 35 feet from track centerline; up to 77 VdB at 50 feet; and up to 70 VdB at 100 feet.
37 Observed speeds were up to 77 mph for these events. Vibration levels were also measured near
38 receptor site R21 at 2 Antioch Drive. Ground vibration during Caltrain passbys measured up to 80
39 VdB at 35 feet for observed speeds up to 76 mph and up to 77 VdB at 50 feet for observed speeds of
40 70 mph.

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

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

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

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

13 ***Santa Clara County***

14 In Palo Alto, vibration levels were measured in 2013 at receptor site R34 at Peers Park. Ground
15 vibration from Caltrain passbys measured up to 77 VdB at 28 feet, up to 74 VdB at 53 feet and up to
16 66 VdB at 103 feet. Observed speeds for these events were in the low 70 mph.

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

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

28 In Sunnyvale, vibration levels were measured in 2013 at receptor site R40 at 125 N. Mary Avenue.
29 Ground vibration from Caltrain passbys measured up to 77 VdB at 50 feet, up to 72 VdB at 100 feet,
30 up to 70 VdB at 150 feet, and up to 68 VdB at 200 feet. Observed speeds for these events were up to
31 79 mph. For the HSR project, Caltrain passby vibration levels measured 80 VdB at 45 feet and 70
32 VdB at 100 feet at HST VIB19. The location is roughly equidistance between receptor sites R43 and
33 R44 and opposite four active tracks.

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

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

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

5 In San Jose, vibration levels were measured at receptor site R48 at 782 Auzerais Avenue. Ground
6 vibration from Caltrain passbys measured up to 89 VdB at 25 feet, 76 VdB at 50 feet, and 69 VdB at
7 100 feet. Observed speeds were only up to 39 mph.

8 **3.11.2 Impact Analysis**

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

12 **3.11.2.1 Methods for Analysis**

13 **Noise Analysis**

14 The noise analysis follows standard methodological guidelines established by the Federal Transit
15 Administration. The noise model includes the following: train horn noise, noise from the wheel/rail
16 interaction, locomotive engine or propulsion noise and aerodynamic effects. The latter include noise
17 at the train noise, around the wheels and at the pantograph (catenary). At speeds below 150 mph,
18 the aerodynamic noises do not contribute to the overall train noise, and thus they have not been
19 explicitly calculated for this analysis.

20 **Existing Noise Exposures**

21 To determine the potential noise level increase from the Proposed Project, existing noise exposures
22 at noise sensitive receptors along the Caltrain corridor were developed to separate noise from
23 Caltrain operations, freight train operations, and non-railroad ambient sources. The noise exposures
24 resulting from Proposed Project operations were then calculated by adding the noise level from
25 proposed future train operations to the existing non-railroad ambient noise level. Table 3.11-6
26 summarizes the existing noise exposures from Caltrain, freight, and non-railroad ambient sources at
27 representative analysis sites. Locations of the representative receptor sites are listed in Table 3.11-6
28 and are also shown in Attachment C of Appendix C, Noise Study (WIA 2013). The methods for
29 determining existing ambient noise levels for these sources are described below.

30 ***Adjustments to the Measured Ambient Noise Levels***

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

1 discussions of the adjustments to the measured noise levels and how each of the existing ambient
2 noise levels were established for each representative site.

3 ***Existing Caltrain Operations***

4 Existing Caltrain diesel trains were modeled using sound exposure level (SEL) references for diesel
5 locomotives and commuter rail cars provided in the FTA guidelines (Federal Transit Administration
6 2006). The calculations assume each Caltrain train consists of one locomotive and five passenger
7 cars at the existing service level of 92 trains per day (and 5 trains per peak hour per direction) and
8 maximum train speeds up to 79 mph. The FTA model levels were compared to measurements
9 conducted in 2013, and the results confirmed the FTA model values.

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

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

24 ***Existing Freight Train Operations***

25 The freight trains normally operate between 8 p.m. and 5 a.m.⁵ The noise measurement results show
26 clear peaks in the hourly noise levels between 10 p.m. and 5 a.m., and these peaks were attributed to
27 freight activity. The influence of freight activity on L_{dn} levels was investigated by comparing the
28 measured L_{dn} levels (including all hours) with equivalent “non-freight” L_{dn} levels (excluding data
29 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}
30 levels, depending on location, and 2 dBA lower on average. This suggests that freight activity has the
31 effect of increasing the total L_{dn} levels by 1 to 4 dBA, and that the freight noise level is generally
32 within 2 dBA (+ or -) of the Caltrain noise level. In situations where non-rail noise sources dominate,
33 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).

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

Receptor Site No.	City	Location	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	San Francisco	Oakdale Ave and Quint Ave	W	MFR	110	N32	135	69	63	65	65
2	San Francisco	Reddy St and Williams Ave	E	SFR	80	N33	170	70	65	65	66
3	San Francisco	Carr St and Paul Ave	E	SFR	90	N32	135	70	64	66	66
4	San Francisco	Tunnel Ave and Lathrop Ave	E	SFR	120	N31	70	69	66	65	60
5	San Bruno	Herman St and Tanforan Ave	W	SFR	110	R05	85	76	71	73	69
6	San Bruno	Huntington Ave and San Bruno Ave	E	MFR	50	R07	100	77	74	73	67
7	San Bruno	Montgomery Ave and Walnut St	W	SFR	120	R07	100	74	70	71	64
8	San Bruno	1st Ave and Pine St	E	SFR	100	N53	80	74	71	70	64
9	San Bruno	Huntington Ave and Sylvan Ave	W	SFR	150	N53	80	72	69	68	62
10	San Bruno	San Antonio Ave and San Benito Ave	W	SFR	170	N26	180	67	60	62	64
11	Millbrae	Monterey St and Santa Paula Ave	E	MFR	160	N25	150	71	66	66	67
12	Millbrae	Hemlock Ave and Hillcrest Blvd.	W	SFR	90	R12	244	72	68	69	61
13	Burlingame	California Dr and Dufferin Ave	W	SFR	150	N50	140	68	61	63	65
14	Burlingame	California Dr and Mills Ave	W	SFR	160	R14	155	70	66	64	66
15	Burlingame	California Dr and Palm Dr	W	SFR	190	N22	145	70	64	66	66
16	Burlingame	Park Ave and Carolan Ave	E	SFR	160	N22	145	71	66	66	67
17	San Mateo	Grand Blvd and San Mateo Blvd	W	SFR	40	R18	40	76	73	73	60
18	San Mateo	Railroad Ave and Monte Diablo	E	SFR	70	R18	40	72	69	68	56
19	San Mateo	B St and 9th Ave	W	MFR	110	N47	40	73	68	68	69
20	San Mateo	South Blvd and 16th Ave	W	SFR	85	N20	95	67	64	62	60
21	San Mateo	Pacific Blvd and Otay Ave	E	SFR	100	N19	90	72	68	68	65
22	San Mateo	Country Rd and Dale View Ave	E	MFR	120	R22	128	70	65	64	67
23	Belmont	Country Rd and Marine View	E	MFR	120	N18	120	73	68	68	69
24	San Carlos	Country Rd and Springfield Ave	E	SFR	100	N17	85	70	67	66	60
25	Redwood City	D St and Stafford St	E	SFR	90	N16	80	73	70	70	61
26	Redwood City	Cedar St and Main St	E	SFR	50	N47	40	76	73	72	66

Receptor Site No.	City	Location	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)
27	Redwood City	198 Buckingham Ave	W	MFR	110	R27	70	69	65	65	62
28	San Mateo County	Arrowhead Lane and 5th Ave	E	SFR	50	N14	55	72	68	68	65
29	Atherton	Lloyd Dr and Fair Oaks Lane	W	SFR	60	N13	45	70	68	66	51
30	Atherton	Felton Dr and Encinal Ave	E	SFR	65	N13	45	70	68	66	51
31	Menlo Park	Burgess Dr and Alma St	E	MFR	175	N45	130	67	60	60	65
32	Palo Alto	Mitchell Lane and University Ave	W	MFR	100	N44	60	68	65	64	60
33	Palo Alto	Alma St and Lincoln Ave	E	SFR	120	N42	35	69	65	63	65
34	Palo Alto	Residences near Peers Park	W	SFR	40	R34	40	72	70	67	62
35	Palo Alto	Alma St and El Dorado Ave	E	MFR	160	N10	120	76	70	70	73
36	Palo Alto	4237 Park Blvd	W	SFR	50	R36	35	78	74	75	68
37	Mountain View	Central Exp and Thompson Ave	E	SFR	150	N9	135	75	68	70	71
38	Mountain View	Evelyn Ave and Bryant St	W	MFR	110	N8	285	73	69	69	66
39	Mountain View	Central Exp and Whisman Ave	E	SFR	150	N39	185	72	61	61	71
40	Mountain View	S. Bernardo Ave and Evelyn Ave	E	SFR	75	N7	90	68	65	63	60
41	Sunnyvale	Asilomar Ave and Mary Ave	E	MFR	80	N7	90	70	66	66	61
42	Sunnyvale	332 Angel Ave	E	SFR	80	N6	100	71	67	65	66
43	Sunnyvale	Fair Oaks Ave and Evelyn Ave	W	MFR	75	N6	100	71	65	65	68
44	Santa Clara	Agate St and Lawrence Exp	W	MFR	85	R44	130	71	66	66	67
45	Santa Clara	Agate Dr and Bowers Ave	W	SFR	110	N4	160	68	62	63	64
46	Santa Clara	Alvarado Dr and San Thomas Exp	W	SFR	95	N37	220	68	64	62	64
47	Santa Clara	2109 Main St	W	SFR	95	N3	140	68	64	62	64
48	San Jose	782 Auzerais Ave	W	SFR	60	R48	45	81	77	78	65
49	San Jose	456 Jerome St	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.

Locations of the representative receptor sites are shown in Attachment C of Appendix C, Noise Study (WIA 2013).

Source: WIA 2013.

1 **Non-Railroad Ambient Noise Estimates**

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

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

12 **Proposed Train Operations**

13 The proposed project would replace approximately 75 percent of the locomotive and passenger car
14 fleet for San Francisco to San Jose service with EMU technology with a catenary system in 2020
15 2019. The EMU trains were assumed to be six cars long, with three motor cars (powered cars) and
16 three non-powered trailer cars. The Proposed Project assumes maximum train speeds would not
17 change; however, there would be a greater number of total trains per day. The analysis also assumes
18 EMU cars would be roughly the same length as the existing Caltrain rail cars.

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

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

34 As described in Chapter 2, Project Description, Caltrain presumes that temporal separation between
35 EMUs and freight trains will not ultimately be required for the Project and thus that freight
36 operational windows would not substantially change with the Project.

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.

1 **Train Horns and Crossing Bells**

2 Train horns and crossing bells are major noise sources associated with train operations. Trains
3 sound their horns before roadway crossings and when approaching a passenger station. The
4 location and number of roadway crossings and stations would not be changed as a result of the
5 Proposed Project.

6 The horn noise prediction model and horn usage factors are described above under the *Existing*
7 *Caltrain Operations*. The number of train operations would slightly increase for the proposed
8 operations. The effect of increasing the total number of daytime trains (7 a.m. to 10 p.m.) from 77 to
9 98 trains would equate to 0.9 dB relative increase in the daytime equivalent noise level (L_{eq}). The
10 effect of increasing the total number of nighttime trains (10 p.m. to 7 a.m.) from 15 to 16 (or peak
11 hour trains from 5 to 6) would equate to 0.8 dB relative increase in the nighttime L_{eq} .

12 **Special Track Work**

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

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

21 **Curving Noise (Wheel Squeal)**

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

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

33 **Ancillary Facilities**

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

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

1 **Train Station**

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

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

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

14 **Construction**

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

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

29 The FTA method and noise data were used to determine construction noise exposure for each piece
30 of equipment. The noise data include the maximum noise level (L_{max}) of construction equipment
31 operating at full power at a reference distance of 50 feet and the usage factors for the equipment.
32 The usage factor is the percentage of time each piece of construction equipment is typically operated
33 at full power over the specified time period and is used to estimate L_{eq} values from L_{max} values. For
34 example, the L_{eq} value for a piece of equipment that operates at full power over 50% of the time is 3
35 dB less than the L_{max} value.

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

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

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

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

14 **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

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
Telescoping boom bucket trucks	71	65	71	65
Generator (nighttime lighting)	72	66	72	66
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.

1

2 **Vibration Analysis**

3 **Train Operations**

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

8 The factors would remain the same with the Proposed Project as under the existing condition with
 9 the one exception that the EMU vehicle may have different vibration characteristics than the existing

1 locomotive powered trains. Therefore, for any given receptor, all factors remain the same with the
2 exception of the EMU vehicle.

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

9 **Construction**

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

23 **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.

24

25 **3.11.2.2 Thresholds of Significance**

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

- 28 • Expose persons to or generate noise levels in excess of FTA thresholds.

- 1 • Expose persons to or generate groundborne vibration or groundborne noise levels in excess of
2 FTA thresholds.
- 3 • Be located within an airport land use plan area, or, where such a plan has not been adopted,
4 within 2 miles of a public airport or public use airport and expose people residing or working in
5 the project area to excessive noise levels.
- 6 • Be located in the vicinity of a private airstrip and expose people residing or working in the
7 project area to excessive noise levels.

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

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

18 **FTA Noise Criteria**

19 **Operation Noise Criteria**

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

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

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

40 ***Severe impact:*** Project-generated noise in the severe impact range can be expected to cause a
41 significant percentage of people to be highly annoyed by the new noise levels and represents the

1 most compelling need for mitigation. Noise mitigation will normally be specified for sensitive
 2 receptors where a severe impact occurs unless there are truly extenuating circumstances that
 3 prevent implementation of mitigation.

4 **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.

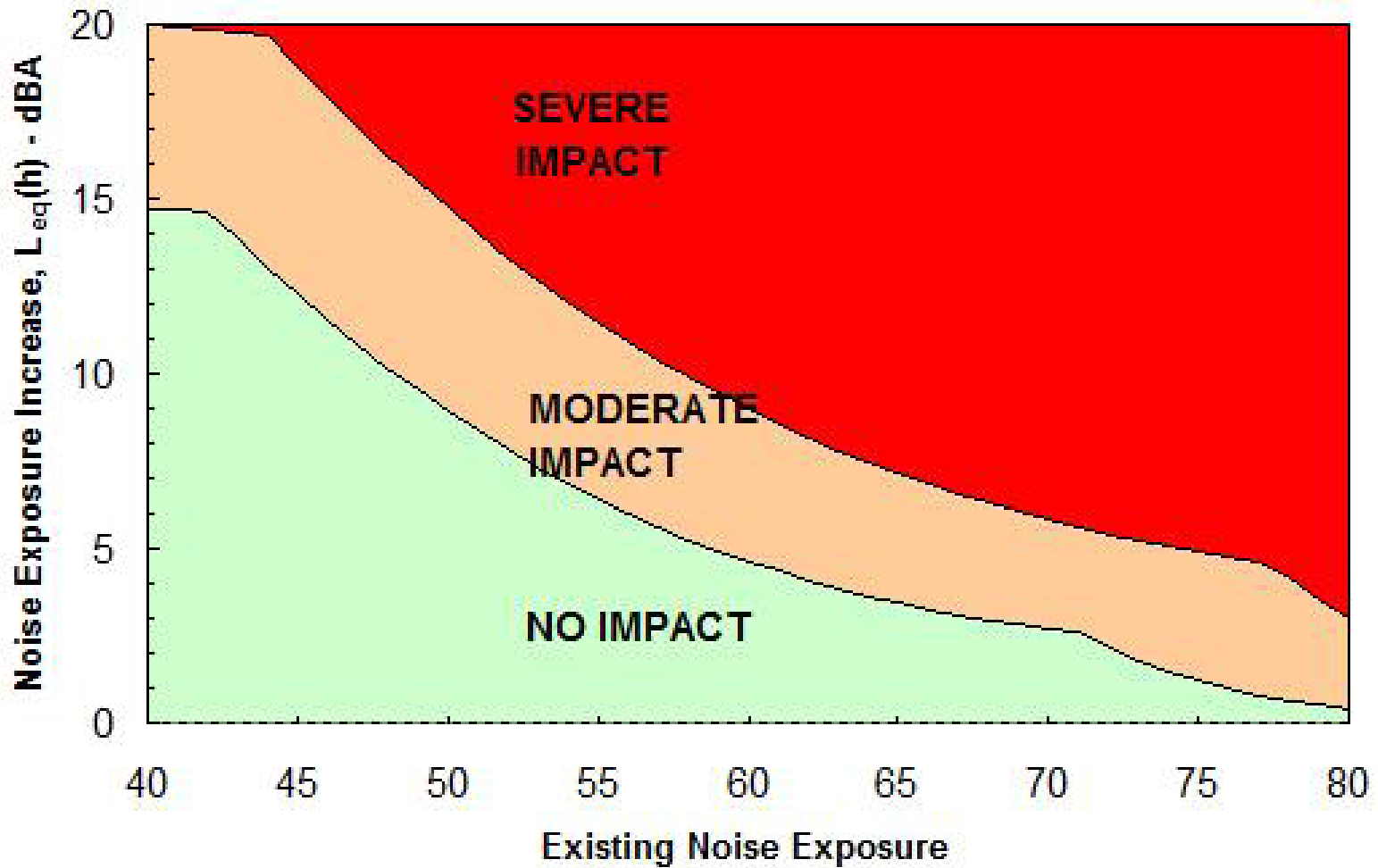
Source: FTA 2006.

5
 6 The thresholds for these three levels of impact, as indicated in Figures 3.11-6 and 3.11-7, are based
 7 on the projected increase of the existing ambient noise level associated with operation of the
 8 Proposed Project. The thresholds also may be used to evaluate the Proposed Project in combination
 9 with other new planned projects to determine cumulative impacts.

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

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

26 The FTA criteria can also be presented in terms of absolute levels for evaluating noise from the
 27 transit project alone. However, the absolute criteria is only applicable to new transit sources where



Source: Federal Transit Administration 2006.

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

1 the existing noise levels generated by existing transit systems, roadway, and other sources will not
 2 change as a result of the project. The absolute criteria assume the project noise can be added to the
 3 existing noise to calculate a new total noise level. If the existing noise was dominated by a source
 4 that changed due to the project, it would be incorrect to add the project noise to the existing noise.
 5 Therefore, the relative form of the noise criteria must be used for projects involving proposed
 6 changes to an existing transit system.

7 **Stationary Source Criteria**

8 The noise criteria for stationary sources, such as traction power substations, switching stations, and
 9 paralleling stations, were established by the FTA methods described above. The noise from these
 10 facilities is evaluated as part of the entire project noise, and the impact is based on comparing the
 11 project noise with the existing conditions. Most local codes within the Caltrain corridor limit noise
 12 levels from continuous operations (such as those generated from stationary sources) to the same as
 13 the existing ambient. In some cases, codes allow a 5 to 10 dBA increase above the existing ambient
 14 background, which would result in a net increase of 3 to 6 dBA over the existing ambient condition.
 15 For existing noise environments on the order of 65 to 70 L_{dn} , the FTA noise criteria for land use
 16 category 1 and 2 typically defines a moderate noise impact as a noise increase of approximately 1 to
 17 2 dBA and a severe impact as a noise increase of at least 3 dBA, which is consistent with or more
 18 restrictive than local codes.

19 **Construction Noise Criteria**

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

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

31 **Table 3.11-10. FTA Construction Noise Assessments Criteria**

Land Use	8-hour L_{eq} (dBA)		Daily Noise Level (dBA) 30-day Average
	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)	
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.

32

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

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

14 **FTA Vibration Criteria**

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

20 **Operation Vibration Criteria**

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

24 The FTA guidance document provides ground-borne vibration criteria to assess the human response
25 to different frequencies of ground-borne vibration events from a new project, as shown in Table
26 3.11-11. In addition, the guideline provides criteria for special buildings that are very sensitive to
27 ground-borne vibration generated from a new project. The impact criteria for these special
28 buildings are shown in Table 3.11-12.

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

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

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

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

Land Use Category	Ground-Borne Vibration Impact Levels (VdB relative to 1 micro-inch/sec)		
	Frequent Events ^a	Occasional Events ^b	Infrequent Events ^c
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 VdB ^d	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.

6

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

Type of Building or Room	Ground-Borne Vibration Impact Levels (VdB relative to 1 micro-inch/sec)	
	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

8

9 **Construction Vibration Criteria**

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

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

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

10 **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.

11

12 **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

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

15 To assess impacts on noise sensitive receptors, a calculation was performed to determine the
16 distances from the construction activities where an 80-dBA exposure would occur over an 8-hour
17 period⁷. The 80-dBA exposure level represents the noise limit for daytime construction at
18 residential land uses. The significance criteria described in Table 3.11-10 for different land uses
19 (residential, commercial, industrial) would apply as well as the different (and lower) criteria for
20 nighttime work. The 80-dBA level was used for the purposes of identifying where daytime impacts
21 would occur on residential receptors only. Impacts at nighttime are considered separately below.

22 Table 3.11-14 summarizes the distances at which sensitive residential receptors could be potentially
23 exposed to substantial increases in construction noise during daytime. As shown in Table 3.11-6,
24 noise sensitive receptors along the project corridor are located as close as 35 feet from the near
25 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.

1 **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.	

2

3 Noise sensitive land uses adjacent to construction lay-down or staging areas could also experience

4 construction noise impacts. These are areas where construction equipment and materials are stored

5 and accessed during the construction period. At the time of this study, specific locations and details

6 of the lay-down areas were unknown. If lay-down areas are selected within 90 feet of a residential

7 area, noise impacts could result.

8 Because commercial and industrial land uses are less sensitive to noise, daytime construction

9 impacts would likely only occur when construction is immediately adjacent to commercial land uses.

10 Daytime impacts are not likely to occur on adjacent industrial land uses.

11 Nighttime construction near residential uses would have larger impacts than daytime construction

12 would have. The distance to the 70 dBA residential nighttime criteria would be less than shown in

13 Table 3.11-14. The number of residences affected by nighttime construction would be greater than

14 the number of residences impacted by daytime construction noise with the same noise level.

15 Although the measures specified in Mitigation Measure NOI-1a would generally reduce the

16 construction noise levels, the measures would not necessarily guarantee that sensitive residential

17 receptors would not be exposed to noise levels exceeding the 80 dBA limit during the day or the 70

18 dBA limit at night. In specific, given the active railroad, it is probable that construction near some

19 residential areas will have to be conducted at night to avoid disruption of passenger rail operations

20 and to complete the project on schedule. Furthermore, at TPFs, a temporary sound wall may be

21 effective, but in many cases (such as OCS pole installation) the nature of the construction work

22 makes use of such sound walls infeasible.

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

6 Project Variant 1 would result in less OCS construction south of the Tamien Station but would shift
7 the PS7 location from near Kurte Park to adjacent to Alma Avenue. The PS7 location would be
8 separated from residential areas by the active railroad tracks and thus construction would not result
9 in a change in overall impacts compared to that of the Proposed Project.

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

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

- 14 ● An active community liaison program shall be established. The community liaison program
15 will keep residents informed about construction plans so residents may plan around noise
16 or vibration impacts and will provide a conduit for residents to express any concerns or
17 complaints. Construction contact information shall be provided to local residents and posted
18 on construction sites adjacent to residential areas. Residents within 300 feet of upcoming
19 construction shall be notified 10-days in advance of the start of construction in an area
20 wherever possible.
- 21 ● Contractors shall be required to use newer equipment fitted with the manufacturers'
22 recommended noise abatement measures, such as mufflers, engine covers, and engine
23 vibration isolators intact and operational. Newer equipment will generally be quieter in
24 operation than older equipment. All construction equipment shall be inspected at periodic
25 intervals to ensure proper maintenance and presence of noise control devices (e.g., mufflers
26 and shrouding). Electric or "quiet" equipment shall be used for generators, compressors,
27 and other construction equipment where feasible.
- 28 ● Contractors shall employ construction methods or equipment that will provide the lowest
29 level of noise and ground vibration impact near residences and consider alternative
30 methods that are suitable for the soil condition. The contractor shall be required to select
31 construction processes and techniques that create the lowest noise levels.
- 32 ● Truck loading, unloading, and hauling operations shall be conducted so that noise and
33 vibration are kept to a minimum by carefully selecting routes to avoid going through
34 residential neighborhoods to the greatest possible extent. Deliveries of materials and
35 equipment shall be prioritized for daytime hours whenever feasible.
- 36 ● Ingress and egress to and from the staging area shall be on collector streets or higher street
37 designations (preferred), and through routes for trucks will be designed to the extent
38 feasible to minimize the frequency of backup alarm sound.
- 39 ● Idling equipment shall be turned off whenever feasible.
- 40 ● When practicable, temporary noise barriers will be used to protect sensitive receptors
41 against excessive noise from construction activities. Partial enclosures around continuously

- 1 operating equipment or temporary barriers along construction boundaries will be
2 considered.
- 3 ● Construction activities within residential areas will be minimized during evening, nighttime,
4 weekend, and holiday periods to the extent feasible.
 - 5 ● Noise and vibration monitoring shall be conducted to verify compliance with the noise
6 limits. Independent monitoring should be performed to check compliance in particularly
7 sensitive areas. Contractors will be required to modify and/or reschedule their construction
8 activities if monitoring determines that maximum limits are exceeded at residential land
9 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

10 **Train Operations**

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

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

- 27 ● ~~In At 41 33~~ study locations, the positive effect of quieter EMUs would outweigh the influence of
28 increased horn noise based on comparing No Project with Proposed Project conditions.
- 29 ● At eight locations, the adverse effects of increased horn noise would outweigh the positive effect
30 of quieter EMUs, and future noise levels under the Proposed Project would be slightly higher
31 than existing No Project noise levels but less than the FTA thresholds.
- 32 ● ~~At eight locations, the positive effect of quieter EMUs would be offset by the increase in horn~~
33 ~~noise such that noise conditions would not change.~~

1 Compared to existing noise levels, the project would have the following effects:

- 2 • decrease in noise levels: 36 study locations;
- 3 • no change in noise levels: 9 study locations; and
- 4 • increase in noise levels of 0.1 dB (less than FTA threshold impact level): 4 study locations.

5 The stationary corona noise that can be heard from power transmission lines is very low. It is on the
6 order of 25 dBA at the edge of the right-of-way for a 250 KV system (CPUC 1999). The low hum from
7 these transmission lines can be enhanced during periods of high humidity, but the overall noise level
8 is well below that caused by the existing Caltrain system, and thus, does not contribute to the overall
9 train noise.

10 Tree removal required by the ESZ would not result in any meaningful increase in noise. Dense tree
11 zones can provide noise control, but only in specific cases, where the zone is particularly wide (FTA
12 guidance states that a tree buffer should be at least 100 feet deep to include attenuation),⁸ blocking
13 the line of sight between the receiver and the source, and extending above the source and laterally
14 beyond the source length. If one or two rows of trees are being removed (5 to 20 feet deep), it
15 should not have any meaningful effect on the A-weighted noise level from trains. While it is possible
16 that humans can detect a change in the timbre or frequency content of the sound, those changes
17 would not appreciably affect the A-weighted noise level. A related effect involves the ground type;
18 the change from a deep tree zone to a hard concrete surface would affect how sound travels, but the
19 effect of one or two rows of trees is insubstantial compared to the rest of the ground. The PCEP does
20 not propose any new hard concrete surfaces along the ROW as part of the overhead contact system
21 and the only hard concrete surfaces would be for the traction power facilities.

22 The conclusion above on tree removal on noise is backed up by research on the effect of tree buffers.
23 For example, the State of Virginia commissioned a study in 2007 to research the effect of a dense
24 conifer stand as a noise barrier for highway noise reduction (Lee et al. 2007). In this paper, they
25 summarized prior literature findings that greatest reductions were found with vegetation belts of
26 between 20 and 30 meters (66 to 99 feet) but that some studies concluded that the noise
27 attenuation was so small it would not be perceived by humans. The literature review also concluded
28 in order for vegetation to reduce noise, it needed to be densely planted with no gaps to let noise
29 through. The Lee 2007 study used tree depth of 20 meters (66 feet) consisting of conifers and
30 evaluated 15 different locations but found that there was minimal noise attenuation due to the tree
31 buffer. No matter how the sites were examined analytically, there was no measurable difference in
32 road noise relative to tree characteristic and all the differences at the more distant measurement
33 locations were due simply to the distance effect rather than to any additional mitigating effects of
34 trees. Most differences in noise levels from the studied tree buffers were on the order of plus or
35 minus 1.0 dB (Lee et al. 2007).

⁸ For example, the Federal Highway Administration (FHWA) describes that, in general, plantings do not provide much sound attenuation adjacent to roadways, but they recommend buffers of up to 100 feet where proposed for noise reduction. See: http://www.fhwa.dot.gov/environment/noise/noise_compatible_planning/federal_approach/audible_landscape/al04.cfm.

Also the FTA Transit Noise and Vibration Impact Assessment (FTA 2006) specifies that the attenuation effect of trees should only be included where there are at least 100 feet of trees between source and receiver. See: http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf.

1 Based on the evidence described above, the removal of trees along the Caltrain ROW should not
2 have a substantial effect on noise levels.⁹

3 As shown in Table 3.11-15, there are no study locations where noise increase would exceed the FTA
4 moderate impact or severe impact level.

5 Therefore, Proposed Project operations would have a less-than-significant impact along the Caltrain
6 corridor.

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

11 Project Variant 1 (Electrification to just south of the Tamien Station) would not change train
12 operations and thus would not change train noise. Project Variant 2 (Deferral of electrification of
13 storage tracks at the San Francisco 4th and King Station) would result in slightly more diesel train
14 noise at the 4th and King station due to use of diesel locomotives or diesel yard haulers to
15 periodically move EMUs to storage tracks as necessary for maintenance or repair. However, the use
16 of diesel trains for movement to storage tracks would be the same as under No Project conditions
17 and thus this would not be a new impact compared to No Project conditions.

18 **Traction Power Facilities**

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

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

⁹ Tree removal impacts will also be reduced with revised project design assumptions as well as the impacts of Mitigation Measure BIO-5 which will include alternative pole design/alignments where feasible and replanting of trees where unavoidable. Some of the replacement trees per Mitigation Measure BIO-5 may be placed outside the electrical safety zone between the rails and noise receptors, where feasible and where property owners allow (if on private property), which will help to offset the loss of trees at some locations.

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

Receptor Site No	City	Location	Side of Alignment	Land Use ^a	Distance to Receptor (feet)	Measurement Site ID	Proposed Project Operation			FTA Impact Criteria		
							Existing 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	San Francisco	Oakdale Ave and Quint Ave	W	MFR	110	N32	69	<u>68.8</u>	<u>-0.2</u>	1.1	2.9	No
2	San Francisco	Reddy St and Williams Ave	E	SFR	80	N33	70	<u>69.7</u>	<u>-0.3</u>	1.0	2.8	No
3	San Francisco	Carr St and Paul Ave	E	SFR	90	N32	70	<u>69.7</u>	<u>-0.3</u>	1.0	2.8	No
4	San Francisco	Tunnel Ave and Lathrop Ave	E	SFR	120	N31	69	<u>68.9</u>	<u>-0.1</u>	1.1	2.9	No
5	San Bruno	Herman St and Tanforan Ave	W	SFR	110	R05	76	<u>75.4</u>	<u>-0.6</u>	0.3	2.1	No
6 ^d	San Bruno	Huntington Ave and San Bruno Ave	E	MFR	50	R07	77	<u>74.6</u>	<u>-2.4</u>	0.3	2.0	No
7 ^d	San Bruno	Montgomery Ave and Walnut St	W	SFR	120	R07	74	<u>72.3</u>	<u>-1.7</u>	0.5	2.3	No
8 ^d	San Bruno	1st Ave and Pine St	E	SFR	100	N53	74	<u>71.6</u>	<u>-2.4</u>	0.5	2.3	No
9 ^d	San Bruno	Huntington Ave and Sylvan Ave	W	SFR	150	N53	72	<u>69.5</u>	<u>-2.5</u>	0.8	2.5	No
10	San Bruno	San Antonio Ave and San Benito Ave	W	SFR	170	N26	67	<u>66.8</u>	<u>-0.2</u>	1.2	3.2	No
11	Millbrae	Monterey St and Santa Paula Ave	E	MFR	160	N25	71	<u>71.0</u>	<u>0.0</u>	1.0	2.6	No
12	Millbrae	Hemlock Ave and Hillcrest Blvd.	W	SFR	90	R12	72	<u>72.0</u>	<u>0.0</u>	0.8	2.5	No
13	Burlingame	California Dr and Dufferin Ave	W	SFR	150	N50	68	<u>67.8</u>	<u>-0.2</u>	1.2	3.1	No
14	Burlingame	California Dr and Mills Ave	W	SFR	160	R14	70	<u>70.1</u>	<u>0.1</u>	1.0	2.8	No
15	Burlingame	California Dr and Palm Dr	W	SFR	190	N22	70	<u>70.0</u>	<u>0.0</u>	1.0	2.8	No
16	Burlingame	Park Ave and Carolan Ave	E	SFR	160	N22	71	<u>71.0</u>	<u>0.0</u>	1.0	2.6	No
17	San Mateo	Grand Blvd and San Mateo Blvd	W	SFR	40	R18	76	<u>76.0</u>	<u>0.0</u>	0.3	2.1	No
18	San Mateo	Railroad Ave and Monte Diablo	E	SFR	70	R18	72	<u>71.9</u>	<u>-0.1</u>	0.8	2.5	No
19	San Mateo	B St and 9th Ave	W	MFR	110	N47	73	<u>73.1</u>	<u>0.1</u>	0.6	2.4	No
20	San Mateo	South Blvd and 16th Ave	W	SFR	85	N20	67	<u>66.5</u>	<u>-0.5</u>	1.2	3.2	No
21	San Mateo	Pacific Blvd and Otay Ave	E	SFR	100	N19	72	<u>71.9</u>	<u>-0.1</u>	0.8	2.5	No
22	San Mateo	Country Rd and Dale View Ave	E	MFR	120	R22	70	<u>69.7</u>	<u>-0.3</u>	1.0	2.8	No
23	Belmont	Country Rd and Marine View	E	MFR	120	N18	73	<u>72.9</u>	<u>-0.1</u>	0.6	2.4	No
24	San Carlos	Country Rd and Springfield Ave	E	SFR	100	N17	70	<u>70.0</u>	<u>0.0</u>	1.0	2.8	No
25	Redwood City	D St and Stafford St	E	SFR	90	N16	73	<u>73.1</u>	<u>0.1</u>	0.6	2.4	No
26	Redwood City	Cedar St and Main St	E	SFR	50	N47	76	<u>76.0</u>	<u>0.0</u>	0.3	2.1	No
27	Redwood City	198 Buckingham Ave	W	MFR	110	R27	69	<u>68.6</u>	<u>-0.4</u>	1.1	2.9	No
28	San Mateo County	Arrowhead Lane and 5th Ave	E	SFR	50	N14	72	<u>71.6</u>	<u>-0.4</u>	0.8	2.5	No
29	Atherton	Lloyd Dr and Fair Oaks Lane	W	SFR	60	N13	70	<u>69.7</u>	<u>-0.3</u>	1.0	2.8	No
30	Atherton	Felton Dr and Encinal Ave	E	SFR	65	N13	70	<u>69.7</u>	<u>-0.3</u>	1.0	2.8	No

Receptor Site No	City	Location	Side of Alignment	Land Use ^a	Distance to Receptor (feet)	Measurement Site ID	Existing	Proposed Project Operation		FTA Impact Criteria		
							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
31	Menlo Park	Burgess Dr and Alma St	E	MFR	175	N45	67	66.8	-0.2	1.2	3.2	No
32	Palo Alto	Mitchell Lane and University Ave	W	MFR	100	N44	68	67.7	-0.3	1.2	3.1	No
33	Palo Alto	Alma St and Lincoln Ave	E	SFR	120	N42	69	68.6	-0.4	1.1	2.9	No
34	Palo Alto	Residences near Peers Park	W	SFR	40	R34	72	71.5	-0.5	0.8	2.5	No
35	Palo Alto	Alma St and El Dorado Ave	E	MFR	160	N10	76	75.6	-0.4	0.3	2.1	No
36	Palo Alto	4237 Park Blvd	W	SFR	50	R36	78	78.1	0.1	0.2	1.8	No
37	Mountain View	Central Exp and Thompson Ave	E	SFR	150	N9	75	74.7	-0.3	0.4	2.2	No
38	Mountain View	Evelyn Ave and Bryant St	W	MFR	110	N8	73	72.7	-0.3	0.6	2.4	No
39	Mountain View	Central Exp and Whisman Ave	E	SFR	150	N39	72	71.9	-0.1	0.8	2.5	No
40	Mountain View	S. Bernardo Ave and Evelyn Ave	E	SFR	75	N7	68	67.4	-0.6	1.2	3.1	No
41	Sunnyvale	Asilomar Ave and Mary Ave	E	MFR	80	N7	70	69.8	-0.2	1.0	2.8	No
42	Sunnyvale	332 Angel Ave	E	SFR	80	N6	71	70.9	-0.1	1.0	2.6	No
43	Sunnyvale	Fair Oaks Ave and Evelyn Ave	W	MFR	75	N6	71	70.8	-0.2	1.0	2.6	No
44	Santa Clara	Agate St and Lawrence Exp	W	MFR	85	R44	71	71.0	0.0	1.0	2.6	No
45	Santa Clara	Agate Dr and Bowers Ave	W	SFR	110	N4	68	67.7	-0.3	1.2	3.1	No
46	Santa Clara	Alvarado Dr and San Thomas Exp	W	SFR	95	N37	68	67.6	-0.4	1.2	3.1	No
47	Santa Clara	2109 Main St	W	SFR	95	N3	68	67.6	-0.4	1.2	3.1	No
48	San Jose	782 Auzerais Ave	W	SFR	60	R48	81	81.0	0.0	0.1	1.0	No
49	San Jose	456 Jerome St	E	SFR	50	R49	71	70.1	-0.9	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.

Locations of the representative receptor sites are shown in Attachment C of Appendix C, Noise Study (WIA 2014).

Source: WIA 2014 2013.

- 1 • **TPS1 Option 3:** Traction Power Supply Substation TPS1 Option 3 is located on vacant land
2 adjacent to commercial property on West Harris Avenue in South San Francisco. The Motel 6, at
3 111 Mitchell Avenue, South San Francisco, is within 125 feet. The projected noise increase
4 would be 1.2 dBA, at a distance of 70 feet, exceeding the FTA Moderate Impact threshold.
- 5 • **PS5, Option 2:** Paralleling Station PS5, Option 2 would be located within the JPB ROW adjacent
6 to a mixed residential/commercial project that is presently in construction at 195 Page Mill
7 Road in Palo Alto. The projected noise increase would exceed the FTA Severe Impact threshold
8 without mitigation.

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

Facility ^a	Receptor Address ^b	Land Use ^c	With Project							FTA Impact Criteria			Impact Type (number of impacts) ^g
			Receptor Distance to Ancillary Facility feet	Receptor Distance to Caltrain Near Track feet	Existing Total Noise Exposure ^d	Freight + All Other Ambient Noise	Project Train Noise ^e	Substation Noise	Total Noise Exposure ^f	Increase	Moderate	Severe	
			L _{dn} , dBA							Noise Exposure Increase			
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, <u>South</u> San Francisco	Hotel	70	1400	72	72	44	67	73	1.2	0.8	2.5	MI (1)
<u>TPS1-Opt. 4</u>	<u>[none]</u>	--	--	--	--	--	--	--	--	--	--	--	--
PS3-Opt. 1 & Opt. 2 ^h	1283 California Drive, <u>Burlingame</u> San Francisco	SFR	120	165	73	71	66	62	73	-0.1	0.6	2.4	--
PS4-Opt. 1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
PS4-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
<u>PS4-Opt. 3</u>	<u>[none]</u>	--	--	--	--	--	--	--	--	--	--	--	--
SWS1-Opt. 1	2690 Westmoreland Ave., Redwood	SFR	180	110	69	67	62	59	68	-0.7	1.1	2.9	--

Facility ^a	Receptor Address ^b City	Land Use ^c	With Project										FTA Impact Criteria		
			Receptor Distance to Ancillary Facility feet	Receptor Distance to Caltrain Near Track feet	Existing Total Noise Exposure ^d	Freight + All Other Ambient Noise	Project Train Noise ^e	Substation Noise	Total Noise Exposure ^f	Increase	Moderate	Severe	Noise Exposure Increase	Impact Type (number of impacts) ^g	
L _{dn} , dBA															
SWS1-Opt. 2	[none]	=	=	=	=	=	=	=	=	=	=	=	=	=	
PS5-Opt. 2	2617 Alma Street, Palo Alto	MFR	180	160	76	75	66	59	75	-0.7	0.3	2.1	--		
	195 Page Mill Road, Palo Alto	MFR /Mixed	5	62	72	68	70	77-85	79-86	6.5-13.6	0.8	2.5	SI (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	--		
PS5-Option 1B	Location not modelled, but results would be similar to those for 102 Greenmeadow Way for PS5, Option 1 since distance to nearest residence at PS5, Option 1B would be similar.														
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]	--	--	--	--	--	--	--	--	--	--	--	--		
PS7 Variant A	Alma Avenue, San Jose	SFR	145	75	70	70	54	61	70	0.0	1.0	2.7	--		
PS7 Variant A and B	Alma Avenue, San Jose	SFR	150	115	67	66	56	60	67	0.6	1.3	3.3	--		

^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.

^h PS3, Option 2 would be located within 250 feet of single-family residential land uses on California Drive in Burlingame. Option 2 would be located farther from these sensitive receptors than Option 1. There would be no noise operational noise impacts from Option 1; therefore, due to the greater distance, it was concluded that there would be no noise impacts from Option 2 and operational noise levels for Option 2 were not calculated.

Source: WIA 2014 (Appendix C).

1 Because the operation of ~~two one~~ of ancillary facilities would cause an increase in ambient noise
2 levels that exceed the FTA moderate or severe impact criteria, operational noise impact from
3 ancillary facilities is considered a significant impact. With the implementation of Mitigation Measure
4 NOI-1b, impacts related to ~~the~~ one TPF facility (TPS1, Option 3) and one PS facility (PS5, Option 2)
5 would be reduced to a less-than-significant level.

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

9 A qualified acoustical consultant shall review final mechanical equipment and site design and
10 calculate expected exterior noise levels at adjacent noise sensitive receptors to limit the
11 substation noise at the TPS1, Option 3 site if selected for a substation site and at the PS5, Option
12 2 site if selected as a paralleling station site. If TPS1, Option 1, ~~or~~ TPS1, Option 2, or TPS1, Option
13 4 sites are selected instead, then this mitigation will not be required for TPS1, Option 3. If PS5,
14 Option 1 or Option 1B were selected in instead, then this mitigation will not be required for PS5,
15 Option 2.

16 A moderate noise impact has been identified at TPS1 Option 3 based on the FTA methodology
17 and reference data. If the projected noise contribution from the substation is reduced by at least
18 2.8 dBA the impact will be eliminated. A performance criterion which limits the substation noise
19 to a maximum noise level of 60 dBA at 50 feet, or no more than 63 dBA L_{dn} at the closest nearby
20 noise sensitive receptor (111 Mitchel Avenue) would be sufficient to eliminate the moderate
21 noise impact.

22 A severe noise impact has been identified at PS5, Option 2 before mitigation and using FTA
23 methodology and reference data. If the projected transformer noise level at the fenceline of the
24 adjacent mixed use project could be reduced to 58 dBA (or 64.4 L_{dn}) the impact would be less
25 than the FTA moderate impact level and the noise impact at this location would be less than
26 significant.

27 TPS1, Option 3, and PS5, Option 2 noise levels shall comply with IEEE national standards and
28 guidelines for electrical power facilities. Station layouts and specific noise control measures will
29 be developed during the design phase to minimize noise impacts resulting from the TPFs. Such
30 noise control measures may include the following:

- 31 ● Locate electrical noise-generating equipment farther away from the property lines of noise
32 sensitive sites, if at all possible.
- 33 ● Consider the use of special enclosures for all transformers to mitigate the associated low
34 frequency noise impacts.
- 35 ● Reduce potential noise impacts from the ventilation system for switchgear by using
36 acoustical louvers, line duct silencers, and hoods on the vent openings, and/or by locating
37 vents at the side of the building that is not facing residences.
- 38 ● At PS5, Option 2, compliance with the performance criteria may require relocation of the
39 facility southward to place the transformer at least 25 feet (for an oil-filled transformer
40 type) to 55 feet (for a dry-type transformer) from the mixed use location. The areas to the
41 south of the mixed use project are commercial buildings set back farther from the JPB ROW
42 than the mixed use project and would be considered non-sensitive receptors. As shown in

1 Figure 3.11-8, there are two potentially feasible locations south of PS5, Option 2 (referred to
2 as PS5, Option 2B and PS5, Option 2C) that would be more than the required distances from
3 the mixed use development and would avoid a significant noise impact.

4 Since one of the options for mitigation at PS5, Option 2 includes alternative locations (Options 2B
5 and 2C), a brief analysis of potential secondary environmental effects of the alternative locations
6 was conducted to ensure that no new significant impacts would occur with potential relocation.
7 CEQA allows that the secondary effects of mitigation can be analyzed at a lesser level of detail than
8 the proposed project. All applicable mitigation for the Proposed Project would apply to Option 2B or
9 2C if adopted as part of mitigation. What follows is a summary analysis by environmental resource
10 area in this EIR:

- 11 • Aesthetics – Option 2B and 2C would be within the western portion of JPB ROW adjacent to
12 commercial facilities along Park Boulevard. Overall, these options would have less effect on
13 visual aesthetics than Option 2.
 - 14 ○ Option 2B would be adjacent to commercial uses at 3045 Park Boulevard which is currently
15 used as a body shop and rental car facility, and there would be views of the paralleling
16 station from these uses. Another commercial facility (3101 Park Boulevard) would be
17 slightly east of Option 2B and is currently used by an internet company (Groupon) and the
18 parking lot of this facility is visually screened from the JPB ROW by fence line vegetation. The
19 commercial uses are not considered to have visually sensitive receptors. Because Option 2B
20 would be at least 90 feet away from the mixed use development it would have far less visual
21 aesthetic effect on the residential facility than Option 2. Option 2B would have the same
22 effect to residences on the east side of Alma Street as PS5 Option 2.
 - 23 ○ Option 2C would be adjacent to commercial uses at 3197 Park Boulevard which is currently
24 used as a building contractor office and adjacent to a City of Palo Alto substation; there
25 would be views of the paralleling station from these uses. The commercial uses are not
26 considered to have visually sensitive receptors. Because Option 2C would be approximately
27 800 feet away from the mixed use development it would have no visual aesthetic effect on
28 the residential facility. Option 2C would have the same effect to residences on the east side
29 of Alma Street as PS5 Option 2.
- 30 • Air Quality – Options 2B and 2C would have the same construction effects as Option 2 because
31 the same amount of construction would be required. Options 2B and 2C would not change
32 operational emissions.
- 33 • Biological Resources – Both Options 2B and 2C would be in areas of disturbed JPB ROW. There is
34 no vegetation at Option 2B. There is limited planted vegetation at Option 2C. Option 2C is
35 adjacent to Matadero Creek, but the creek is a concrete flood channel at this location and thus
36 does not contain biological habitat. Thus these options would have no additional impact on
37 biological resources.
- 38 • Cultural Resources – There are no known cultural resources at the Option 2B or 2C locations.
- 39 • EMF/EMI – As explained in Section 3.5, the EMF levels outside the perimeter of the paralleling
40 stations are well below health reference levels. The commercial facilities adjacent to Options 2B
41 or 2C do not appear to be facilities (like hospitals, medical imaging facilities, or emergency
42 communications facilities) that would have highly sensitive equipment that would be a concern
43 for EMI. Option 2C is adjacent to a City of Palo Alto substation and the site would need to be
44 assessed to ensure no EMI from the substation on the paralleling stations and vice versa. In

1 accordance with mitigation in Section 3.5, the JPB would examine adjacent areas along the
2 electrification route for sensitive facilities and follow proper design controls as necessary to
3 abate EMI (including the City of Palo Alto substation location, as appropriate).

- 4 • Geology, Soils, and Seismicity – Options 2B and 2C have the same general geological, soil, and
5 seismic setting as Option 2 and thus impacts would be the same as Option 2.
- 6 • Greenhouse Gas Emissions and Climate Change - Options 2B and 2C would have the same
7 construction effects as Option 2 because the same amount of construction would be required.
8 Options 2B and 2C would not change operational emissions.
- 9 • Hazards and Hazardous Materials – The records search for PS5, Option 2 discloses the potential
10 hazardous material sites within 0.25 mile which would include the area surrounding Options 2B
11 and 2C. Thus these sites would have similar hazardous material impacts as Option 2.
- 12 • Hydrology and Water Quality – Options 2B and 2C would have the same construction and
13 operational effects as Option 2 as they would require the same amount of construction and
14 would have the same amount of impervious space. Like Option 2 neither Option 2B or 2C are in
15 the 100-year flood plain, but both would have potential for flooding due to dam failure.
- 16 • Land Use and Recreation – As noted above, Options 2B and 2C would be adjacent to existing
17 commercial and/or utility uses which would be more compatible with adjacent land uses
18 compared with Option 2 which would be adjacent to a mixed residential/commercial
19 development. Option 2C would be adjacent to the City of Palo Alto substation but well away
20 from related transmission wires connected to the substation.
- 21 • Noise and Vibration – As noted above, Options 2B and 2C would have lower noise impacts than
22 Option 2 because they would be adjacent to commercial uses instead of residential uses.
23 Provided the sites are at least 25 to 55 feet (depending on transformer type) from the mixed use
24 development, noise impacts would be less than significant and no site design mitigation would
25 be necessary.
- 26 • Population and Housing – Like Option 2, Options 2B and 2C would have no significant effects on
27 population or housing.
- 28 • Public Services and Utilities – Similar to Option 2, at or near Options 2B and 2C, there are aerial
29 fiber-optic cables, underground fiber-optic cables, distribution power aerial, and City storm
30 water system facility. Mitigation for utilities in Section 3.13 would apply to these facilities like it
31 would apply to Option 2.
- 32 • Transportation and Traffic – Options 2B and 2C would not change operational traffic effects of
33 the project. For construction, access to Options 2B and 2C would be from Page Mill Road like the
34 access to Option 2 unless access is negotiated with the adjacent commercial property owners.
- 35 • Cumulative Impacts – Since the impacts for Options 2B and 2C would be the same or less than
36 Option 2, there would be no change to the cumulative impact contributions of the Proposed
37 Project.

38 Based on the analysis above, if the adopted mitigation for noise impacts at PS5, Option 2 were to be
39 relocation of the facility to Option 2B or 2C, no new significant impacts or substantially more severe
40 impacts would occur compared with those disclosed for Proposed Project paralleling stations. No
41 impacts would be worse than at the Option 2 location.

Path: K:\Projects_3\Caltrain_Modernization\mapdocs\PD_Figures\Fig_3_11_8_ParallelingStationsfb_20141118.mxd; User: 29391; Date: 11/19/2014



Source: Imagery, ESRI 2013

Note: This is a new figure for the Final EIR

Figure 3.11-8
Proposed Paralleling Station (PS) 5, Option 2 and Potential Mitigation Options 2b and 2c
Peninsula Corridor Electrification Project

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

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

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

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

23 **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.

24

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

13 Residents and other sensitive receptors are also located within the annoyance distances in Table
14 3.11-17 and, thus, could be significantly annoyed due to construction vibration. The effect would be
15 more acute with equipment with high vibration potential, such as vibratory hammers or vibratory
16 compactor/rollers. With implementation of Mitigation Measure NOI-2a, impacts resulting from
17 construction vibration annoyance would be less than significant.

18 Project Variant 1 (Electrification to just south of the Tamien Station) would have less OCS
19 construction than the Proposed Project. PS7 would be relocated from near Kurte Park to adjacent to
20 Alma Avenue, but construction vibration impacts at this location would not be substantially
21 different than overall construction impacts disclosed for the Proposed Project. Mitigation Measure
22 NOI-2a would apply to vibration impacts associated with the PS7 Variant location. Project Variant 2
23 (Deferral of electrification of storage tracks at the San Francisco 4th and King Station) would result in
24 less construction than the Proposed Project.

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

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

- 28 ● Where feasible, avoid placing OCS poles within 25 feet of structures or use alternative
29 construction methods for pile driving (such as augurs) to minimize potential vibration
30 damage.
- 31 ● Where vibratory compacting/rolling is proposed within 15 feet of structures, utilize
32 alternative equipment (such as non-vibratory rollers) to minimize potential vibration
33 damage.
- 34 ● Where pile driving is proposed within 50 feet of structures or vibratory compacting/rolling
35 within 25 feet, preconstruction surveys shall be conducted to document the existing
36 condition of buildings in case damage is reported during or after construction.
- 37 ● Damaged buildings due to project construction shall be repaired or compensation paid.

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

- 40 ● When possible, limit the use of construction equipment that creates high vibration levels
41 near residential structures.
- 42 ● Require vibration monitoring during vibration-intensive activities.

- 1 • Where feasible, plan the hours of vibration-intensive equipment, such as vibratory pile
2 drivers or vibratory rollers, so that impacts on residents are minimal (e.g., weekdays during
3 daytime hours only, when as many residents as possible are away from home).

4 The JPB and/or the Design-Build contractor will coordinate with Caltrans during development
5 of the construction vibration plan concerning construction vibration that may occur near
6 Caltrans facilities.

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

Level of Impact Less than significant

7 As presented in Table 3.11-4, existing vibration levels for Caltrain’s diesel service at 50 feet from the
8 outermost track vary from 72 to 80 VdB, depending on local site conditions and speed. As presented
9 in Table 3.11-5, existing vibration levels for freight at 100 feet from the outermost track vary from
10 73 to 81 VdB. These existing levels exceed FTA annoyance thresholds of 72 VdB for immediately
11 adjacent residences and of 75 VdB for immediately adjacent institutional buildings, but these levels
12 do not approach structural damage thresholds.

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

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

22 Using FTA vibration reference levels (FTA 2006) for rapid transit trains (which FTA guidance
23 recommends for electric commuter trains), vibration levels with Caltrain EMUs could be 73 Vdb at
24 50 feet from the outermost track at 50 mph. Adjusting to the 79 mph speed, the vibration levels for
25 the new Caltrain EMUs could be 77 VdB. This level is within the range of existing vibration levels
26 along the Caltrain corridor noted above.

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

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

35 New traction power facilities would not generate significant vibrations.

36 Thus, operational vibration impacts would be less than significant.

37 Project Variant 1 (Electrification to just south of the Tamien Station) would not change train
38 operations and thus would not change train vibration. Project Variant 2 (Deferral of electrification of

1 storage tracks at the San Francisco 4th and King Station) would result in slightly more diesel train
2 vibration at the 4th and King station due to use of diesel locomotives or diesel yard haulers to
3 periodically move EMUs to storage tracks as necessary for maintenance or repair. However, the use
4 of diesel trains for movement to storage tracks would be the same as under No Project conditions
5 and thus this would not be a new impact compared to No Project conditions.