3.4 Noise and Vibration

3.4.1 Introduction

This section describes the regulatory setting, affected environment, and potential impacts related to noise and vibration in the San Francisco to San Jose Project Section (Project Section, or project) resource study area (RSA). The potential impacts related to noise and vibration that would result from the construction and operation of the project alternatives are evaluated and presented in accordance with applicable guidelines. This section also describes mitigation measures that would reduce the identified impacts.

Primary Noise and Vibration Impacts

- Train operations would expose 1,758 (Alt A), 1,648 (Alt B [I-880]), or 1,628 (Alt B [Scott Blvd]) sensitive receptors to severe noise impacts and 4,296 (Alt A), 4,186 (Alt B [I-880]), or 4,141 (Alt B [Scott Blvd]) sensitive receptors to moderate noise impacts in 2040 without mitigation, respectively.
- Significant traffic-related noise (greater than or equal to 3 dB increase) would occur in 2029 at two roadway segments near the 4th and King Street Station and in 2040 at 4 (Alt A) to 5 (Alt B) roadway segments near San Jose Diridon Station.
- Train operations would generate 2,493 (Alt A), 2,307 (Alt B [I-880]), or 2,366 (Alt B [Scott Blvd]) vibration impacts and 18 ground-borne noise impacts (both alternatives) due to annoyance.

Noise and vibration are key elements of the environmental impact assessment for a high-speed rail (HSR) project. Increases in noise and vibration are frequently cited among the potential impacts of most concern to residences near a rail alignment. Project noise and vibration impacts consist of construction-related noise and vibration impacts; HSR operations noise and vibration impacts, such as noise impacts from trains, train horns, stations, and the light maintenance facility (LMF); and vehicular traffic noise impacts related to the stations and LMF. HSR operations vibration impacts are discussed with regard to annoyance only, because HSR operations vibration levels would be substantially below building damage criteria.

The project would use existing and in-progress infrastructure improvements developed by Caltrain for its Caltrain Modernization Program, including electrification of the Caltrain corridor as part of the Peninsula Corridor Electrification Project (PCEP)[1] and positive train control. With the HSR project, blended service would operate in the Caltrain corridor with both intercity HSR trains and commuter Caltrain trains sharing the same rail corridor between San Francisco and San Jose.

Additional improvements beyond the Caltrain Modernization Program would be required to accommodate HSR services, construction of which would temporarily generate noise and vibration along the Caltrain corridor. The project would modify tracks to support higher speeds while maintaining passenger comfort; modify stations and platforms to accommodate HSR trains passing through or stopping at existing stations; implement safety and security improvements for at-grade roadway crossings and at existing Caltrain stations; build an LMF; and build communication radio towers at approximately 2.5-mile intervals. Alternatives A and B would largely be identical, except for the location of the LMF in Brisbane, and the additional passing tracks and viaduct that would be built under Alternative B, would provide faster average operational service times for HSR operations.

The project would be within an existing rail corridor that presently has passenger service consisting of 92 Caltrain trains per day between Santa Clara and San Francisco and approximately 6 freight trains per day. Between Santa Clara and San Jose, there are 92 Caltrain trains per day, 8 Altamont Corridor Express (ACE) trains, 15 Capitol Corridor trains, and approximately 9 freight trains per day. Within this corridor, the HSR project would result in the

[1] The PCEP will provide electrification infrastructure and electrical multiple units to allow conversion of 75 percent of the Caltrain service between San Jose and San Francisco from diesel service to electrified service operating up to 79 miles per hour. In addition, the PCEP will increase Caltrain daily service from 92 to 112 trains per day. The construction and operations impacts of the PCEP on noise and vibration compared to existing conditions were evaluated by Caltrain in the PCEP EIR (PCJPB 2015).

following changes to rail operations, all of which would affect noise and vibration conditions along the Caltrain corridor:

- **Increase in the number of passenger trains**—The HSR project would add an estimated 122 to 176 revenue trains and 12 nonrevenue trains per day to the Caltrain corridor (depending on location along the corridor). During the peak hour, up to 4 trains per hour per direction would be added (for a total of 56 trains during the peak hours).
- **Change in passenger train technology**—In order to operate a blended system efficiently, Caltrain operations would need to shift to 100 percent electric multiple unit (EMU) trains compared to only 75 percent EMUs with the PCEP. HSR would use 100 percent EMUs.
- **Change in passenger train speeds**—With track curve straightening, passenger service speeds would be up to 110 miles per hour (mph) in certain locations for both Caltrain and HSR service.
- **New traction power substation (TPSS) facility—**One new TPSS would be built on the east side of the Caltrain corridor south of Interstate (I-) 880 in San Jose (just southeast of the I-880 overcrossing) under Alternative B.

This analysis evaluates changes in noise and vibration levels between the No Project condition (which includes planned changes in Caltrain operations as part of PCEP) and the Plus Project condition (which considers the combined implementation of PCEP and the HSR project).

The following appendices in Volume 2 of this Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS) provide additional details on noise and vibration:

- Appendix 2-A, Roadway Crossings, Modifications, and Closures, describes road crossings of the alignment, road relocations, and road closures resulting from construction of the project.
- Appendix 2-B, Railroad Crossings, describes railroad crossings of the project alternatives.
- Appendix 2-D, Applicable Design Standards, describes the relevant design standards for this project.
- Appendix 2-E, Project Impact Avoidance and Minimization Features, provides the list of all impact avoidance and minimization features (IAMF) incorporated into the project.
- Appendix 2-I, Regional and Local Plans and Policies, provides a list by resource of all applicable regional and local plans and policies.
- Appendix 2-J, Policy Consistency Analysis, provides a summary by resource of project inconsistencies and reconciliations with local plans and policies.
- Appendix 3.4-A, Noise and Vibration Technical Report, provides technical analysis to support this section for the area north of Scott Boulevard. Additional technical details can be found in the *San Jose to Merced Project Section Noise and Vibration Technical Report* (San Jose to Merced Noise and Vibration Technical Report) (California High-Speed Rail Authority [Authority] 2019a).[2]
- Appendix 3.4-B, Noise and Vibration Mitigation Guidelines, presents the Authority's noise and vibration mitigation guidelines.

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[2] Technical reports for the project evaluate the portions of the HSR alignment between 4th and King Street Station in San Francisco and Scott Boulevard in Santa Clara, while technical reports for the adjacent San Jose to Merced Project Section evaluate the portions of the HSR alignment south of Scott Boulevard to the Project Section terminus at West Alma Avenue south of the San Jose Diridon Station.

The following eight Draft EIR/EIS resource sections present additional information related to noise and vibration in other subject areas:

- Section 3.2, Transportation, evaluates impacts related to transportation resources, including roadway and rail traffic, that would lead to changes in noise and vibration in the RSA.
- Section 3.7, Biological and Aquatic Resources, evaluates impacts of project construction and operations on wildlife that would be affected by noise and vibration.
- Section 3.9, Geology, Soils, Seismicity, and Paleontological Resources, evaluates areas with sensitive surrounding land uses and soil that would be affected by vibration.
- Section 3.12, Socioeconomics and Communities, evaluates sensitive communities and residential areas that would be affected by noise and vibration.
- Section 3.13, Station Planning, Land Use, and Development, evaluates locations where sensitive land uses and adjacent development would be affected by noise and vibration.
- Section 3.14, Parks, Recreation, and Open Space, evaluates adjacent parks and recreation areas that would be affected by noise and vibration.
- Section 3.16, Cultural Resources, evaluates historic architectural resources that would be affected by noise and vibration.
- Section 3.18, Cumulative Impacts, evaluates cumulative impacts from non-project sources from noise and vibration.

3.4.1.1 Definition of Terminology

This subsection provides definitions for noise analyzed in this Draft EIR/EIS.

Noise

Noise is discussed in terms of a “source-path-receptor” framework, as follows:

- Source—The *source* generates noise levels that depend on the type of source (e.g., an HSR train) and its operating characteristics (e.g., speed).
- Path—Between the source and the receptor is the *path*, where the noise is reduced by distance, intervening buildings or other features, and topography.
- Receptor—The *receptor* is the noise-sensitive land use (e.g., residence, hospital, or school, referred to as *sensitive receptors*) exposed to noise from the source.

Environmental noise impacts are assessed at the receptor. Noise criteria are established for the various types of receptors individually because not all receptors have the same noise sensitivity.

The Authority used three primary noise level descriptors (metrics) to assess noise impacts from traffic and transit projects: equivalent sound level (L_{eq})[3], day-night sound level (L_{dn})[4], and sound exposure level (SEL)[5].

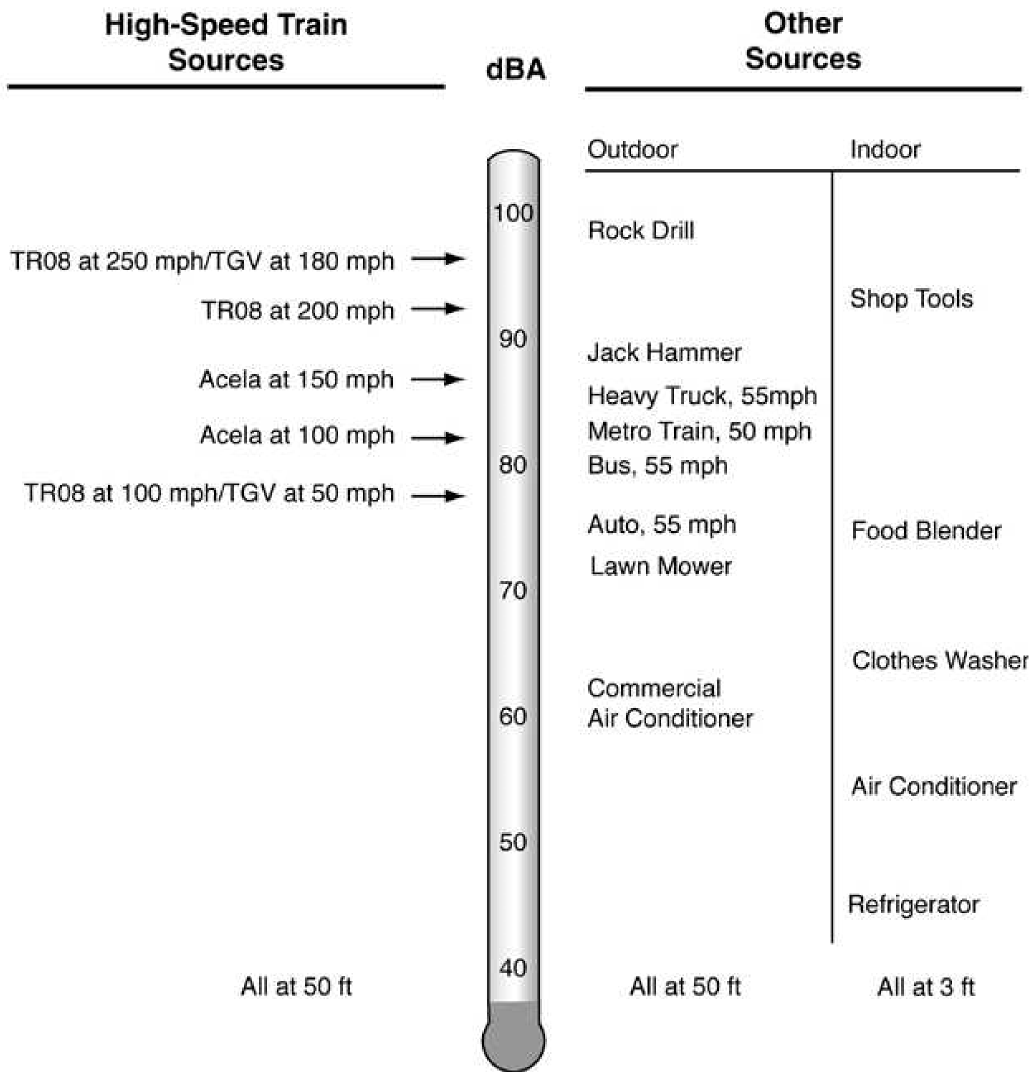
The frequency describes the tonal character of noise. Individual frequencies or a range of frequencies are expressed in terms of the rate of fluctuation of the air pressure in cycles per seconds or Hertz (Hz). The average human ear and brain system can generally perceive noise frequencies between 20 Hz and 20,000 Hz. However, the human hearing system does not respond equally to all frequencies; it is more sensitive to mid-band frequencies (e.g., 500 to 2,000 Hz). Thus, when describing sound and its effects on a human population, A-weighted decibel

[3] L_{eq} refers to a receptor’s energy-averaged noise exposure from all events over a specified period (e.g., 1 minute, 1 hour, 24 hours).

[4] L_{dn} refers to a receptor’s energy-averaged noise exposure from all events over a 24-hour period with a penalty added for nighttime (10:00 p.m. to 7:00 a.m.) noise periods.

[5] SEL refers to a receptor’s combined noise exposure from a single noise event condensed into a 1-second duration.

(dBA) sound pressure levels are used to account for the response of the human ear by de-emphasizing the low and very high frequency components of the sound. The A-weighted sound level correlates well with human response and is expressed in terms of a single number. Figure 3.4-1 illustrates typical A-weighted noise levels of HSR trains, as well as other indoor and outdoor noise sources. Typical A-weighted sound levels range from the 40s to the 90s (in dBA), where 40 is very quiet and 90 is very loud. On average, each A-weighted sound level increase of 10 decibels (dB) corresponds to an approximate doubling of subjective loudness.



Source: FRA 2012

Figure 3.4-1 Typical A-Weighted Maximum Sound Levels

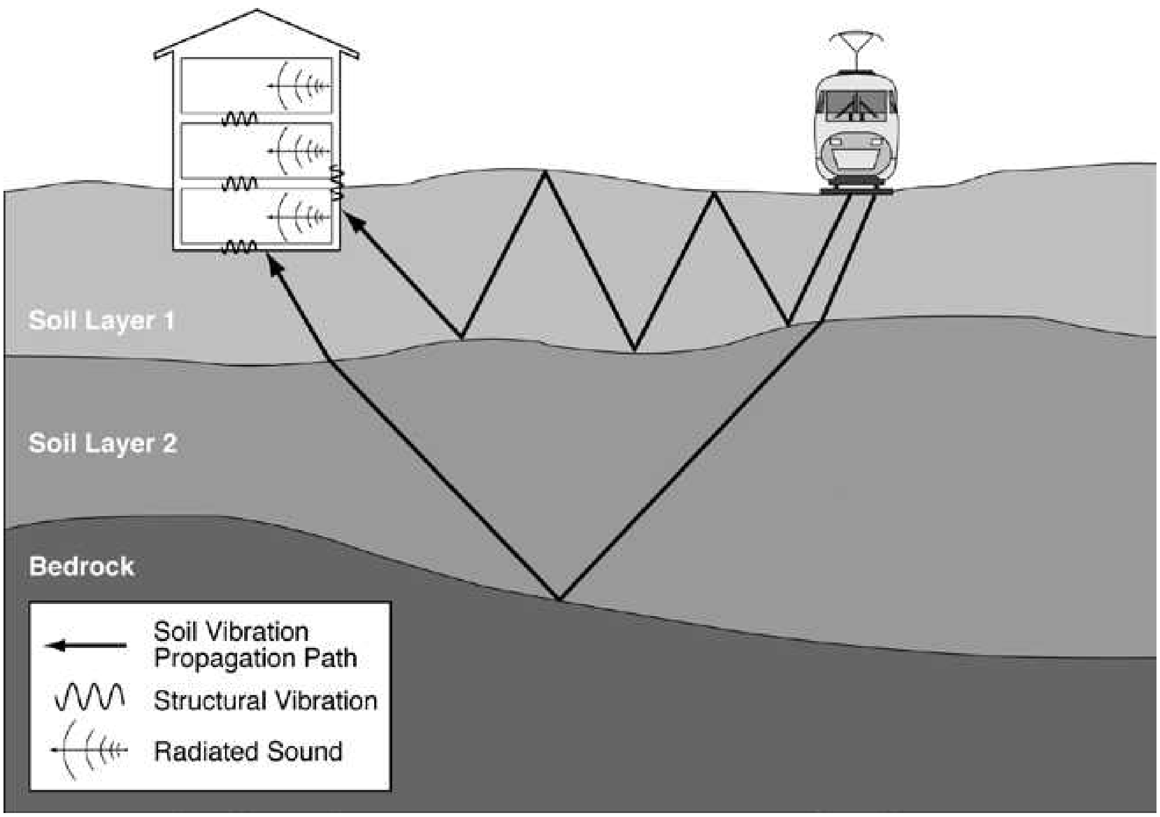
Vibration

Vibration is also discussed in terms of a "source-path-receptor" framework, as follows:

- Source—The *source* generates energy that causes vibration, such as the operation of construction equipment (e.g., an auger) that could cause ground vibrations that spread through the ground and diminish in strength with distance from the source.

- Path—Once the vibration is in the ground, it propagates through the various soil and rock layers to the foundations of nearby buildings (the receptors). Ground-borne vibrations generally decline with distance, depending on the local geological conditions.
- Receptor—A *receptor* is a vibration-sensitive building (e.g., residence, hospital, school), where the vibrations may cause perceptible shaking of the floors, walls, and ceilings, and a rumbling sound inside rooms. Not all receptors have the same vibration sensitivity. Consequently, criteria are established for the various types of receptors.

As with sound, vibration attenuates as a function of the distance between the source and the receptor. Vibration caused by trains moving along a transit structure, such as at-grade ballast and tie track, radiates energy into the adjacent soil. Buildings respond differently to ground vibration depending on the type of foundation, the mass of the building, and the building interaction with the soil. Once inside the building, vibration propagates throughout the building with some attenuation with distance from the foundation, but often with amplification due to floor resonances. The basic concepts for rail system-generated ground vibration are illustrated on Figure 3.4-2.



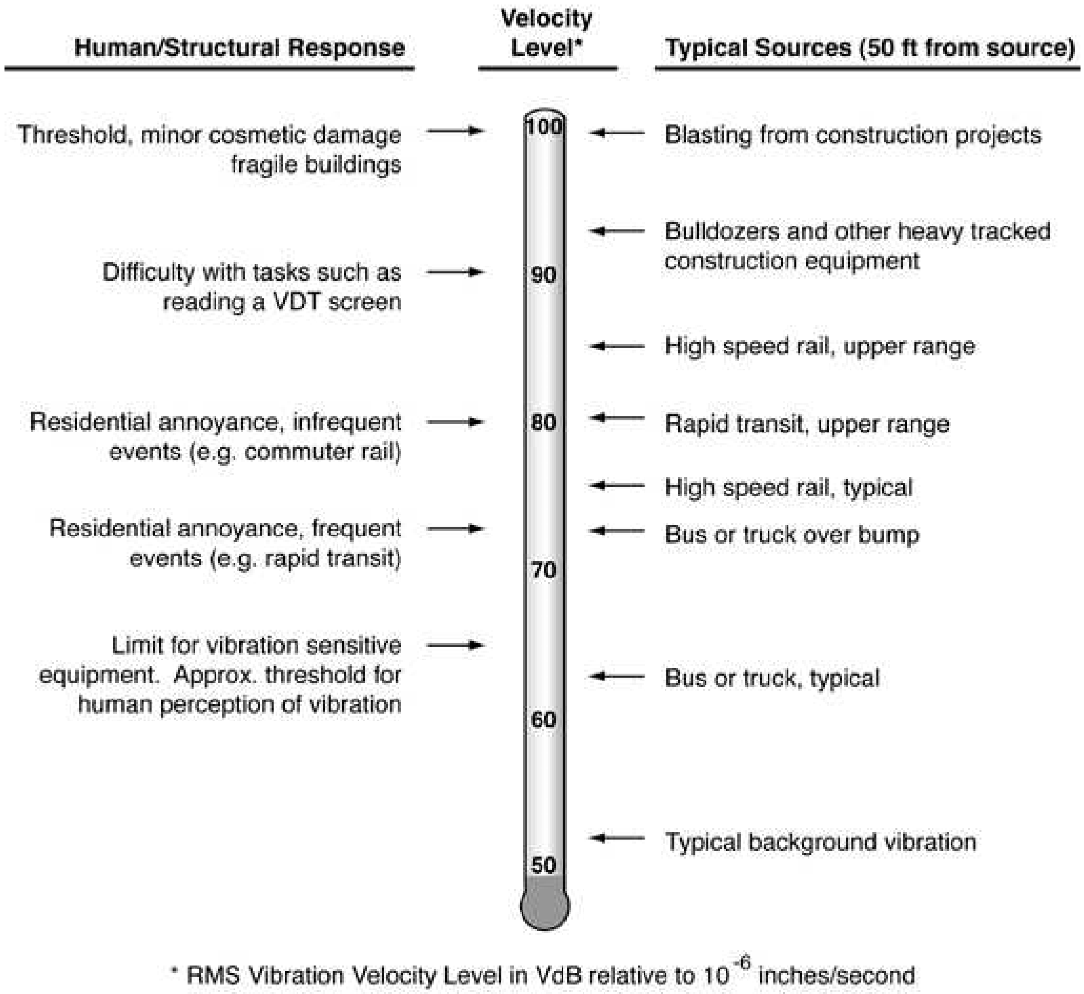
Source: FRA 2012

Figure 3.4-2 Propagation of Ground-Borne Vibration into Buildings

Vibration can be described by its peak or root-mean-square (RMS) amplitudes. The RMS amplitude (expressed as vibration decibels [VdB]) is useful for assessing human annoyance, while peak vibration is most often used for assessing the potential for damage to building structures. Building damage is often discussed in terms of peak velocity, or peak particle velocity (PPV). Construction vibration is assessed in terms of PPV. Refer to Volume 2, Appendix 3.4-A, for additional details regarding noise and vibration descriptors.

Vibration is evaluated for its potential to cause damage to buildings, disrupt sensitive operations, or cause annoyance to humans within buildings. Although the threshold of human perception to vibration is approximately 65 VdB, annoyance does not usually occur until the vibration exceeds 70 VdB.

Figure 3.4-3 illustrates the typical levels of human response and, at much higher levels, the response of structures to ground-borne vibration. The figure illustrates that the threshold of human perception is about 65 VdB, while the threshold for cosmetic damage to buildings is about 100 VdB. However, the threshold for building damage is directly related to the condition of the structure. While it is very rare that transportation-generated ground vibration approaches building damage levels, certain construction activities can produce high vibration levels.



Source: FRA 2012

Figure 3.4-3 Typical Levels of Ground-Borne Vibration and Response to Vibration

3.4.2 Laws, Regulations, and Orders

This section presents federal and state laws, regulations, and orders applicable to noise and vibration affected by the project. The Authority would implement the HSR project in compliance with all federal and state regulations. Volume 2, Appendix 2-I, provides a listing of regional and local plans and policies relevant to noise and vibration considered in the preparation of this analysis.

3.4.2.1 Federal

Noise Control Act of 1972 (42 U.S.C. § 4901)

The Noise Control Act of 1972 (42 United States Code § 4901) was the first comprehensive statement of national noise policy. It declared, "it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare." Although the act, as a funded program, was ultimately abandoned at the federal level, it served as the catalyst for comprehensive noise studies and the generation of noise assessment and mitigation policies, regulations, ordinances, standards, and guidance for many states, counties, and municipal governments. For example, the noise elements of community general plans and local noise ordinances studied as part of this analysis were largely created in response to passage of the act.

Occupational Safety and Health Administration Occupational Noise Exposure (29 C.F.R. § 1910.95)

The Occupational Safety and Health Administration (OSHA) (29 Code of Federal Regulations [C.F.R.] § 1910.95) has regulated worker noise exposure to a time-weighted average of 90 dBA over an 8-hour work shift. Areas where levels exceed 85 dBA must be designated and labeled as high-noise-level areas where hearing protection is required. This noise exposure criterion for workers would apply to project construction activities. Noise from construction activities might also elevate noise levels at nearby construction sites to levels that exceed 85 dBA and thus trigger the need for administrative or engineering controls and hearing conservation programs for worker safety, as detailed by OSHA.

Federal Railroad Administration

Noise and Vibration Impact Assessment Guidelines

The Federal Railroad Administration (FRA) provides guidance regarding the evaluation of noise and vibration impacts from construction and operation of high-speed trains in *High-Speed Ground Transportation Noise and Vibration Impact Assessment* (FRA guidance manual) (FRA 2012). The manual includes prediction methods, assessment procedures, and impact criteria for noise and vibration. Section 3.4.4.3, Methods for Impact Analysis, discusses the noise and vibration impact criteria.

Railroad Noise Emission Compliance Regulations (49 C.F.R. Part 210)

The FRA's Railroad Noise Emission Compliance Regulations (49 C.F.R. Part 210) prescribe minimum compliance regulations for enforcement of Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers (40 C.F.R. Part 201) adopted by the U.S. Environmental Protection Agency (USEPA). New locomotives must meet the following noise standards: 70 dBA at 100 feet while stationary at idle throttle setting, 87 dBA at 100 feet while stationary at all other throttle settings, 90 dBA at 100 feet while moving. Rail cars must meet the following noise standards: 88 dBA while moving at speeds of 45 mph or less, and 93 dBA at 100 feet while moving at speeds faster than 45 mph.

Whether or not the USEPA standard applies to high-speed trainsets, the analysis in this Draft EIR/EIS does not assume that Authority trainsets would comply with it because the Authority is not aware of any high-speed trainsets manufactured in the world today that meet this standard at all speeds. A noise-generation standard specific to high-speed trains does exist in Europe (European TSI Standard), and a trainset manufactured to that standard generally complies with the USEPA standard at speeds below 190 to 200 mph; for this Project Section, train speeds would not exceed 110 mph. Above 200 mph, airflow over the trainset and its pantograph and related apparatus is the main source of noise, which presently-known technology cannot resolve to comply with the USEPA standard (if applicable). The analysis in this Draft EIR/EIS, both prior to mitigation and after mitigation, assumes a trainset generating noise in compliance with the European TSI standard, because trainsets currently in manufacture and operation in Europe can meet this standard; the analysis does not assume a trainset that meets the USEPA standard.

Locomotive Horn Rule (49 C.F.R. Part 222 and Part 229)

FRA regulations require that engineers sound their locomotive horns while approaching public grade crossings until the lead locomotive fully occupies the crossing. In general, the regulations require locomotive engineers to begin to sound the train horn for a minimum of 15 seconds, and a maximum of 20 seconds, in advance of public grade crossings. Engineers must also sound the train horn in a standardized pattern of two long, one short, and one long blast and the horn must continue to sound until the lead locomotive or train car occupies the grade crossing. Additionally, the minimum sound level for the locomotive horn is 96 dBA, while the maximum sound level (L_{max}) is 110 dBA, both measured at 100 feet forward of the locomotive.

FRA allows public authorities to establish a quiet zone, which is segment of a rail line, within which is situated one or a number of consecutive public road-rail crossings at which locomotive horns are not routinely sounded, provided sufficient safety measures are implemented at the crossing to prevent/minimize the potential for accidents to occur. Railroad authorities, including the Peninsula Corridor Joint Powers Board [PCJPB], the Authority, and railroad companies (such as Union Pacific Railroad) cannot establish quiet zones; only local cities and counties can establish them by applying to the FRA.

At a minimum, new quiet zones must be at least 0.5 mile in length and contain at least one public grade crossing (i.e., a location where a public highway, road, or street crosses one or more railroad tracks at grade). Every public grade crossing in a quiet zone must be equipped at a minimum with active grade crossing warning devices consisting of flashing lights and gates.

If a public authority wants to establish a new quiet zone, it must conduct an assessment of hazards related to the crossings in the proposed zone and implement sufficient safety measures to reduce the proposed quiet zone's risk level to an acceptable level. Improvements may include roadway medians or channelization devices to discourage motorists from driving around a lowered crossing gate; a four-quadrant gate system to block all lanes of highway traffic; converting a two-way street into a one-way street and installing crossing gates; and permanent or temporary (nighttime) closure of the crossing to highway traffic. As an alternative, communities may also choose to silence routine locomotive horn sounding through the installation of wayside horns at public grade crossings. Wayside horns are train-activated stationary acoustic devices at grade crossings that are directed at highway traffic as a one-for-one substitute for train horns.

As described in Chapter 2, Alternatives, the project includes the following improvements in all blended service segments with at-grade crossings: fencing of the right-of-way, four-quadrant gates and roadway channelization at at-grade crossings, and intrusion detection and monitoring systems. The installation of these features would assist local cities and counties to establish quiet zones should they decide to do so, but cities or counties would need to go through the quiet zone process with the FRA first to establish such zones.

Federal Transit Administration Guidelines

The Federal Transit Administration (FTA) provides guidance regarding the evaluation of noise and vibration impacts associated with construction and operation of non-high-speed trains in the *Transit Noise and Vibration Impact Assessment Manual* (FTA guidance manual) (FTA 2018). The manual includes prediction methods, assessment procedures, and impact criteria for noise and vibration. Although it was originally developed for use on public mass transit projects, the FTA guidance manual includes a method that is applicable to activities at existing stations that would provide HSR service, LMF activities, and conventional-speed rail operations. The FTA construction noise and vibration assessment method is consistent with the FRA method. Section 3.4.4.3 discusses the noise and vibration impact criteria.

Federal Highway Administration Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 C.F.R. Part 772)

The Federal Highway Administration (FHWA) stipulates procedures and criteria for noise assessment studies of highway projects (23 C.F.R. Part 772). It requires that noise abatement measures be considered on all major highway projects if the project will cause a substantial increase in traffic noise levels or if projected traffic noise levels approach or exceed the noise abatement criteria (NAC) level for activities occurring on adjacent lands. These noise criteria are assigned to exterior and interior activities.

If motor vehicle traffic noise from federally funded projects is predicted to approach or exceed the NAC during the noisiest 1-hour period, noise abatement measures must be considered, and, if determined to be reasonable and feasible, they must be incorporated as part of the project. Consistent with FHWA guidelines, the California Department of Transportation (Caltrans) defines "approach" as being within 1 dBA of the NAC. Caltrans criteria also consider that a 12-dB increase in peak-hour traffic noise is a significant increase as defined by the FHWA procedures.

3.4.2.2 State

General Plan Guidelines (Cal. Gov. Code § 65302(f)), Appendix C, Noise Element Guidelines

The noise element of a community's general plan provides a basis for a comprehensive local program to control and abate environmental noise and to protect citizens from excessive exposure. The California Governor's Office of Planning and Research (OPR) *State of California 2017 General Plan Guidelines* outlines the development of the noise element for local agencies (OPR 2017).

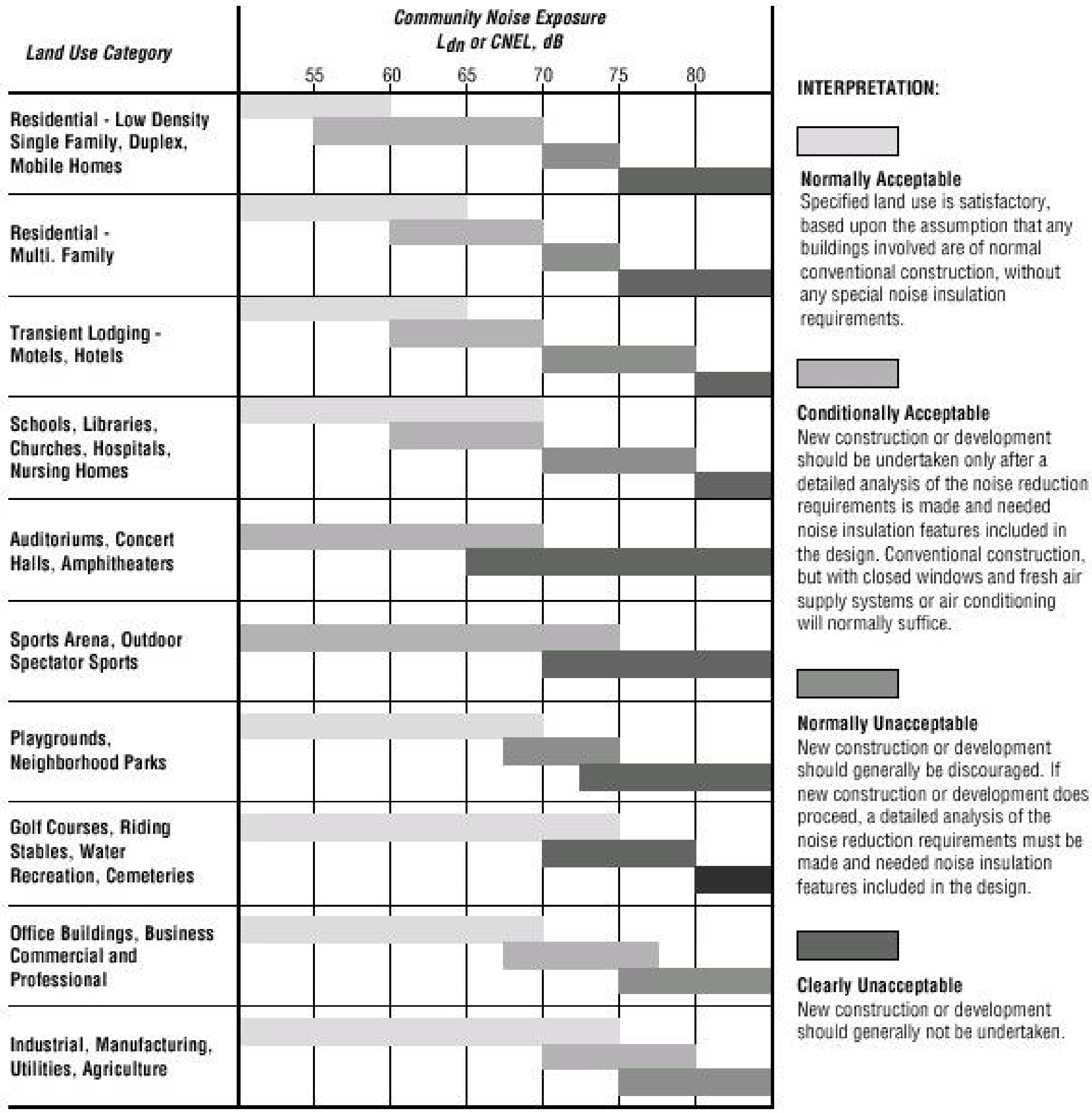
Figure 3.4-4 illustrates the land use compatibility guidelines. It is often adopted by city and county agencies for land use planning purposes for acoustical compatibility based on existing ambient noise levels in the community. For example, commercial land uses are considered appropriate where existing noise levels might be considered too high for residential development.

California Department of Transportation Traffic Noise Analysis Protocol

The Caltrans *Traffic Noise Analysis Protocol* (Caltrans 2011) establishes guidelines for evaluating traffic noise impacts along highways where frequent-outdoor-use areas are located and for determining reasonable and feasible noise abatement measures. These criteria are relevant to the extent that the project could result in reconstruction or reconfiguration of an existing highway or traffic lanes, or could affect traffic patterns. Under FHWA and Caltrans policies, noise abatement should be considered for transportation improvement projects when various traffic NAC are exceeded.

California Noise Control Act (Cal. Health and Safety Code § 46010 et seq.)

The relevant legacy of the California Noise Control Act of 1973 (California [Cal.] Health and Safety Code, Division 28, Noise Control Act, § 46000 et seq.) was the development of the required content of the noise element of general plans. This legislation provides guidance to local governments for preparing the required noise elements in city and county general plans, pursuant to California Government Code Section 65302(f).



Source: OPR 2017

Figure 3.4-4 State of California Land Use Compatibility Guidelines

3.4.2.3 Regional and Local

Counties and cities in California prepare general plans with noise policies and ordinances according to guidelines outlined in the discussion of state regulations. In preparing the noise element, a city or county must identify local noise sources, and analyze and quantify, to the extent practicable, current and projected noise levels for various sources. These noise sources may include highways and freeways; passenger and freight railroad operations; ground rapid transit systems; commercial, general, and military aviation and airport operations; and other ground stationary noise sources, which would include HSR alignments. Noise-level contours must be mapped for these sources using the community noise equivalent level (CNEL) or the L_{dn}, and are to be used as a guide in land use decisions to minimize the exposure of community residents to excessive noise. General plans may but usually do not address ground-borne vibration.

These noise elements often describe the existing L_{dn} near airports and incorporate specific allowable noise levels to achieve a quality environment. Where airports exist, many airports identify an airport noise impact area, which identifies adverse noise impacts within the 65-CNEL noise contour generated by the airport.

Volume 2, Appendix 2-I, lists all regional and local policies applicable to the project. The HSR system is not subject to local general plan policies and ordinances related to noise limits or to locally based criteria concerning noise and vibration for the project alternatives.

3.4.3 Consistency with Plans and Laws

As indicated in Section 3.1.5.3, Consistency with Plans and Laws, the California Environmental Quality Act (CEQA) and Council on Environmental Quality (CEQ) regulations require a discussion of inconsistencies or conflicts between a proposed undertaking and federal, state, regional, or local plans and laws. As such, this Draft EIR/EIS describes inconsistency of the project with federal, state, regional, and local plans and laws to provide planning context.

A number of federal and state laws and implementing regulations, listed in Section 3.4.2.1, Federal, and Section 3.4.2.2, State, govern compliance with noise emission limits for construction projects and for transportation facilities. As noise and vibration assessment is highly technical, there are several published federal and state guidance documents for how to assess potential impacts. Consistent with the guidance, a summary of the federal and state requirements and methods considered in this analysis follows:

- FHWA and FRA guidelines for emissions of noise from transportation sources and for the abatement of excessive noise emissions.
- OSHA regulations that provide permissible construction worker noise exposure limits.
- FTA guidelines regarding modeling noise impacts from station activities, yard and maintenance facility activities, and conventional-speed rail operations.
- The Caltrans *Traffic Noise Analysis Protocol* (Caltrans 2011), which provides a methodology for evaluating noise from roadway operations and for evaluating the effectiveness and feasibility of different sound abatement methods for highway-related projects.
- FRA guidelines regarding modeling and mitigating noise and vibration from construction sources at sensitive receptors in proximity to construction. The construction analysis methods discussed in the FHWA and FTA guidelines and the Caltrans protocol were not used; however, some construction equipment reference sound levels from FHWA were used.

The Authority, as the lead agency proposing to build and operate the HSR system, is required to comply with all federal and state laws and regulations and to secure all applicable federal and state permits prior to initiating construction on the selected alternative. Therefore, there would be no inconsistencies between the project alternatives and these federal and state laws and regulations.

The Authority is a state agency and therefore is not required to comply with local land use and zoning regulations; however, it has endeavored to design and build the HSR system to be consistent with land use and zoning regulations. For example, the project alternatives incorporate IAMFs that would require the contractor to prepare a plan to demonstrate how construction noise levels would be maintained below applicable standards. The Authority has also adopted statewide policies that seek to reduce noise impacts associated with new sources of transportation noise (see Volume 2, Appendix 3.4-B). The Authority reviewed a total of 22 local plans containing 176 policies, guidelines, or goals, as well as 19 codes or ordinances, to assess project consistency with plans, policies, and ordinances. The project alternatives would be consistent with 155 policies and inconsistent with 21 policies from general plans, and inconsistent with portions of noise ordinances established by 17 jurisdictions. A brief description of these inconsistencies follows:

- **Operational noise exceedances**—Although mitigation measures would reduce the project's operational noise impacts, noise impacts would not be reduced to the standards for residential, commercial, and institutional land uses established by the following general plan policies:
  - San Francisco General Plan, Environmental Protection Element (City and County of San Francisco 2004), Policy 11.1
  - Daly City 2030 General Plan (City of Daly City 2013), Policies NE-3, NE-4, N-5
  - South San Francisco General Plan (City of South San Francisco 1999), Policy 9-G-2
  - San Bruno General Plan (City of San Bruno 2009), Policy HS-33
  - City of Millbrae General Plan (City of Millbrae 1998), Policy NS2.1
  - City of San Mateo General Plan, Noise Element (City of San Mateo 2010), Policy N 2.2
  - Belmont 2035 General Plan (City of Belmont 2017), Policy 7.1-3
  - San Carlos 2030 General Plan (City of San Carlos 2009), Policy NOI-1.3
  - Redwood City General Plan (City of Redwood City 2010), Goal PS-14.1
  - Atherton General Plan (Town of Atherton 2002), Noise Element Policy 5.720
  - City of Menlo Park General Plan, Open Space/Conservation, Noise and Safety Elements (City of Menlo Park 2013), Policy N1.2
  - Santa Clara County General Plan (County of Santa Clara 1994), Policy C-HS 24
  - Palo Alto Comprehensive Plan (City of Palo Alto 2017), Policy N-6.1
  - Mountain View 2030 General Plan (City of Mountain View 2012), Policy NOI 1.1
  - Sunnyvale General Plan (City of Sunnyvale 2011), Policy SN-8.5
  - City of Santa Clara 2010–2035 General Plan (City of Santa Clara 2010), Policy 5.10.6-P2
  - Envision San José 2040 General Plan (City of San Jose 2018), Land Use Compatibility Guidelines for Community Noise in San Jose, Table 4
- **Burlingame Downtown Specific Plan (City of Burlingame 2018), Section 7.2.4; and City of San Mateo General Plan, Noise Element (City of San Mateo 2010), Policy N 2.5**—The project would be at grade along most of its length, including through Burlingame and San Mateo, resulting in inconsistencies with policies that call for the rail line to be depressed below street level, in part to reduce noise impacts.
- **Codes of ordinances or zoning regulations from the City/County of San Francisco, San Mateo County, Cities of Brisbane, Daly City, South San Francisco, San Bruno, San Mateo, Belmont, San Carlos, Redwood City, Town of Atherton, Menlo Park, Santa Clara County, Palo Alto, Sunnyvale, City of Santa Clara and City of San Jose**—Project construction would occur within a constrained operating rail corridor, and as such some trackwork and roadway work would be done at night to avoid disruption to Caltrain commuter rail operations and roadway operations. Even with the project features and mitigation measures, there would be locations where it is not technically feasible to meet the noise limits and permitted construction hours established by these local jurisdictions.

3.4.4 Methods for Evaluating Impacts

The evaluation of impacts from noise and vibration is a requirement of the National Environmental Policy Act (NEPA) and CEQA. The following sections summarize the RSAs and the methods used to analyze noise and vibration. As summarized in Section 3.4.1, Introduction, other resource sections in this Draft EIR/EIS also provide additional information related to noise and vibration.

3.4.4.1 Definition of Resource Study Area

RSAs are the geographic boundaries in which the environmental investigations specific to each resource topic were conducted. The RSAs for impacts from noise and vibration encompass the areas directly or indirectly affected by project construction and operation of the project. Separate RSAs are defined for noise and vibration, as summarized in Table 3.4-1.

Table 3.4-1 Definition of Noise and Vibration Resource Study Areas

Type	General Definition
Noise	
Construction and operations	The noise RSA extends approximately 2,500 feet from the project alternatives' centerlines and includes all sensitive receptors potentially exposed to noise impacts.
Vibration	
Construction and operations	The vibration RSA extends 220 feet from the project alternatives' centerlines and includes all sensitive receptors potentially exposed to vibration impacts.

RSA = resource study area

The noise RSA extends approximately 2,500 feet from the project alternatives' centerlines and includes all sensitive receptors potentially exposed to noise impacts. This noise RSA is larger than the maximum FRA-recommended screening distances for HSR trains listed in Table 3.4-2. The maximum FRA-recommended screening distance for HSR in an existing railroad corridor is 500 feet in quiet suburban environments with train operation speeds up to 170 mph; however, this recommendation assumes that there would be 50 train operations per day. Consistent with FRA methods, the noise RSA for the project was extended beyond the maximum FRA-recommended screening distances to reflect the higher frequency of train operations, which would total 144 revenue and nonrevenue trains per day.

Table 3.4-2 Federal Railroad Administration-Recommended Screening Distances for Evaluation of High-Speed Rail Noise Impacts[1]

Corridor Type	Existing Noise Environment	Screening Distance for Project Type and Speed Regime (feet from centerline)[2]	
		90 to 170 miles per hour	> 170 miles per hour
Railroad	Urban/noisy suburban—unobstructed	300	700
	Urban/noisy suburban—intervening buildings[3]	200	300
	Quiet suburban[4]	500	1,200
Highway	Urban/noisy suburban—unobstructed	250	600
	Urban/noisy suburban—intervening buildings[3]	200	350
	Quiet suburban	400	1,100
New Rail	Urban/noisy suburban—unobstructed	350	700
	Urban/noisy suburban—intervening buildings[3]	250	350
	Quiet suburban	600	1,300[4]

Source: FRA 2012

[1] Noise screening distances for Regime II (mechanical noise resulting from wheel/rail interactions and guideway vibrations) and Regime III (aerodynamic noise resulting from airflow moving past the train).

[2] Measured from centerline of guideway or rail corridor. Minimum distance is assumed to be 50 feet.

[3] Rows of buildings are assumed to be at 200 feet, 400 feet, 600 feet, 800 feet and 1,000 feet parallel to the guideway.

[4] Distance was extended to 2,500 feet for analysis of the project.

The project's vibration RSA extends 220 feet from the project alternatives' centerlines. This distance is consistent with the FRA screening procedures and was established to identify where vibration impacts from HSR might occur. The vibration analysis is not directly linked to the frequency of trains per day; therefore, the vibration RSA has not been scaled. Table 3.4-3 presents the FRA-recommended screening distances for vibration assessments of various land uses. To include all potentially affected areas along the project, the highest speed and frequent event categories were used to establish screening distances. Typically, the noise-sensitive land uses are also vibration sensitive; hence, the analyses are closely linked and the same locations are assessed for impacts from both noise and vibration.

Table 3.4-3 Federal Railroad Administration-Recommended Screening Distances for Vibration Assessments

		Screening Distance (feet from centerline) Train Speed		
Land Use	Train Frequency[1]	Less than 100 mph	100 to 200 mph	200 to 300 mph
Residential	Frequent	120	220	275
	Infrequent	60	100	140
Institutional	Frequent	100	160	220
	Infrequent	20	70	100

Source: FRA 2012
mph = miles per hour
[1] Frequent = more than 70 passbys per day; Infrequent = fewer than 70 passbys per day

The same RSAs apply to direct and indirect impacts. Direct impacts consist of increases in noise and vibration as a result of construction activities or HSR operation, while indirect impacts for noise include the project's impact on traffic patterns, which indirectly affect noise levels.

3.4.4.2 Impact Avoidance and Minimization Features

IAMFs are project features that are considered to be part of the project and are included as applicable in each of the project alternatives for purposes of the environmental impact analysis. Volume 2, Appendix 2-E, provides the full text of the IAMFs that are applicable to the project. NV-IAMF#1: Noise and Vibration, is applicable to the construction-phase noise and vibration analysis.

This environmental impact analysis considers this IAMF as part of the project design. In Section 3.4.6, Environmental Consequences, each impact narrative describes how this project feature is applicable and, where appropriate, effective at avoiding or minimizing potential impacts to less than significant under CEQA.

3.4.4.3 Methods for Impact Analysis

This section describes the sources and methods the Authority used to analyze potential project impacts from noise and vibration. These methods apply to both NEPA and CEQA analyses unless otherwise indicated. Section 3.1.5.4, Methods for Evaluating Impacts, describes the general framework for evaluating impacts under NEPA and CEQA.

This section describes the approach to establishing the existing noise and vibration conditions, identifies applicable criteria used for HSR construction and operations noise and vibration thresholds, and summarizes the process for predicting construction and operations noise and vibration levels. The noise and vibration predictions for the project alternatives were based on the detailed analysis method described in the FRA guidance manual and the FTA guidance manual where applicable, for example when evaluating station activities, yard and maintenance facility activities, and conventional-speed rail operations. Table 3.4-4 lists key assumptions for the operations noise and vibration analyses.

Table 3.4-4 Key Assumptions for the Operational Noise and Vibration Analysis

Component	Condition[1]			
	Existing (2017)	2029 No Project	2029 Plus Project	2040 Plus Project
Caltrain	40–92 trains per day[2] 79 mph maximum 100% diesel locomotives	54–114 trains per day[2] 79 mph maximum 25% diesel locomotives, 75% EMU	54–114 trains per day[2] 79 mph maximum 100% EMU	52–114 trains per day[2] 110 mph maximum 100% EMU
HSR (Project)	Not applicable	Not applicable	48–59 EMU trains per day[3] 79 mph maximum 4th and King Street Interim Station	134–176 EMU trains per day[3] 110 mph maximum Downtown station at Salesforce Transit Center
Freight[4]	2–9 diesel trains per day	2–15 diesel trains per day	2–15 diesel trains per day	2–23 diesel trains per day
ACE/Amtrak Capitol Corridor[5]	8–22 diesel trains per day	42 diesel trains per day	42 diesel trains per day	20–50 diesel trains per day
Coast Starlight[6]	2 diesel trains per day	2 diesel trains per day	2 diesel trains per day	2 diesel trains per day
Coast Daylight[7]	Not applicable	2 diesel trains per day	2 diesel trains per day	4 diesel trains per day
TAMC Salinas Rail Extension[8]	Not applicable	8 diesel trains per day	8 diesel trains per day	12 diesel trains per day
BART SVSX[9]	Not applicable	315 electric trains per day	315 electric trains per day	315 electric trains per day

ACE = Altamont Corridor Express
BART = Bay Area Rapid Transit
EMU = electrical multiple unit
mph = miles per hour
TAMC = Transportation Agency for Monterey County
[1] Except as noted for Caltrain and BART, rail operations analyses used 100 percent diesel locomotives. Caltrain will use EMUs with the Peninsula Corridor Electrification Project. BART uses electric train cars.
[2] Peak hour operations do not directly affect the noise analysis; for the existing condition Caltrain includes 5 trains per peak hour per direction and 6 trains per peak hour per direction for all future conditions. The range in Caltrain depends on location; the lower number is for trains south of the San Jose Diridon Station and the higher number is for trains north of the San Jose Diridon Station.
[3] Peak hour operations do not directly affect the noise analysis; for 2029 HSR includes 2 trains per peak hour per direction and for 2040 includes 4 trains per peak hour per direction from San Francisco to the San Jose Diridon Station; south of the San Jose Diridon Station, the peak hour would include 14 trains in 2040.
[4] Freight currently operates and would continue to operate on the same tracks used by Caltrain. Freight operates at night to avoid conflicts with passenger rail services due to slower freight train operating speeds.
[5] ACE/Amtrak Capitol Corridor currently operates and would continue to operate south of the Santa Clara Caltrain Station on separate tracks owned by Union Pacific Railroad. For the year 2040, ACE will operate a different number of trains north and south of Diridon Station.
[6] Coast Starlight currently operates and would continue to operate south of the Santa Clara Caltrain Station on separate tracks owned by Union Pacific Railroad.
[7] Coast Daylight currently operates and would continue to operate south of the San Jose Diridon Station on separate tracks owned by Union Pacific Railroad.
[8] TAMC Salinas Rail Extension currently operates and would continue to operate south of the San Jose Diridon Station on separate tracks owned by Union Pacific Railroad.
[9] BART SVSX would operate between the Santa Clara and San Jose Diridon Stations on separate tracks primarily within tunnel.

The Authority evaluated the following scenarios determined by the key elements and changes:

- **Existing Conditions**—Reflects current noise and vibration conditions based on current measurements.

- **2029 No Project condition**—Reflects future noise and vibration conditions in 2029 for the 4th and King Street Station area only, including planned changes in Caltrain operations.
- **2029 Plus Project condition**—Evaluates the potential impacts of project operations in 2029, for the 4th and King Street Station area only, which is the interim northern HSR terminus for 2029. By 2040, with the Downtown Extension (DTX), the northern HSR terminus would be at the Salesforce Transit Center.
- **2040 No Project condition**—Reflects future noise and vibration conditions in 2040, including planned changes in Caltrain operations, for all locations other than the 4th and King Street Station area that is evaluated for 2029 conditions.
- **2040 Plus Project condition**—Evaluates the full potential impacts of the project on 2040 conditions for all locations other than the 4th and King Street Station area that is evaluated for 2029 conditions.

Noise impact assessments are all conducted by comparing future conditions to existing conditions. The results reported for No Project conditions are provided for informational purposes only.

Noise

Existing Noise

Existing noise levels in the noise RSA were established by taking extensive field noise measurements in 2009, 2010, 2013, 2016, and 2017. Long-term noise measurements (1 to 3 days in duration) were taken to characterize the existing ambient noise in the RSA. A total of 86 measurements of ambient noise were taken in the noise RSA. The Authority obtained the L_{max} and L_{eq} for each hour, and used the L_{eq} to calculate the L_{dn}.

Specific locations for conducting the noise measurements throughout the RSA were selected based on the environmental conditions expected in different areas of the communities along the alignment, the type of receptors potentially affected, the proximity of the receptors to a major arterial road or freeway, and the distance of the receptors (primarily residences) to the existing Caltrain tracks. Most of the selected measurement sites between San Francisco and San Jose represent receptors that are directly exposed to existing noise from Caltrain and other passenger and freight trains. To categorize the dominant existing noise sources in the RSA, measurement sites were located adjacent to roadways along the alignment, near existing rail sources, near existing roadway sources, and near both existing rail and roadway sources.

Noise Level Terminology

- L_{max} is the maximum sound level
- L_{eq} is the equivalent, energy-averaged RMS noise exposure over a given time period (often over 1 hour)
- L_{dn} is the total noise exposure over a 24-hour period with a penalty added for sounds generated between 10 p.m. and 7 a.m.

The field noise measurement data was used to validate an existing noise spreadsheet model based on the FTA guidance manual methodology. This validated model, which incorporates existing train operations, horn, and traffic noise, was then used to calculate existing ambient noise levels at all receptors. Volume 2, Appendix 3.4-A, provides additional information on this modeling approach.

Impact Criteria

Construction

The FRA guidance manual includes construction noise assessment criteria as shown in Table 3.4-5. An 8-hour L_{eq} and a 30-day average noise exposure L_{dn} are used to assess impacts. A 30-day average L_{dn} is used to assess impacts in residential areas, and a 30-day average 24-hour L_{eq} is used to assess impacts in commercial and industrial areas. The noise emission levels of the construction equipment, utilization factor, hours of operation, and location of equipment are used to calculate 8-hour and 30-day average noise exposures. FRA assessment criteria are used throughout the RSA.

Table 3.4-5 Detailed Assessment Criteria for Construction Noise

Land Use	8-Hour L_{eq} (dBA)		L_{dn} (dBA)
	Day	Night	30-Day Average
Residential	80	70	75
Commercial	85	85	80[1]
Industrial	90	90	85[1]

Source: FRA 2012
dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
[1] 24-hour L_{eq}, not L_{dn}

Operations

The HSR system uses noise impact criteria and analytical methods adopted by the FRA to assess the contribution of the noise from HSR operations and construction to the existing environment and noise impact criteria, and analytical methods adopted by the FTA to assess the contribution of the noise from conventional-speed rail operations and stationary facilities. The FRA noise impact criteria are based on maintaining a noise environment considered acceptable for land uses where noise may have an impact. Land use also factors into determining an impact; while impacts on industrial uses are not considered, places where people sleep or where quiet is an integral component of the land use require evaluation to determine if noise impacts would occur and if mitigation is appropriate. Table 3.4-6 summarizes the three land use categories used by the FRA.

Table 3.4-6 Federal Railroad Administration Land Use Categories for Noise Exposure

Land Use Category	Noise Metric (dBA)	Land Use Category[1, 2]
1	Outdoor $L_{eq}(h)$[3]	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. Also included are recording studios and concert halls.
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 $L_{eq}(h)$[1]	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches, where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, and museums can be considered to be in this category. Certain historical sites, parks, campgrounds, and recreational facilities are also included.

Source: FRA 2012
dBA = A-weighted decibel
L_{dn} = day-night sound level
$L_{eq}(h)$ = hourly equivalent sound level
[1] Parks are only considered to be noise sensitive if the park is used in a manner that is noise sensitive; active outdoor land use, for example, such as pedestrian and bike paths, are not considered noise sensitive.
[2] Historic sites and properties protected under Section 4(f) of the U.S. Department of Transportation Act and Section 106 of the National Historic Preservation Act are not intrinsically noise sensitive; inclusion in noise-sensitive land use categories is dependent upon land use activities (e.g., if outdoor interpretation is a critical component of a historic site, then the site would be included in Category 1).
[3] L_{eq} for the noisiest hour of transit-related activity during hours of noise sensitivity.

FRA noise impact criteria for human annoyance are based on the comparison of existing outdoor noise levels and future outdoor noise levels from the project. The FRA noise impact criteria specify a comparison of future with existing noise levels, because comparison of a projection with an existing condition is more reflective of an impact than a comparison of two projections. Noise-level increases are categorized as no impact, moderate impact, or severe impact. Moderate and severe impacts are defined as follows:

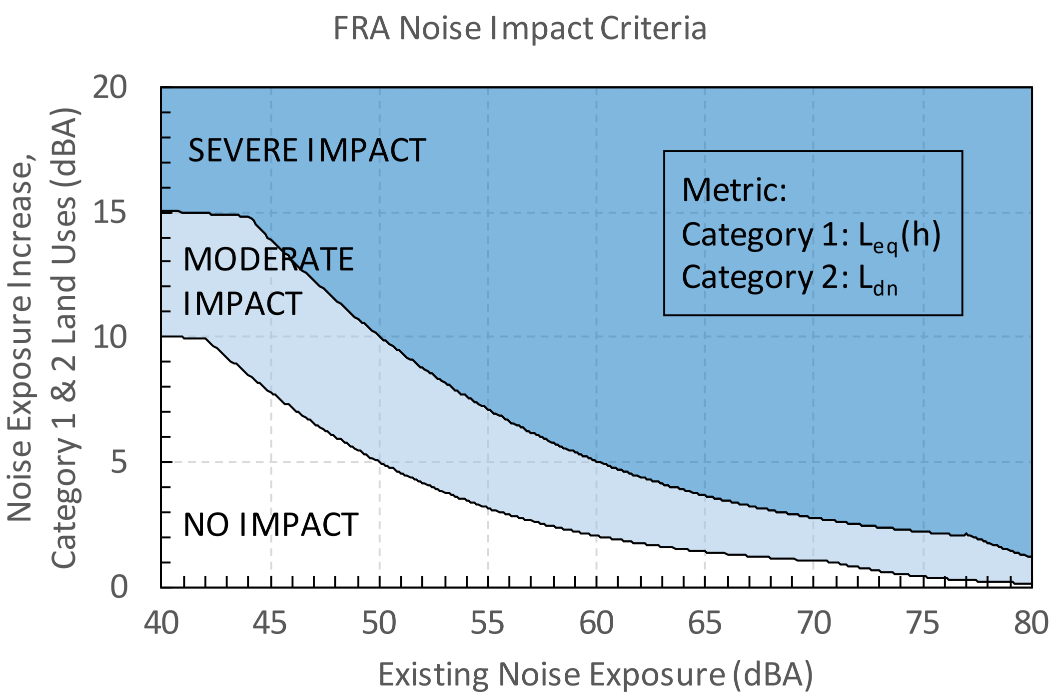
- **Moderate impact**—The change in noise level is noticeable to most people, but may not be sufficient to cause strong, adverse reactions from the community. Project-specific factors would be considered to determine the magnitude of impact and the need for mitigation, including the number of affected noise-sensitive sites, the existing level of noise exposure, and the costs associated with mitigation.
- **Severe impact**—Project-generated noise in the severe impact range can be expected to cause a substantial percentage of people to be highly annoyed by the new noise levels. It is FRA policy to implement noise mitigation for sensitive receptors experiencing severe impacts unless there are truly extenuating circumstances that prevent implementation.

The FRA criteria are presented in terms of relative levels for evaluating the total future noise exposure increases, or increases in combined noise exposure, from the project alternatives. If the existing noise were dominated by a source that changed because of the project, it would be incorrect to add the project noise to the existing noise. Therefore, the relative form of the noise criteria must be used for projects involving proposed changes to an existing rail transit system such as a shift in the location or profile of existing passenger or freight tracks or a change in the vehicle technology. Figure 3.4-5 illustrates the relative form of the criteria as they apply to Category 1 and 2 land uses and Figure 3.4-6 illustrates the criteria as they apply to Category 3 land uses. These criteria are based on the increase of the existing ambient noise level associated with project operations and can be used to evaluate the project in combination with other new planned projects (i.e., cumulative impact per CEQA). These criteria are applied to the outside of building locations at noise-sensitive areas.

To determine the severity of a noise impact, the Authority identified the land use category (Table 3.4-6), applied the appropriate noise metric (L_{dn} or L_{eq}), calculated the existing exterior noise exposure for each receptor or group of similar receptors, and then combined project noise exposure with the existing condition, or the cumulative noise exposure associated with the project alternatives and other projects using the data on Figure 3.4-5 and Figure 3.4-6.

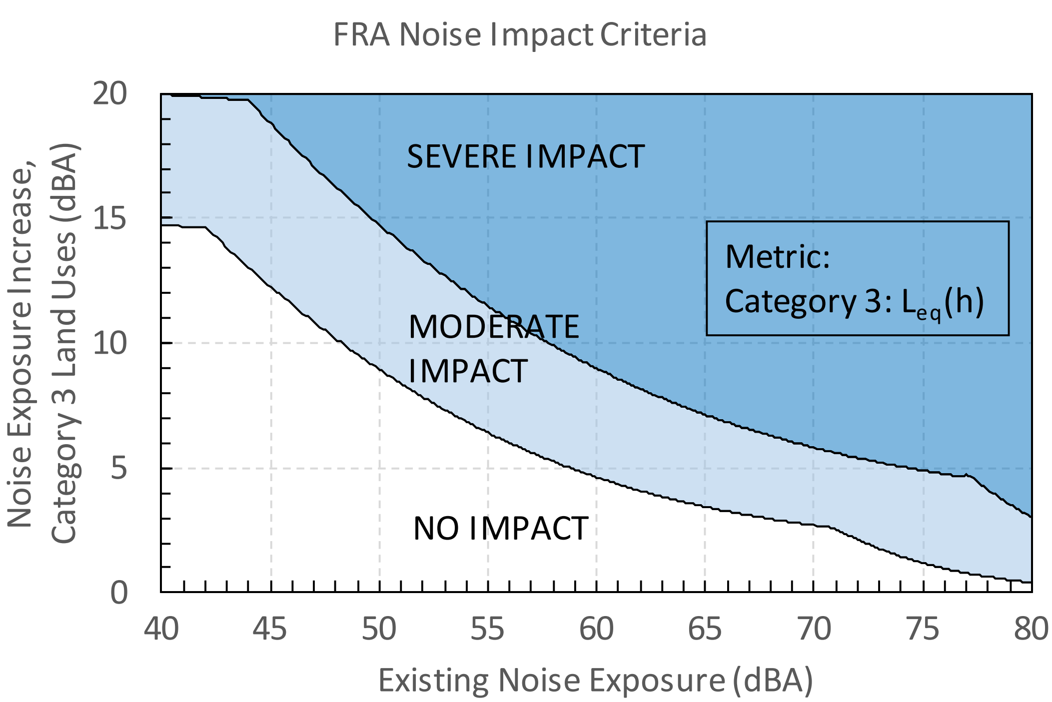
Consider a hypothetical residential property (Category 2) that has an existing noise exposure of L_{dn} 60 dBA. The noise exposure resulting from the project plus regional growth and other planned projects could result in a project noise level exposure of L_{dn} 65 dBA. Combining the project noise with the existing noise level[6] would result in a total combined noise exposure of L_{dn} 66 dBA or a potential increase of 6 dBA over the existing noise level. Volume 2, Appendix 3.4-A, provides more details. Using Figure 3.4-5, one would start with the horizontal axis at 60 dBA for the existing condition to draw a vertical line, then draw a horizontal line from 6 dBA on the left-hand axis. The intersection of these two lines determines the severity of impact. In this hypothetical example, the intersection of these two lines would fall in the severe impact range.

[6] Decibels are added logarithmically; 10 times the logarithm of 2 is 3 dB, so that 60 + 60 = 63 dB. Adding a smaller number to a larger number raises the latter by no more than 3 dB. Thus, 60 + 65 = 66 in decibels.



Source: FRA 2012

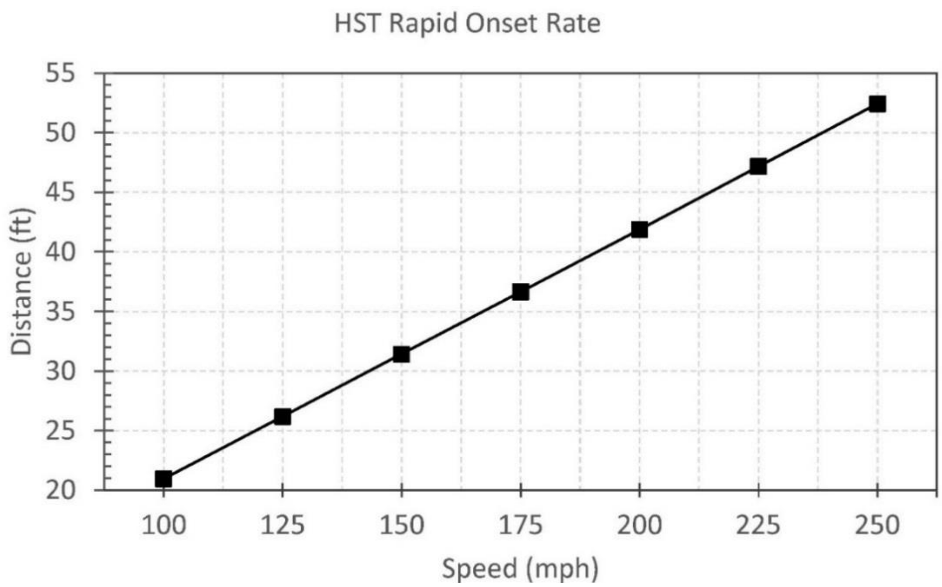
Figure 3.4-5 Allowable Increase in Combined/Cumulative Noise Levels (Land Use Categories 1 & 2)



Source: FRA 2012

Figure 3.4-6 Allowable Increase in Combined/Cumulative Noise Levels (Land Use Category 3)

An additional environmental concern for train operation at 110 mph is the rapid rise in sound level that can occur for trains travelling at very high speeds. Under certain conditions, a rapid rise of sound level can result in a startle effect, particularly for a receptor near the tracks. The rate at which train sound levels increase is referred to as the *onset rate* and is a function of train speed and distance from the tracks. Research has found that a sudden increase in sound (i.e., a rapid onset rate) can result in greater annoyance than sounds of similar levels that vary less rapidly or are steady (FRA 2012). When onset rates exceed about 30 dB/second people tend to be startled or surprised by the sudden onset of the sound. Figure 3.4-7 illustrates the potential for startle as a function of train speed and distance from the train.



Source: FRA 2012

Figure 3.4-7 Distance from Tracks within which Startle Can Occur for Train Passby

According to the FRA guidance manual (FRA 2012), the understanding of startle effects to date is partially based on using U.S. Air Force research for sudden onset of noise from aircraft. The FRA guidance notes that there are a number of unresolved issues regarding application of the U.S. Air Force research to determine the startle effects of HSR, such as the scheduled nature, lower sound levels and lower onset rates of train passbys compared to military aircraft flights. The FRA guidance states that without better definition of the application of results of noise from aircraft overflights to noise from HSR passbys, it is appropriate to consider startle effects as “additional information” included in HSR impact assessments as opposed to being included in the calculation of noise exposure itself. The FRA guidance does not provide a threshold in the form of an “onset rate that could be considered significant enough to cause startle on a regular basis”. Thus, the 30-dB/second onset rate is considered indicative of when startle can occur, but is not considered a significance threshold for determining when startle would occur on a regular basis.

Prediction Methods

Construction Noise

Construction noise impacts were assessed using the method described in the FRA guidance manual (FRA 2012). Construction noise estimates are always approximate because of the lack of specific information available at the time of the environmental analysis. The contractor would make decisions about the procedures and equipment to be used. Project designers try to minimize constraints on how construction would be performed, and which equipment would be used to facilitate cost-effective construction. Nevertheless, estimated construction scenarios for typical railroad construction projects allow a quantitative construction noise assessment by comparing the predicted noise levels with impact criteria appropriate for the construction stage. The methods include the following data:

- Noise emissions from equipment expected to be used by contractors during typical construction activity types
- Usage scenarios for how the equipment would be operated as they relate to noise
- Estimated time duration/schedule information
- Estimated site layouts of equipment along the right-of-way
- Relationship of the construction activities to nearby noise-sensitive receptors

Because many of the construction noise sources are mobile and some activities are focused on the track area, while some could extend to other areas of the right-of-way, the noise analysis is based on developing the typical, maximum noise levels on an L_{eq} basis over an 8-hour work day. Thus, the construction noise estimates are based on the noisiest pieces of equipment using the distance to the center of the construction zone.

Operations Noise

The method to assess operations noise impacts is consistent with the detailed analysis approach established in the FRA guidance manual (FRA 2012). For noise from stations, the LMF, and noise from conventional-speed railroad noise sources, the noise analysis is consistent with the methods outlined in the FTA guidance manual (FTA 2018). This section describes the methods for assessing potential noise impacts from train operations under the No Project Alternative and project alternatives in 2029 and 2040; horn noise; impacts associated with the onset of passing HSR trains; and noise impacts of stations, the LMF, vehicular traffic, and traction power facilities. These analyses take into account the existing noise conditions, which include railroad, highway, airport, and industrial sources.

Train horn noise is an important feature of the project, because existing train operations sound warning horns approaching at-grade crossings and Caltrain passenger stations. Existing Caltrain locomotives feature horns at 16 feet above top of rail (ATOR) that produce an L_{max} of 96 dBA at 100 feet from the track. Future Caltrain EMUs will feature horns mounted at 3 feet ATOR with an L_{max} of 96 dBA at 100 feet from the track. Freight trains feature horns at 16 feet ATOR with an L_{max} of 107 dBA at 100 feet from the track. Future HSR trains would feature horns mounted at 7 feet ATOR with an L_{max} of 96 dBA at 100 feet from the track. Volume 2, Appendix 3.4-A, contains additional information about train horns.

The analysis of HSR 2029 project operations at the 4th and King Street Station assumes HSR service from San Francisco to Bakersfield (Silicon Valley to Central Valley) only. Train service would include revenue-service trains and nonrevenue-service trains with daily trips to and from the Brisbane LMF. The 2029 analysis conducted for the 4th and King Street Station included the area from just south of Mission Bay Drive to 4th and King Street. Table 3.4-7 summarizes the number of daily HSR trains for this area.

The analysis of HSR project operations in 2040 assumes HSR Phase 1 service, which would connect San Francisco with Los Angeles through the Central Valley. Table 3.4-7 summarizes the number of daily HSR trains for various portions of the Project Section. The number of daily trains would be the same under both project alternatives. HSR service from the 4th and King Street Station to the Salesforce Transit Center was previously and separately evaluated in the EIR/EIS for the DTX (USDOT et al. 2004, 2018). The 2040 analysis was conducted from the point at which the HSR trains would emerge from the DTX tunnel south of Mission Bay Drive in San Francisco to Scott Boulevard in Santa Clara. The 4th and King Street Station was not included in the 2040 analysis because that portion of the alignment will be part of the DTX tunnel in 2040, and that project has already been environmentally cleared. Volume 2, Appendix 3.4-A, contains a detailed discussion of assumptions used for vehicle technology, train lengths, track configurations, and design speeds.

Table 3.4-7 Assumed 2029 and 2040 HSR Operations for Noise Impact Assessment

Segment	Total Number of HSR Trains (Both Directions)		
	Daytime[1]	Nighttime[2]	Peak Hour (Approximate)[3]
2029			
San Francisco 4th and King Street Station and Approach	44	15	5
2040			
San Francisco to Brisbane LMF	110	34	9
Brisbane LMF to Millbrae Station	108	26	9
Millbrae Station to Scott Boulevard	108	26	9
Scott Boulevard to San Jose Diridon Station	108	26	8
San Jose Diridon Station to West Alma Avenue	148	28	14

Source: Authority 2018
HSR = high-speed rail
LMF = light maintenance facility
[1] Daytime is defined as between 7:00 a.m. and 10:00 p.m.
[2] Nighttime is defined as between 10:00 p.m. and 7:00 a.m.
[3] There are 6 peak hours of operation per day from 6:30 a.m. to 9:30 a.m. and from 4:30 p.m. to 7:30 p.m. There are 12 hours of non-peak operation from 6:00 a.m. to 6:30 a.m., 9:30 a.m. to 4:30 p.m., and from 7:30 p.m. to 12:00 a.m. The actual number of trains per hour during peak hours of operation are approximate because there would be one to two nonrevenue train movements per hour in addition to standard revenue service operations.

Noise predictions were based on the noise source reference levels for the specific vehicle technology proposed for the HSR system provided in the FRA guidance manual for a very high-speed EMU train, adjusted for maximum 110 mph operational speed. The noise source reference levels for very high-speed EMU trains are included in Table 4-6 of Appendix 3.4-A and in Table 5-2 of the FRA guidance manual (FRA 2012); further information regarding the analysis is provided in Volume 2, Appendix 3.4-A. Noise predictions accounted for the proposed operations schedule, ground propagation attenuation effects, cross-sectional geometry of the trackway and superstructure (e.g., elevated guideway), and shielding provided by existing noise barriers and intervening rows of buildings.

Adjustments were made to predicted noise levels to account for increases in localized noise due to special trackwork, such as crossovers or turnouts. The project alternatives would use the same type of special trackwork as currently exists in the corridor. All special trackwork frogs (rail hardware where tracks cross one another) in the Project Section for both alternatives on blended service tracks shared with Caltrain trains were assumed to be standard frogs. In the San Jose Diridon Station Approach Subsection, Alternative B (Viaduct to Scott Boulevard) south of Scott Boulevard or Alternative B (Viaduct to I-880) south of I-880 would operate on dedicated HSR tracks and use special trackwork, such as moveable-point frogs, to avoid significant gaps in the rail running surface, and any insulated joints would be low-impact joints.

The analysis of project operations in 2029 and 2040 also evaluates the planned changes in Caltrain operations for blended service between San Francisco and San Jose based on methods in the FTA guidance manual for conventional-speed railroads. The Caltrain PCEP will electrify the Caltrain corridor between San Francisco and the Tamien Station in San Jose, replace 75 percent of diesel-locomotive-hauled coaches with EMUs, and increase service to six trains per peak hour per direction. With the commencement of blended service operations, Caltrain service will consist of 100 percent EMUs. These changes to Caltrain service would increase the existing noise environment in the RSA; therefore, the Caltrain PCEP is evaluated as part of the analysis of project operations and the combined noise analysis in 2029 and 2040. The Authority modeled noise level changes associated with changes in passenger and freight operations in 2029 and

2040 based on FTA methods, and incorporated this analysis into the 2029 and 2040 No Project conditions and the 2029 and 2040 Plus Project combined conditions.

Train horn noise associated with HSR operations was also evaluated. The existing rail tracks include numerous at-grade crossings and Caltrain passenger station platforms where Caltrain and freight trains are currently required to sound their warning horns. HSR trains would also sound horns as they approach at-grade crossings and passenger stations (see Volume 2, Appendix 3.4-A, for specific locations). To assess noise levels associated with the at-grade crossings and horn-sounding locations for each project alternative, the Authority used existing field noise measurements of passenger and freight trains and applied the horn noise model (FRA 2000) to receptors within 0.25 mile of locations where horns must be sounded. The noise level from the HSR train horn was assumed to be the same noise level as the Caltrain horn. The sounds from crossing bells near existing at-grade crossings was also considered in the noise measurement program and modeled based on the methods in the FTA guidance manual.

In addition to predicting noise levels associated with train operations, noise impacts associated with other noise sources including HSR passbys, station noise, LMF noise, and vehicle traffic noise was evaluated. A brief overview of the methods for each of these evaluations is as follows (refer to Volume 2, Appendix 3.4-A, for additional detail):

- **Startle and annoyance from rapid onset of HSR passbys**—An onset rate of 30 dBA per second and the FRA impact criteria illustrated on Figure 3.4-4 was used to establish distances from the track centerlines within which startle effects would likely be experienced. The distances from the outermost track centerline were compared to the location of sensitive receptors beyond the access-restricted right-of-way to identify receptors that could experience startle and annoyance from the rapid onset of HSR and Caltrain passbys.
- **Station noise**—The impacts of station noise associated with train movements and vehicular traffic on nearby noise-sensitive receptors was assessed according to the methods summarized in Section 5.2 of the FRA guidance manual (HSR train operations) and Section 4.4 of the FTA guidance manual (parking facilities). Noise levels associated with HSR train operations were modeled based on the train operating schedules, equipment type, speed profile, and track configuration. Station plan layouts and number of planned parking spaces were used, where applicable, to predict the noise exposure from the parking facilities at nearby noise-sensitive receptors. A reference SEL of 92 dBA at 50 feet distance corresponding to 1,000 cars in a peak activity hour (derived from the FTA guidance manual Section 4.4) was used to predict the additional noise from the parking lots, where applicable, at each of the HSR station stops. The Authority tabulated the predicted noise levels from HSR trains at the stations and from the parking facilities along with the existing ambient noise exposures, and determined levels of impact (no impact, moderate impact, or severe impact) by comparing the existing and projected noise exposure to the impact criteria illustrated on Figures 3.4-4 and 3.4-5.
- **LMF noise**—The methods in Section 4.4 of the FTA guidance manual were used to predict noise exposure from the Brisbane LMF. A reference SEL of 118 dBA at 50 feet distance corresponding to 20 train movements in a peak-activity hour was used to predict noise from the facility. The planned LMF layouts and number of movements per day were used to calculate noise exposure at nearby noise-sensitive receptors. The predicted noise levels from the Brisbane LMF were then combined with the HSR operations noise predictions and compared to the impact criteria previously described.
- **Vehicle traffic noise**—The changes in noise levels resulting from increased vehicle traffic volumes near the stations that would provide HSR service and the Brisbane LMF were assessed by comparing daily traffic volumes for roadway segments near these HSR station stops and LMF for each project alternative to existing traffic volumes. Consistent with FRA guidance, traffic growth factors under the No Project and project alternatives were calculated to assess noise levels. At locations where the growth factors for a project alternative resulted in a 3 dB or greater increase in noise (equivalent to a doubling of traffic volumes), the

Authority evaluated the increase in traffic volume that would be related to the project. Additional information regarding this analysis is provided in Volume 2, Appendix 3.4-A.

- **Traction power facilities (TPF)**—Additional equipment (e.g., transformers) may be installed to handle HSR electrical loads at the Caltrain PCEP TPFs. The HSR equipment would be similar in terms of size and capacity to the Caltrain equipment. Under Alternative B, a new TPSS would be installed in San Jose south of I-880, which would encompass approximately 32,000 square feet (200 feet by 160 feet), and include two 115/50-kilovolt or 230/50-kilovolt single-phase transformers at 60 megavolt amperes. The FRA does not have its own analysis techniques because these facilities are not unique to HSR systems, and FRA references the FTA method. In the PCEP analysis potentially affected noise-sensitive receptors from PCEP TPFs were identified using the FTA screening distance of 250 feet from the various facilities (i.e., TPSSs, paralleling station, or switching station). The Authority used the results from the PCEP EIR (PCJPB 2015) to calculate the total project noise level at the receptors identified within the screening distance. Volume 2, Appendix 3.4-A, provides additional information regarding this analysis for locations north of Scott Boulevard. The San Jose to Merced Noise and Vibration Technical Report provides additional information for locations south of Scott Boulevard (Authority 2019a). There may be temporary construction activity at the PCEP TPF sites along the corridor during equipment installation as well as at the new TPSS site.

Vibration

Existing Vibration

Measurement sites were selected to capture overall ground vibration as well as spectral components (frequency content of the ground vibration) of the train passbys, which are influenced by the local soil conditions and input forces unique to different types of trains. Sites with high potential for vibration impacts were prioritized, and because Caltrain train vibration is the dominant existing source of ground vibration in most of the RSA, the vibration survey focused on obtaining ground vibration measurements during Caltrain passbys at typical setback distances of the sensitive receptors from the nearest track. Measurements of the existing vibration levels associated with train passbys were conducted at 37 sites in the vibration RSA, as summarized in Table 3.4-12.

Results of the ambient vibration survey indicate the existing overall vibration levels throughout the corridor vary based on Caltrain speed and the degree of variability in soil vibration attenuation characteristics. These factors were used in the selection of field vibration propagation locations for testing that was performed for the detailed analysis.

Impact Criteria

Construction

The construction vibration assessment is based on the FRA guidance manual, which covers potential impacts on buildings and potential annoyance to building occupants. Table 3.4-8 shows the FRA guidelines for vibration damage criteria from construction activity. These limits were used to identify areas that should be addressed during engineering design of the project.

To analyze temporary annoyance to building occupants during the nighttime period or interference with vibration-sensitive equipment inside special-use buildings during construction, FRA recommends using the long-term operations vibration criteria for a general assessment.

Table 3.4-8 Federal Railroad Administration Construction Vibration Damage Criteria

Building Category	PPV (in/sec)	Approximate L_v[1]
I. Reinforced concrete, steel or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Nonengineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

Source: FRA 2012
µin/sec = microinches per second
in/sec = inches per second
L_v = velocity level
PPV = peak particle velocity
RMS = root-mean-square
VdB = vibration decibels
[1] RMS VdB re: 1 µin/sec

Operations

Vibration impact levels are determined by the type of land uses affected, the number of daily vibration events, and the type of analysis being conducted (i.e., ground-borne vibration or ground-borne noise). The FRA provides guidelines to assess the human response to different levels of ground-borne noise and vibration as shown in Table 3.4-9. Ground-borne noise and vibration levels represent the vibration during a train passby (RMS vibration level of an event). The guidelines provide additional criteria for special-use buildings that are sensitive to ground-borne noise and vibration as shown in Table 3.4-10. The Authority considered the number of daily train events (more than 70 trains per day indicates that HSR service would be considered a frequent event), and applied the criteria in Table 3.4-9 and Table 3.4-10 to occupied spaces in potentially affected buildings (i.e., receptors). Ground-borne vibration is assessed at the building façade. Ground-borne noise is assessed inside buildings.

Table 3.4-9 Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re: 1 µin/sec)			GBN Impact Levels (dB re: 20 µPa)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[5]	N/A[5]	N/A[5]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Source: FRA 2012
µin/sec = microinch per second
µPa = micro-Pascal
dB = decibel
dBA = A-weighted decibel
GBN = ground-borne noise
GBV = ground-borne vibration
N/A = not applicable
VdB = vibration decibels
[1] *Frequent Events* is defined as more than 70 vibration events of the same kind per day.
[2] *Occasional Events* is defined as between 30 and 70 vibration events of the same kind per day.
[3] *Infrequent Events* is defined as fewer than 30 vibration events of the same kind per day.
[4] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research would require detailed evaluation to define the acceptable vibration levels. Lower vibration levels in a building often require special design of the heating, ventilation, and air-conditioning systems and stiffened floors.
[5] Vibration-sensitive equipment is not sensitive to ground-borne noise.

Table 3.4-10 Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special-Use Buildings

Land Use Category	GBV Impact Levels (VdB re: 1 µin/sec)		GBN Impact Levels (dB re: 20 µPa)	
	Frequent Events[1]	Infrequent Events[2]	Frequent Events[1]	Infrequent Events[2]
Concert halls	65 VdB	65 VdB	25 dBA	25 dBA
TV studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Source: FRA 2012
µin/sec = microinch per second
µPa = micro-Pascal
dB = decibel
dBA = A-weighted decibel
GBN = ground-borne noise
GBV = ground-borne vibration
VdB = vibration decibels
[1] *Frequent Events* is defined as more than 70 vibration events per day.
[2] *Occasional or Infrequent Events* is defined as fewer than 70 vibration events per day.

In most cases, for at-grade or aerial train operations, airborne noise would be substantially louder than the ground-borne noise, and thus ground-borne noise is not perceived separately from the airborne noise. However, only ground-borne noise and not airborne noise was evaluated at receptors above existing tunnels in San Francisco because these receptors would not perceive airborne noise due to the intervening rock and soil.

Additional vibration criteria was applied where the project would be in the existing rail corridor from San Francisco to San Jose. When there are existing significant sources of vibration (e.g., trains) at locations affected by the project, existing vibration levels were factored into the assessment. FRA provides guidance on how to apply the vibration impact criteria based on the number of daily train operations and the degree to which existing railroad tracks would be relocated. Appendix 3.4-A in Volume 2 summarizes how the vibration impact criteria are applied in existing rail corridors based on train frequency. The project's vibration levels were then compared to the criteria in Tables 3.4-9 and 3.4-10.

Prediction Methods

Construction Vibration

Construction vibration impacts were assessed in accordance with Chapter 10 of the FRA guidance manual for quantitative construction vibration assessments. HSR construction activity scenarios were developed to quantitatively estimate construction vibration, comparing the predicted ground-borne vibration levels with appropriate construction stage impact criteria. Quantitative construction vibration analysis was conducted where there was a potential for pile driving, vibratory compaction, demolition, or excavation near vibration-sensitive structures. Criteria for annoyance (Tables 3.4-9 and 3.4-10) and damage (Table 3.4-8) were applied to determine impacts from construction vibration. The following information was used to assess the construction vibration levels:

- Vibration source levels from equipment expected to be used by contractors
- Estimated site layouts of equipment along the right-of-way
- Distance from the construction activities to nearby vibration-sensitive receptors

Operations Vibration

The FRA guidance manual provides three levels of analysis: screening, general assessment, and detailed analysis. The screening analysis was used to determine the RSA for conducting the detailed analysis of operational vibration and evaluated residential and institutional locations within 220 feet of the alternatives' centerlines.

Ground-borne noise is generated when interior building surfaces such as floors, walls, and ceilings vibrate due to ground-borne vibration from trains. Ground-borne noise is commonly described as the "rumble" from a subway train. The prediction of such noise is directly related to the prediction of vibration inside a building.

The FRA criteria for assessing ground-borne vibration from shared corridors require that the vibration levels resulting from the relocated existing tracks be compared to the existing vibration levels. Thus, separate analyses predicted ground-borne vibration from HSR operations and from existing and future Caltrain operations. This analysis was conducted using the FRA's prediction model for ground-borne vibration, which is an empirical modeling approach that is described in detail in Volume 2, Appendix 3.4-A.

In accordance with FRA guidance, vibration levels from HSR on an aerial structure were assumed to be 10 VdB less than vibration from at-grade or embankment track. Appendix 3.4-A in Volume 2 details the modeling inputs and assumptions used for this assessment.

3.4.4.4 Method for Evaluating Impacts under NEPA

The CEQ NEPA regulations (40 C.F.R. Parts 1500–1508) provide the basis for evaluating project impacts (described in Section 3.1.5.4). As described in Section 1508.27 of these regulations, the criteria of context and intensity are considered together when determining the severity of the change introduced by the project.

- **Context**—For this analysis, the *context* for noise impacts is the ambient noise and sensitivity of receptors. For vibration analysis, the context is the existing land use.
- **Intensity**—For this analysis, *intensity* is determined by assessing the degree to which construction and operations of the project would change noise and vibration levels, using FRA guidelines (see impact criteria for noise and vibration in Section 3.4.4.3). These guidelines contain criteria for determining whether project-generated noise or vibration would result in an impact and of what severity.

3.4.4.5 Method for Determining Significance under CEQA

The Authority is using the following thresholds to determine if a significant impact from noise and vibration would occur as a result of the project alternatives. For the CEQA analysis, the project would result in a significant noise or vibration impact if it would result in any one of the following:

- Generate a substantial temporary or permanent increase in ambient noise levels in excess of severe impact standards for a severe impact established by FRA for high-speed ground transportation and by FTA for transit projects.
- Generate excessive ground-borne vibration or ground-borne noise levels.

As discussed in Section 3.4.4.3, the analysis relies on noise and vibration standards developed by FTA and FRA to determine whether the project would result in significant noise or vibration impacts. These standards are derived primarily from the FRA guidance manual (FRA 2012), which is based on the FTA guidance manual (FTA 2018). The noise impact criteria established in these documents is based on the level of human annoyance, and were developed to apply to a wide variety of surface transportation modes and to respond to the varying sensitivities of communities to projects under different background noise conditions. The vibration standards address both human reaction to vibration as well as the potential for physical damage. The FRA standards were developed specifically for assessing noise and vibration impacts caused by HSR projects, and the FTA standards were developed for rail projects and their associated stationary facilities. Accordingly, these standards serve as appropriate thresholds for determining whether the project would result in significant noise or vibration impacts.

For determining the significance of impacts related to traffic noise, the analysis relies in part on criteria that are included in the FHWA's Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 C.F.R. Part 772), which are implemented by Caltrans through its *Traffic Noise Analysis Protocol* (Caltrans 2011). These criteria are based on the level of human perception or annoyance and consider various types of land uses. Although the FHWA regulations only apply to projects funded or approved by FHWA, the criteria in these regulations are regularly considered in assessing noise impacts associated with motor vehicles. Moreover, the Caltrans *Traffic Noise Analysis Protocol* provides policy guidance for assessing traffic noise impacts as well as NAC. Therefore, the criteria provided in these documents serve as appropriate thresholds for determining whether traffic noise would result in a significant impact. Section 3.4.4.3 provides a description of the federal noise standards and impact criteria used to determine the significance of noise impacts.

3.4.5 Affected Environment

3.4.5.1 Noise

This section summarizes the noise measurement results and describes the noise-sensitive land uses in the RSA. Section 3.4.4.3 provides a summary of the existing noise model used to identify the existing ambient noise conditions at all noise-sensitive receptors in the RSA.

Noise Measurement Results

A total of 86 measurements of ambient noise were taken in the noise RSA. These measurements included ambient noise at 17 locations in the San Francisco to South San Francisco Subsection between Fourth and King Street and Linden Avenue, 19 locations in the San Bruno to San Mateo Subsection between Linden Avenue and Ninth Avenue, 28 locations in the San Mateo to Palo Alto Subsection between Ninth Avenue and San Antonio Road, 11 locations in the Mountain View to Santa Clara Subsection between San Antonio Road and Scott Boulevard, and 11 locations in San Jose Diridon Station Approach Subsection between Scott Boulevard and West Alma Avenue. Volume 2, Appendix 3.4-A, includes maps of these measurement locations north of Scott Boulevard; the San Jose to Merced Noise and Vibration Technical Report includes maps of the locations south of Scott Boulevard (Authority 2019a).

Table 3.4-11 shows the results of the ambient noise measurements conducted between 2009 and 2017.[7] The major noise sources for much of the RSA are trains presently operating in the existing rail corridor. In some areas the alignment is adjacent to major highways where the existing noise environment is dominated by traffic noise. The measurement results in Table 3.4-11 were used to validate the existing noise spreadsheet model and predict existing noise levels at all noise-sensitive locations throughout the project. Appendix B of the Noise and Vibration Technical Report (Volume 2, Appendix 3.4-A) includes measurement site photos and plots of ambient noise measurement results north of Scott Boulevard; the San Jose to Merced Noise and Vibration Technical Report maps locations south of Scott Boulevard (Authority 2019a).

The typical ambient Ldn for a downtown city environment would be expected to be near 80 dBA. Urban residential areas typically have an ambient Ldn ranging from 70 dBA ("very noisy") to 60 dBA ("quiet"). Suburban residential areas typically have ambient Ldn between 50 and 55 dBA (FTA 2018).

[7] The noise analysis includes noise measurements collected in 2009 and 2010 by the Authority's contractors for unpublished noise and vibration technical studies. Noise measurements conducted in 2013 were obtained for the PCEP EIR (PCJPB 2015). Noise measurements in 2016 and 2017 were collected for this assessment.

Table 3.4-11 Ambient Noise Measurement Results

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
San Francisco to South San Francisco Subsection					
N01	370 Townsend Street, San Francisco	Residential	2/13/2017	79	78
N02	469 Berry Street, San Francisco	Residential	2/13/2017	73	72
N03	431 Pennsylvania Avenue, San Francisco	Residential	11/6/2009	65	73
N04	1174 22nd Street, San Francisco	Residential	11/30/2009	74	74
N05	48 Reddy Street, San Francisco	Residential	11/6/2009	64	62
N06	2403 Mendell Street, San Francisco	Residential	5/26/2016	69	68
N07	88 Kalmanovitz, San Francisco	Residential	6/14/2010	64	64
N08	48 Gould Street, San Francisco	Residential	6/14/2010	68	73
N09	327 Tunnel Avenue, San Francisco	Residential/ Church	5/26/2016	73	69
N10	18 McDonald Avenue, Daly City	Residential	5/26/2016	67	67
N11	104 Main Street, Daly City	Residential	5/26/2016	65	68
N12	163 Mission Blue Drive, Brisbane	Residential	5/26/2016	65	64
N13	42 San Francisco Avenue, Brisbane	Residential	5/31/2016	65	64
N14	50 Joy Avenue, Brisbane	Residential	11/3/2009	76	72
N15	1300 Veterans Boulevard, South San Francisco	Hotel	3/9/2010	77	75
N16	242 Village Way, South San Francisco	Residential	11/3/2009	77	76
N17	111 Mitchell Avenue, South San Francisco	Hotel	5/31/2016	69	67
San Bruno to San Mateo Subsection					
N18	1289 Herman Street, San Bruno	Residential	5/17/2013	78	76
N19	1209 Herman Street, San Bruno	Residential	11/3/2009	76	75
N20	847 Huntington Avenue, San Bruno	Residential	5/31/2016	75	77
N21	576 First Avenue, San Bruno	Residential	3/9/2010	75	75
N22	265 San Luis Avenue, San Bruno	Residential	5/31/2016	66	67
N23	1036 San Antonio Avenue, Millbrae	School	3/9/2010	70	68
N24	254 Monterey Street, Millbrae	Residential	11/3/2009	71	70
N25	20 Hillcrest Boulevard, Millbrae	Residential	5/17/2013	63	62
N26	267 Aviador Avenue, Millbrae	Residential	6/1/2016	65	63
N27	150 Serra Avenue, Millbrae	Hospital	3/9/2010	73	72
N28	1710 California Drive, Burlingame	Hospital/ Residential	3/9/2010	68	66
N29	1457 California Drive, Burlingame	Residential	5/17/2013	71	73

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
N30	1279 California Drive, Burlingame	Residential	6/1/2016	73	77
N31	966 California Drive, Burlingame	School	3/9/2010	74	76
N32	815 Carolan Avenue, Burlingame	Residential	10/30/2009	71	70
N33	112 Myrtle Road, Burlingame	Residential	2/13/2017	79	81
N34	362 Villa Terrace, San Mateo	Residential	2/13/2017	79	80
N35	142 North Railroad Avenue, San Mateo	Residential	5/17/2013	74	72
N36	396 Catalpa Street, San Mateo	Residential	10/30/2009	69	68
San Mateo to Palo Alto Subsection					
N37	200 12th Avenue, San Mateo	Residential	6/1/2016	65	66
N38	1416 South Railroad Avenue, San Mateo	Residential	10/30/2009	67	67
N39	2600 South Delaware Street, San Mateo	Residential	6/1/2016	73	71
N40	8 Antioch Drive, San Mateo	Residential	10/28/2009	73	71
N41	102 Blossom Circle, San Mateo	Residential	5/17/2013	70	70
N42	792 Old County Road, Belmont	Residential	6/2/2016	70	68
N43	1088 Sylvan Drive, San Carlos	Residential	6/2/2016	71	69
N44	1552 West El Camino Real, San Carlos	Hotel	3/9/2010	73	73
N45	1840 Stafford Street, San Carlos	Residential	10/28/2009	73	74
N46	100-198 Winklebleck Street, Redwood City	Commercial	10/28/2009	69	71
N47	300 Cedar Street, Redwood City	Residential	6/2/2016	78	80
N48	198 Buckingham Avenue, Redwood City	Residential	5/17/2013	71	67
N49	200 Berkshire Avenue, North Fair Oaks	Residential	6/2/2016	69	69
N50	3390 Glendale Avenue, North Fair Oaks	Residential	6/3/2016	71	67
N51	1601 Stone Pine Lane, Menlo Park	Residential	10/23/2009	70	74
N52	1128 Merrill Street, Menlo Park	Commercial	3/9/2010	72	68
N53	638 Alma Street, Menlo Park	Park	3/9/2010	68	68
N54	248 Alma Street, Menlo Park	Residential	10/23/2009	66	67
N55	118 West El Camino Real, Menlo Park	Residential	6/3/2016	65	69
N56	Lucas Lane and Encina Avenue, Palo Alto	Hospital	3/5/2010	72	70
N57	Lucas Lane and Embarcadero Road, Palo Alto	School	3/5/2010	74	72
N58	1528 Mariposa Avenue, Palo Alto	Residential	10/23/2009	61	59
N59	Peers Park, Palo Alto	Residential	5/17/2013	71	71
N60	195 Page Mill Road, Palo Alto	Residential	6/3/2016	67	68
N61	3040 Alma Street, Palo Alto	Residential	6/3/2016	74	73

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
N62	4116 Park Boulevard, Palo Alto	Residential	3/5/2010	62	61
N63	4201 Park Boulevard, Palo Alto	Residential	5/17/2013	80	79
N64	4243 Alma Street, Palo Alto	Church	3/9/2010	75	75
Mountain View to Santa Clara Subsection					
N65	2358 Central Expressway, Mountain View	Residential	6/6/2016	76	77
N66	1929 Crisanto Avenue, Mountain View	Residential	6/6/2016	70	69
N67	112 Horizon Avenue, Mountain View	Residential	10/20/2009	71	70
N68	Central Expressway and Whisman Station Drive, Mountain View	Residential	3/5/2010	71	73
N69	981 Asilomar Terrace, Sunnyvale	Residential	10/20/2009	66	69
N70	110 Waverly Street, Sunnyvale	Residential	6/6/2016	66	66
N71	111 West Evelyn Avenue, Sunnyvale	Commercial	3/5/2010	76	73
N72	Evelyn Terrace, Santa Clara	Residential	10/16/2009	72	69
N73	3585 Agate Street, Santa Clara	Residential	5/17/2013	69	67
N74	2790 Agate Drive, Santa Clara	Residential	10/16/2009	63	61
N75	2400 Walsh Avenue, Santa Clara	School	3/5/2010	64	65
San Jose Diridon Station Approach Subsection					
N76[2]	2079 Main Street, San Jose	Residential	5/3/2016	63	65
N77[2]	1315 De Altura Commons, San Jose	Residential	10/16/2009	65	54
N78[2]	726 Emory Street, San Jose	Residential	3/5/2010	64	65
N79	(adjacent to) 109 Laurel Grove Avenue, San Jose	Residential	5/10/2016	67	70
N80	421 Illinois Avenue, San Jose	Residential	10/12/2010	68	69
N81	663 Delmas Avenue, San Jose	Residential	5/6/2016	61	63
N82	827 Harliss Avenue, San Jose	Residential	10/12/2010	63	62
N83	(adjacent to) 974 McLellan Avenue, San Jose	Residential	5/17/2016	66	63
N84	1197 Lick Avenue, San Jose	Residential	11/11/2014	77	77
N139	782 Auzerais Avenue, San Jose	Residential	5/20/2013	82	81
N140	748 Illinois Avenue, San Jose	Residential	5/20/2013	71	68

dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
[1] The L_{dn} was calculated from the average hourly L_{eq} values collected over the entire measurement period.
[2] Includes existing noise from nearby airport.

San Francisco to South San Francisco Subsection

The San Francisco to South San Francisco Subsection covers the area between the intersection of Fourth Street and King Street in downtown San Francisco to Linden Avenue in South San Francisco. Land uses in this segment are a mix of residential and industrial neighborhoods. The southern part of this subsection is mostly industrial with pockets of single-family residences west of the alignment (on the eastern flank of San Bruno Mountain) and some hotel buildings east of the alignment. The Visitacion Valley/Schlage Lock multifamily residential development, which is currently in construction, is in this subsection. South of I-380, sensitive receptors are on both sides of the alignment.

The existing noise in this subsection is dominated by the daily rail operations that share the alignment. This alignment is a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and Santa Clara and two freight trains daily south of the Quint Street lead from the Port of San Francisco to South San Francisco. The ambient noise levels correspond to a typical dense urban setting. Additional sources of ambient noise are vehicles on I-280 and U.S. Highway (US) 101 and local motor vehicle traffic. Near the southern end of this subsection, aircraft activities associated with the San Francisco International Airport (SFO) influence the ambient noise.

Ambient noise conditions were characterized at 17 locations: N01 to N17. The measured ambient L_{dn} along the San Francisco to South San Francisco Subsection ranged from 64 dBA to 79 dBA, depending on the location.

San Bruno to San Mateo Subsection

The San Bruno to San Mateo Subsection covers the area between Linden Avenue in South San Francisco and Ninth Avenue in San Mateo. This subsection includes the southern portion of South San Francisco, San Bruno, Millbrae, Burlingame, and the northern portion of San Mateo. The adjacent land use is a mix of residential and industrial use, with some commercial use in the central business districts. The southern portion of the subsection is primarily residential land use. The ambient setting of the northern portion of this subsection is urban, while the southern portion is primarily residential.

The existing noise in this subsection is dominated by the daily rail operations that share the alignment. This alignment is a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and Santa Clara and 4 freight trains daily. The ambient noise is typical for an urban/suburban setting. Additional sources of ambient noise are vehicles on US 101 and local motor-vehicle traffic. Aircraft operations noise from SFO is a dominant contributor to the existing ambient noise environment in this subsection because the airport runways are approximately 2,000 feet from the HSR project corridor. Bay Area Rapid Transit (BART) train operations influence noise only for surface operations near and at the Millbrae Station.

Ambient noise conditions were characterized at 19 locations: N18 to N36. The measured ambient L_{dn} along the San Bruno to San Mateo Subsection ranged from 63 dBA to 79 dBA, depending on the location.

San Mateo to Palo Alto Subsection

The San Mateo to Palo Alto Subsection covers the area between Ninth Avenue in San Mateo and San Antonio Road in Palo Alto. This subsection includes the southern portion of San Mateo, Belmont, San Carlos, Redwood City, North Fair Oaks, Atherton, Menlo Park, and Palo Alto. This part of the project has primarily residential land use adjacent to it, much of it abutting backyards.

The existing noise in this subsection is dominated by the daily rail operations that share the alignment. This alignment is a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and Santa Clara and 2 to 4 freight trains daily. In addition, ambient noise is affected by traffic on El Camino Real (State Route [SR] 82), SR 92, SR 84, local traffic, and, to a lesser extent, more distant traffic on US 101. The environmental noise along this subsection corresponds to an urban noise setting with a mix of residential, commercial, and industrial land uses.

Ambient noise conditions were characterized at 28 locations: N37 to N64. The measured ambient L_{dn} along the San Mateo to Palo Alto Subsection ranged from 61 dBA to 80 dBA, depending on the location.

Mountain View to Santa Clara Subsection

The Mountain View to Santa Clara Subsection covers the area between San Antonio Road in Palo Alto and Scott Boulevard in Santa Clara. This subsection runs through Mountain View, Sunnyvale, and the northern portion of Santa Clara. The project abuts residential and commercial areas, and the alignment also runs parallel to an arterial road.

The existing noise in this subsection is dominated by the daily rail operations that share the alignment. This alignment is a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and Santa Clara and 2 freight trains daily. The ambient setting is urban with a mix of residential, industrial, and commercial land uses. Additional sources of ambient noise are vehicle traffic on major arterial roadways such as Mathilda Avenue, Mary Avenue, Shoreline Boulevard, San Antonio Road, San Tomas Expressway, and Lawrence Expressway; and local street traffic.

Ambient noise conditions were characterized at 11 locations: N65 to N75. The measured ambient L_{dn} along the Mountain View to Santa Clara Subsection ranged from 63 dBA to 76 dBA, depending on the location.

San Jose Diridon Station Approach Subsection

The San Jose Diridon Station Approach Subsection covers the area between Scott Boulevard in Santa Clara and West Alma Avenue in San Jose. This part of the project is predominantly within or adjacent to the Caltrain right-of-way as it extends through moderately dense urban areas with mixed land uses.

North of San Jose Diridon Station, the land use on the east side of the existing rail alignment is primarily industrial, while the western side is mainly residential. The closest residences are approximately 30 to 50 feet from the existing railway. Bellarmine College Preparatory School campus is on the western side of the RSA. The closest Bellarmine school buildings are more than 350 feet from the existing railway.[8] At San Jose Diridon Station, there are multifamily buildings along the entire west side of San Jose Diridon Station facing the existing tracks and platforms. Templo La Hermosa church is on the eastern side of the station, beyond the parking lots, approximately 550 feet from the station.

South of San Jose Diridon Station, land uses in the noise RSA include transportation rights-of-way associated with I-280 and SR 87, residential neighborhoods, and some commercial/industrial areas. The San Jose Fire Department Bureau of Field Operations campus is just south of San Jose Diridon Station on the east side of the RSA.[9] Gardner Elementary School is approximately 275 feet south of I-280 on the south side of the RSA.

In this subsection, the alignment is in a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and San Jose Diridon Station, and 40 daily Caltrain trains operating between San Jose Diridon Station and Tamien Station. Between two and nine freight trains run along the route per day. Fourteen Capitol Corridor and eight ACE trains run along the alignment daily between De La Cruz Boulevard and San Jose Diridon Station. ACE trains continue to travel south to Tamien Station to access the layover facility. Amtrak Coast Starlight trains pass through this subsection twice daily. Santa Clara Valley Transportation Authority (VTA) light rail

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[8] Outdoor sports fields associated with Bellarmine are adjacent to the existing railway, but are not considered noise-sensitive uses by the FRA guidance manual (FRA 2012).

[9] Fire stations contain sleeping accommodations and are considered noise-sensitive receptors at all times of day and night.

trains run along the center of SR 87. Other noise sources include traffic on I-880, SR 87, I-280, local roads, and aircraft activities associated with Norman Y. Mineta San Jose International Airport.

Ambient noise conditions were characterized at 11 locations: N76 to N84, N139, and N140. The ambient L_{dn} in the San Jose Diridon Station Approach Subsection ranges from 61 dBA to 82 dBA.

Noise Measurement and Modeling Discussion

To validate the existing noise model, the existing noise spreadsheet model results were compared with the measured values at the locations of the noise monitors. This model separately calculates the contribution from Caltrain rail operations. The comparison of the existing noise model and the measured noise levels at the measurement locations (provided in Volume 2, Appendix 3.4-A) showed a close agreement between the modeled data and existing noise measurement data. The Authority used the existing noise model to calculate ambient noise levels at all sensitive receptors, typically at the building façades, in the RSA.

3.4.5.2 Vibration

This section summarizes the locations and results of vibration measurements by subsection. It also describes the vibration-sensitive land uses and sources of existing vibration in the RSA.

Vibration Measurement Results

Measurements of the existing vibration levels associated with train passbys were taken at 37 sites in the vibration RSA. These measurements were made in the vertical direction, and the results of the existing vibration measurements conducted between 2009 and 2016 are organized by subsection and shown in Table 3.4-12.[10] Volume 2, Appendix 3.4-A, illustrates the locations of the vibration measurement sites north of Scott Boulevard; the San Jose to Merced Noise and Vibration Technical Report maps the locations south of Scott Boulevard (Authority 2019a).

Table 3.4-12 Existing Vibration Measurement Locations

Site	Location	Date	Distance from Track (feet)	Overall Vibration Level (VdB)	Source
San Francisco to South San Francisco Subsection					
V1	391 Pennsylvania Avenue, San Francisco	11/24/2009	120–220	48–52	Caltrain
V2	Williams Avenue & Diana Street, San Francisco	2/24/2010	105–155	62–67	Caltrain
V3	1700 Egbert Avenue, San Francisco	11/3/2009	140–254	61–74	Caltrain
V4	Bayshore Boulevard & Old County Road, Brisbane	6/10/2010	25–118	60–73	Caltrain
V5	29 San Francisco Avenue, Brisbane	11/3/2009	314–414	36–41	Caltrain
V6	257 Village Way, South San Francisco	11/24/2009	275–339	40–42	Caltrain
San Bruno to San Mateo Subsection					
V7	1st Avenue & Pine Street, San Bruno	11/24/2009	100–164	62–64	Caltrain
V8	San Antonio Avenue & Santa Ines Avenue, San Bruno	6/10/2010	70–170	64–70	Caltrain
V9	Center Street & Oak Street, Millbrae	6/29/2016	25–118	66–82	Caltrain

10 Vibration measurements were collected in 2009 and 2010 by the Authority's contractors for unpublished noise and vibration technical studies. Vibration measurements in 2016 were collected as part of this assessment.

Site	Location	Date	Distance from Track (feet)	Overall Vibration Level (VdB)	Source
V10	California Drive & Oxford Road, Burlingame	10/30/2009	100–164	61–69	Caltrain
V11	Carolan Avenue & Park Avenue, Burlingame	11/24/2009	150–214	57–61	Caltrain
V12	360-398 Villa Terrace, San Mateo	10/2/2009	50–114	66–75	Caltrain
V13	Catalpa Street & North Railroad Avenue, San Mateo	8/3/2016	31–146	57–74	Caltrain
San Mateo to Palo Alto Subsection					
V14	Railroad Avenue & 10th Avenue, San Mateo	6/8/2010	60–200	54–73	Caltrain
V15	Pacific Boulevard & East 40th Avenue, San Mateo	10/27/2009	80–174	55–72	Caltrain
V16	1090 Riverton Drive, San Carlos	10/27/2009	100–214	54–60	Caltrain
V17	Pennsylvania Avenue & Beech Street, Redwood City	10/27/2009	50–154	62–75	Caltrain
V18	Westmoreland Avenue & Berkshire Avenue, Redwood City	6/29/2016	24–124	63–79	Caltrain
V19	418 Encinal Avenue, Menlo Park	10/23/2009	50–114	66–71	Caltrain
V20	96 Churchill Avenue, Palo Alto	11/25/2009	50–114	67–74	Caltrain
V21	Peers Park, Palo Alto	6/9/2010	43–200	55–76	Caltrain
V22	100-139 West Meadow Drive, Palo Alto	10/23/2009	50–154	50–74	Caltrain
V23	240 Monroe Drive, Mountain View	3/8/2010	100–115	70	Caltrain
			100	75–81	Freight
Mountain View to Santa Clara Subsection					
V24	40 South Rengstorff Avenue, Mountain View	10/23/2009	50–114	70–79	Caltrain
V25	1929 Crisanto Avenue, Mountain View	6/8/2010	75–200	55–66	Caltrain
V26	200-216 North Mary Avenue, Sunnyvale	6/9/2010	62–132	70–78	Caltrain
V27	102 South Sunnyvale Avenue, Sunnyvale	6/30/2016	25–115	69–82	Caltrain
V28	West Evelyn Terrace, Sunnyvale	12/2/2009	20–84	65–80	Caltrain
V29	Bracher Park, Santa Clara	6/30/2016	40–130	67–80	Caltrain
V30	2419-2429 South Drive, Santa Clara	10/20/2009	140–180	68–72	Caltrain
San Jose Diridon Station Approach Subsection					
V31	2075 Main Street, Santa Clara	10/20/2009	80–125	78–73	Caltrain
V32	890 Newhall Street, San Jose	7/1/2016	50–138	79–73	Caltrain
V33	855 McKendrie Street, San Jose	3/10/2010	70–195	77–70	Caltrain
			83–258	77–68	Amtrak
			100–270	73–64	Freight

Site	Location	Date	Distance from Track (feet)	Overall Vibration Level (VdB)	Source
V34	782 Auzerais Avenue, San Jose	5/29/2013	25–214	89–58	Caltrain
V35	704 Harrison Street, San Jose	7/1/2016	40–114	83–70	Caltrain
V36	Jerome Street & Willis Avenue, San Jose	7/28/2016	105–160	68–56	Caltrain
			45–150	74–59	Caltrain
			45–135	64–54	ACE
V37	Fuller Avenue & Delmas Avenue, San Jose	5/31/2016	40–139	73–58	Caltrain
			54–103	56–50	ACE

ACE = Altamont Corridor Express
VdB = vibration decibels

Typical background vibration levels not near transportation sources are often about 50 VdB. Typical buses or trucks can cause vibration levels of about 60 to 65 VdB at distances of 50 feet. Trains can typically create vibration levels ranging from 65 to 85 VdB at distances of 50 feet (FRA 2012).

At each site, ground-borne vibration levels were recorded at multiple distances. Table 3.4-12 shows the range of distances from the track centerline where the vibration levels were measured. The results include the range of maximum overall ground-borne vibration levels for each type of train passby based on distance from the track. Higher vibration levels occur closer to the existing tracks and the vibration levels decrease with distance from the track.

Figure 3.4-8 illustrates the general attenuation with distance and the range of measured vibration. Volume 2, Appendix 3.4-A, provides more details for locations north of Scott Boulevard; the San Jose to Merced Noise and Vibration Technical Report provides details for locations south of Scott Boulevard (Authority 2019a).

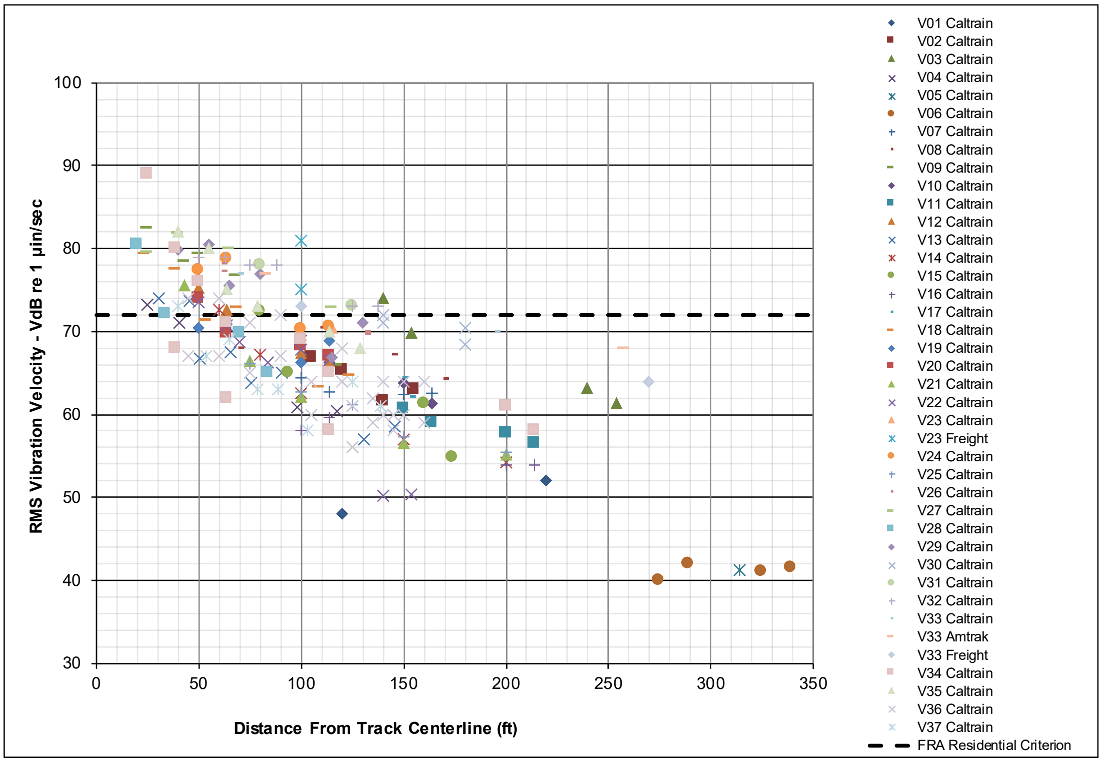

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Figure 3.4-8 Existing Vibration Measurement Levels

For the entire project, the dominant existing vibration sources are train traffic. Traffic on roadways can cause some vibration, but due to the rubber tires on the vehicles, those vibration levels are typically low and isolated to locations very close to roadways. Because vibration-sensitive land uses in the RSA are generally where the vibration RSA is adjacent to existing rail rights-of-way existing ambient vibration measurements were taken at these locations.

The measurements show that the vibration levels decrease with distance, which varies at each site as a function of distance from the track, the train type, and train speed. At most sites, the overall vibration levels exceeded the FRA residential criterion at locations less than 50 feet from the track and at some sites up to approximately 100 feet from the track.

As discussed in Section 3.4.4.3, vibration propagation measurements were also taken at 21 locations to assist in the prediction of ground-borne vibration levels from HSR operations. The vibration propagation measurements are site-specific tests that quantify the efficiency of vibration propagation through the soil at specific locations. Seven borehole vibration propagation tests were conducted in the RSA during previous work in 2010. Volume 2, Appendix 3.4-A, provides the vibration propagation measurement locations north of Scott Boulevard, and Table 3.4-13 summarizes the results. Details for locations south of Scott Boulevard are included in the San Jose to Merced Noise and Vibration Technical Report (Authority 2019a).

Table 3.4-13 Vibration Propagation Measurement Locations

Site	Location	Date	Test Type	Depth (feet)[1]
San Francisco to South San Francisco Subsection				
VP1	Diana Street & Williams Avenue, San Francisco	2/24/2010	Borehole	86
San Bruno to San Mateo Subsection				
VP2	1st Avenue & Pine Street, San Bruno	12/15/2009	Surface	0
VP3	California Drive & South Irwin Place, Millbrae	2/25/2010	Borehole	20, 40, 60
VP4	Catalpa & North Railroad Avenue, San Mateo	8/3/2016	Surface	0
San Mateo to Palo Alto Subsection				
VP5	Railroad Avenue & 10th Avenue, San Mateo	3/29/2010	Borehole	0, 30, 40, 50, 60
VP6	Pacific Boulevard & East 38th Avenue, San Mateo	3/16/2010	Surface	0
VP7	Old County Road & Inverness Drive, San Carlos	3/16/2010	Surface	0
VP8	Pennsylvania Avenue & Cedar Street, Redwood City	12/22/2009	Surface	0
VP9	Stone Pine Lane & Forest Lane, Menlo Park	3/23/2010	Surface	0
VP10	Menlo Park Caltrain Station, Menlo Park	3/22/2010	Borehole	50, 60, 70
VP11	Alma Street & Willow Road, Menlo Park	4/2/2010	Surface	0
VP12	Park Boulevard & South California Avenue, Palo Alto	3/30/2010	Borehole	50, 60, 70, 80, 90
VP13	195 Page Mill Road, Palo Alto	12/18/2009	Surface	0
VP14	240 Monroe Drive, Mountain View	3/8/2010	Surface	0
Mountain View to Santa Clara Subsection				
VP15	1710 Villa Street, Mountain View	3/24/2010	Borehole	80, 90, 100, 110
VP16	West Evelyn Avenue & Franklin Street, Mountain View	3/4/2010	Surface	0
VP17	840 West California Avenue, Sunnyvale	12/14/2009	Surface	0
VP18	South Drive & Palmdale Court, Santa Clara	3/25/2010	Surface	0
San Jose Diridon Station Approach Subsection				
VP19	Main Street & Washington Street, Santa Clara	3/25/2010	Borehole	50, 60, 70
VP20	855 McKendrie Street, San Jose	3/10/2010	Surface	0
VP21	Jerome Street & Willis Avenue, San Jose	7/28/2016	Surface	0

[1] Vibration propagation was measured at multiple depths at borehole sites.

San Francisco to South San Francisco Subsection

In downtown San Francisco, the existing ambient vibration corresponds to a typical dense urban setting. In South San Francisco, the ambient setting is mostly industrial with pockets of single-family residences west of the alignment (on the eastern flank of San Bruno Mountain) and some hotel buildings east of the alignment. In San Francisco and South San Francisco, the project would run mainly under or next to the elevated I-280 corridor. The primary source of vibration is the existing Caltrain alignment, which varies between at-grade, above-grade, and short tunnel sections. Other vibration sources include vehicles on I-280 and local traffic.

Ambient conditions were characterized at six vibration locations representing the typical distance from sensitive receptors to the alignment: V1 through V6. The typical vibration levels from train passbys varied from 74 VdB (at 25 feet) to 48 VdB (at 240 feet), depending on the location of the measurement and distance to the rail alignment. Vibration levels above 65 VdB can be perceptible.

San Bruno to San Mateo Subsection

The San Bruno to San Mateo Subsection passes through San Bruno, Millbrae, Burlingame, and San Mateo. The ambient setting in San Bruno and Millbrae is urban with primarily residential land use. However, there are areas with industrial land use around the northeastern part of San Bruno. In Burlingame and the northern part of San Mateo, the ambient setting is urban with a mix of residential, commercial, and industrial land uses. Throughout this subsection, vibration levels are dominated by Caltrain and freight trains. There are also a few locations from San Bruno to Millbrae near BART. Traffic on I-380 in San Bruno and US 101 from San Bruno to Burlingame also contribute to the existing vibration levels.

Measurements were obtained at seven vibration locations: V7 through V13. The typical vibration levels from Caltrain trains were between 82 VdB (at 25 feet) and 57 VdB (at 200 feet). Vibration levels above 65 VdB can be perceptible.

San Mateo to Palo Alto Subsection

The San Mateo to Palo Alto Subsection passes through San Mateo, Belmont, San Carlos, Redwood City, Atherton, Menlo Park, and Palo Alto. The ambient setting is urban with mostly residential and commercial land uses along with some industrial land uses. Ambient vibration in this subsection is dominated by Caltrain and freight train activities on the existing rail corridor.

The existing vibration ambient conditions were obtained at ten locations: V14 through V23. Ambient vibration from Caltrain trains along this subsection ranged from 79 VdB (at 24 feet) to 54 VdB (at 214 feet). Freight train passby vibration was measured at one site in this subsection, with measured vibration levels between 75 and 81 VdB (at 100 feet). Vibration levels above 65 VdB can be perceptible.

Mountain View to Santa Clara Subsection

The Mountain View to Santa Clara Subsection passes through Mountain View, Sunnyvale, and Santa Clara. The ambient setting of Mountain View and Sunnyvale is urban with residential and commercial land uses. The Santa Clara area includes a mix of residential and industrial development. Vibration levels are mainly influenced by rail operations of Caltrain and freight trains. Other sources of vibration include vehicle traffic on highways such as SR 85, SR 237, and the Central Expressway.

The existing ambient vibration setting was characterized at seven locations: V24 through V30. The typical ground vibration levels obtained during Caltrain train passbys ranged from 82 VdB (at 25 feet) to 55 VdB (at 200 feet). Vibration levels above 65 VdB can be perceptible.

San Jose Diridon Station Approach Subsection

The sensitive land uses in the vibration RSA in this subsection are the same as those described in the noise RSA for this subsection. Existing vibration in this portion of the RSA is dominated by a number of existing rail operations that share the alignment. This alignment is a heavily used rail corridor with 92 daily weekday Caltrain passenger trains currently operating between San Francisco and San Jose Diridon Station. Forty daily Caltrain trains operate through to Tamien Station. Approximately two to nine freight trains run along the route per day. Fourteen Capitol Corridor and eight ACE trains run along the alignment daily between De La Cruz Boulevard and San Jose Diridon Station. ACE trains continue to travel south to Tamien Station to access the layover facility. Amtrak Coast Starlight trains pass through the section twice daily. VTA light rail trains run along the center of SR 87.

Vibration from Caltrain trains was measured at three sites north of San Jose Diridon Station. Overall ground-borne vibration levels from Caltrain measured at the closest positions ranged from

79 VdB (at 50 feet) to 78 VdB (at 80 feet). The vibration levels from Amtrak trains measured at McKendrie Street in San Jose were similar to Caltrain trains. Vibration levels from freight train operations measured at this site ranged from 73 VdB (at 100 feet) to 64 VdB (at 270 feet). Vibration levels above 65 VdB can be perceptible.

Vibration from Caltrain trains was measured at three sites south of San Jose Diridon Station. Overall vibration levels from Caltrain at the closest positions ranged from 83 VdB (at 40 feet) to 68 VdB (at 105 feet). Vibration levels from ACE trains at Jerome Street and Willis Avenue were lower than Caltrain trains.

3.4.6 Environmental Consequences

3.4.6.1 Overview

This section discusses the potential impacts of construction and operations noise and vibration on sensitive receptors and structures from implementing the project alternatives. The analysis evaluates construction noise and vibration, and noise and vibration associated with train operations, passenger stations, and the LMF under the 2029 No Project, 2029 Plus Project, 2040 No Project, and 2040 Plus Project conditions. It also evaluates the potential for human annoyance due to the onset of noise from HSR passbys, and indirect noise impacts associated with changes in vehicular traffic as a result of HSR operations.

The evaluation of vibration impacts focuses on the temporary exposure of sensitive receptors to construction-related vibration annoyance, temporary and permanent exposure of buildings to construction-related vibration damage, and the permanent exposures of sensitive receptors to vibration annoyance from project operations. Due to use of light-weight EMUs that weigh less than current heavy-weight diesel locomotives used for passenger rail and freight service, project operations would not result in vibration levels that exceed existing levels or vibration criteria for the 2029 No Project, 2029 Plus Project and 2040 No Project conditions. Vibration impacts would occur for the 2040 Plus Project conditions, with vibration predicted as high as 89 VdB (0.12 in/sec PPV), which, while clearly perceptible to humans, is well below the lowest building damage criteria (0.2 in/sec PPV), and thus no building damage impacts would be expected to occur at buildings along the project (Categories I, II and III).

The Authority incorporated an IAMF (NV-IAMF#1) into the project to minimize construction-related noise and vibration impacts. The IAMF would require the contractor to prepare and submit to the Authority prior to construction a noise and vibration technical memorandum documenting how the FTA and FRA guidelines for minimizing construction noise and vibration impacts would be employed when work is conducted within 1,000 feet of sensitive receptors. Volume 2, Appendix 2-E, describes this IAMF in detail.

3.4.6.2 Noise

Construction and operations of the project alternatives would result in temporary and permanent impacts from noise. At any one receptor, construction activities would occur over the course of a few days to up to 2 or 4 weeks for many project activities, such as utility relocation, grading, excavation, minor trackwork, demolition, and installation of four-quadrant gates and perimeter fencing. Some activities would occur for a longer period of time, such as those required for the passing track (Alternative B) and modification of stations. In all cases, construction activities would temporarily increase noise levels during the daytime hours and, in the case of substantial trackwork relocation and passing track, nighttime hours. Operations of the project alternatives could increase noise levels associated with the operation of HSR trains, station noise from HSR train movement and parking, LMF noise, and noise from changes in vehicle traffic patterns.

No Project Conditions

The population in the San Francisco Bay Area (Bay Area) is expected to see continued growth through 2040 (see Section 2.6.1.1, Projections Used in Planning). Development in the Bay Area to accommodate the population increase would continue under the No Project conditions and result in associated direct and indirect impacts on sensitive receptors. The No Project condition reflects conditions forecasted by current land use and transportation plans in the vicinity of the project, including planned improvements to the highway, aviation, conventional passenger rail, freight rail, and port systems through the 2040 planning horizon. Without the HSR project, the forecasted population growth would increase pressure to expand highway and airport capacities.

The Authority estimates that additional highway and airport projects (up to 4,300 highway lane miles, 115 airport gates, and 4 airport runways) would be needed to achieve equivalent capacity and relieve the increased pressure (Authority 2012). Planned and other reasonably foreseeable projects anticipated to be built by 2040 include residential, commercial, industrial, recreational, and transportation projects. A full list of anticipated future development projects is provided in Volume 2 in Appendix 3.18-A, Cumulative Nontransportation Plans and Projects List, and Appendix 3.18-B, Cumulative Transportation Plans and Projects Lists.

As described in Section 3.4.5, Affected Environment, much of the RSA currently experiences noise from passenger and freight rail traffic as well as roadway traffic. New or expanded residential and commercial developments could increase existing traffic levels and associated noise in the RSA. An increase in freight and passenger train movement to accommodate growth in the RSA would further increase transportation noise in the RSA. See Volume 2, Appendix 3.4-A for daily train operations under existing conditions, as well as the 2029 and 2040 No Project train operations. The approved Caltrain PCEP would electrify the Caltrain corridor between San Francisco and the Tamien Station in San Jose, convert approximately 75 percent of diesel locomotive-hauled coaches to EMUs, and increase service to six trains per peak hour per direction under the No Project Alternative. For daily train operations south of Scott Boulevard for 2040 No Project conditions, including ACE/Amtrak Capitol Corridor, Coast Starlight, Coast Daylight, the Monterey County Salinas Rail Extension, and the BART Silicon Valley Santa Clara Extension, see the San Jose to Merced Noise and Vibration Technical Report (Authority 2019a). Even if the conditions of the No Project Alternative resulted in a doubling of freeway traffic volumes, freight trains and Caltrain operations, the combined noise increase would be 3 dBA. However, such volume increases would not occur, and therefore under the No Project Alternative the noise increase would not exceed 3 dBA.

Future developments planned under the No Project Alternative would require individual environmental review in accordance with CEQA, including an analysis of noise impacts on sensitive receptors, which would be analyzed under state and federal highway noise criteria. Any increases in noise would be regulated by local general plans and noise and vibration ordinances. It would be the responsibility of the affected jurisdiction to require consistency with local regulations and ordinances aimed at avoiding or reducing permanent increases in noise levels.

Project Impacts

Construction Impacts

Construction of the project alternatives would involve construction, modification, and relocation of existing tracks, stations, and platforms; construction and modification of existing roadways and structures; construction of the Brisbane LMF, and construction of passing tracks and viaduct (under Alternative B); installation of four-quadrant gates at at-grade crossings and perimeter fencing at the edge of the right-of-way; utility relocation; site preparation including demolition, excavation, and grading; and installation of systems components. Chapter 2 describes construction activities.

Impact NV#1: Temporary Exposure of Sensitive Receptors to Construction Noise

Temporary noise impacts could result from activities associated with construction, modification, and relocation of existing tracks, stations, and platforms; modification of existing roadways and structures; construction of the Brisbane LMF, and construction of passing tracks and viaduct (under Alternative B); installation of four-quadrant gates at at-grade crossings and perimeter fencing at the edge of the right-of-way; utility relocation; site preparation including demolition, excavation, and grading; and installation of systems components. Construction noise varies with the construction method, layout of the sites, and the type and condition of the equipment used.

The noisiest pieces of equipment determine the L_{max} from construction activities, which are evaluated on an L_{eq} basis over an 8-hour construction period.

The duration and intensity of construction activities would vary by location and project component. Minor track shifts within the existing Caltrain corridor would be performed by "on-track" equipment that would operate along the existing Caltrain tracks as it adjusts track alignment and ballast and would be expected to last no more than several days at any given location. Generally, about 600 feet of trackwork would be completed within a few days. Installing four-quadrant gates at existing at-grade crossings would occur over a period of 2 to 4 weeks, radio towers would take 3 to 6 months, and modifying the existing Broadway, Atherton, and College Park Caltrain Stations would take 9 to 12 months. The construction of several major project components would, however, occur over several years—expanding the existing 4th and King Street, Millbrae, and San Jose Diridon Stations would take approximately 2 years, while the aerial San Jose Diridon Station under Alternative B would take 3 to 4 years; building the Brisbane LMF would take 2 to 3 years; building the passing track under Alternative B would take 4.5 years, and building the aerial viaduct under Alternative B would take 2.5 years.

While most of these construction activities would occur within the existing Caltrain right-of-way and primarily during daytime hours during the week, work at turnouts, temporary passing tracks, track and overhead contact system pole relocation and some roadway realignments would require weekend and nighttime construction work. Track realignments of less than 10 feet would occur at night or on weekends, and speed restrictions would be imposed until the track realignment is completed. For realignments of more than 10 feet, a parallel track would be built first and then connected to the existing track. Temporary track closure for reconnecting tracks would occur at night or on weekends and would have a duration of 1 to 2 days each. There may also be temporary nighttime construction work associated with the modification of underpasses in the vicinity of the passing track.

The Authority identified seven typical types of construction activities that would be used during project construction, and evaluated the noisiest pieces of equipment required for each activity. Applying the typical L_{max} of each piece of equipment and the utilization factor, the Authority calculated the total 8-hour L_{eq} and the distance at which the L_{eq} would reach the noise impact criteria shown in Table 3.4-5.

Table 3.4-14 summarizes the results of this analysis. For typical at-grade railway construction scenarios, the residential nighttime 8-hour L_{eq} criterion of 70 dBA would potentially be exceeded up to 500 feet from the excavation construction activity, and as far away as 792 feet from the earthwork or retaining walls activity. For typical viaduct construction scenarios, the residential nighttime 8-hour L_{eq} criterion of 70 dBA would potentially be exceeded up to 515 feet from the grading construction activity, and as far away as 774 feet from the concrete pour aerial structure activity. For the construction scenarios at the stations and Brisbane LMF, the residential nighttime 8-hour L_{eq} criterion of 70 dBA could be exceeded up to 354 feet from the superstructure, building shell, and landscaping construction activity and as far away as 706 feet from the pile-driving activity during the foundation work, or 446 feet from non-pile-driving activity during foundation work. The distances identified in Table 3.4-14 would be applicable to both project alternatives because the same types and duration of construction activities would apply to both alternatives.

The potential for noise impacts would be greatest where noise-sensitive land uses are in proximity to major construction activities with a long duration (e.g., LMF, passing tracks, viaduct, station modifications) and nighttime construction activities (e.g., passing tracks, parallel tracks and roadway realignment). The Authority reviewed locations along the alignment where the type of construction activity and the distance to sensitive receptors would result in exceedances of the FRA noise impact criteria for daytime or nighttime (Table 3.4-14). For instance, Alternative A would include the following locations of potential construction noise impacts and would have fewer impacts than Alternative B:

- **San Francisco to South San Francisco Subsection**—Alternative A would modify platforms and tracks at the 4th and King Street Station and the Bayshore Station, build the East Brisbane LMF with connections from the yard lead tracks to the mainline tracks, build the realigned Tunnel Avenue overpass, install four-quadrant gates and radio towers, and realign track at several locations, including the Sierra Lumber Spur, the South San Francisco Yard area, and the Georgia Pacific Lead. The alternative may also require upgrades to PCEP TPFs. These construction activities, some of which would occur at night and on weekends, would generate temporary construction noise impacts where they occur near noise-sensitive land uses. Nighttime work in this subsection would be required to build the Tunnel Avenue overpass and realign tracks. Nighttime construction noise would affect residences within 500 feet of nighttime construction near the 4th and King Street Station and south of Tunnel No. 4 near the Little Hollywood and Visitacion Valley neighborhoods in San Francisco. Construction activities for the East Brisbane LMF would occur approximately 1,900 feet from the nearest residences, which is far enough that they would not be affected by nighttime construction noise.

- **San Bruno to San Mateo Subsection**—Alternative A would expand the existing Millbrae Station, modify the existing San Bruno and Broadway Stations, install four-quadrant gates and radio towers, and realign tracks in San Bruno, Millbrae, Burlingame, and San Mateo. Upgrades to PCEP TPFs may also be required. Construction noise would temporarily affect residences within 500 feet of nighttime track realignment in San Bruno, Millbrae, Burlingame, and San Mateo.
- **San Mateo to Palo Alto Subsection**—Alternative A would realign track in San Mateo, Belmont, San Carlos, Menlo Park, and Palo Alto, modify tracks and platforms at the Hayward Park and Atherton Stations, install four-quadrant gates and radio towers, and potentially upgrade PCEP TPFs, all of which would result in some temporary construction noise impacts. Nighttime construction work associated with track realignments would occur and construction noise would temporarily affect residences within 500 feet of nighttime construction in San Mateo, Belmont, San Carlos, Atherton, Menlo Park, and Palo Alto.

Table 3.4-14 Construction Activity Noise Levels

Construction Activity[1]	Equipment Type	Total 8-Hour L_{eq} (dBA) at 50 feet	Distance to 70 dBA[2] Residential Nighttime Criterion (feet)	Distance to 80 dBA[2] Residential Daytime Criterion (feet)	Distance to 85 dBA[2] Commercial Criterion (feet)	Distance to 90 dBA[2] Industrial Criterion (feet)
Railway						
Clear and grub/grading	Dump truck, water truck, rubber tired dozer, loader, crane; Scraper, grader, crushing equipment, dump truck, rubber tired dozer, excavator, loader, water truck	90	515	163	92	51
Concrete pour aerial structure	Transit mix truck, crane, drill rig, dump truck, flatbed truck, loader, forklift, pump, water truck	94	774	245	138	77
Excavation	Bulldozers, loaders, cranes, dump trucks, water trucks	90	500	158	89	50
Earthwork & retaining walls	Scrapers, graders, compactors, dump trucks, water trucks	94	792	251	141	79
Track construction	Loaders/backhoes, compactors, excavators, flatbed trucks	93	706	223	126	71
Stations and Structures						
Excavation and foundation	Scrapers, graders, compactors, dump trucks, water trucks	89	446	141	79	45
	Pile driving	93	706	223	126	71
Superstructure, building shell, and landscaping	Paver, dump trucks, water trucks	87	354	112	63	35

dBA = A-weighted decibel
L_{eq} = equivalent sound level
[1] Each construction activity involves a number of subtasks. For this analysis it is assumed these subtasks would not occur at the same time. The noise level for the loudest subtask is reported; this represents the worst case for each general construction activity. Installation of four-quadrant gates could require some excavation and foundation support and is expected to be comparable to or less than any of these methods.
[2] Distances for this analysis assume that all pieces of equipment are located at the center of the construction site to develop typical noise levels.

- **Mountain View to Santa Clara Subsection**—Alternative A would realign tracks in Mountain View, Sunnyvale, and Santa Clara, install four-quadrant gates and radio towers, and potentially upgrade PCEP TPFs, resulting in some temporary construction noise impacts. Nighttime track realignment would occur, and construction noise would temporarily affect residences within 500 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara.
- **San Jose Diridon Station Approach Subsection**—Alternative A would realign and install new tracks in San Jose, modify several bridges, expand the San Jose Diridon Station, install four-quadrant gates and a radio tower, and it may be necessary to install additional equipment at the PCEP TPS-2 site in San Jose if electrical load requirements dictate, resulting in temporary construction noise. In track relocation areas between Emory Street and San Jose Diridon Station, the closest receptors are between 200 and 300 feet from track relocation alignments. The closest receptors in this subsection would be within 30 to 40 feet of construction areas between the crossing of I-280 and the crossing of SR 87. Nighttime construction would be required in some areas for track realignments and other trackwork for Alternative A to minimize disruption of existing passenger rail services.

Alternative B would include the following locations of potential construction noise impacts and would have greater impacts than Alternative A due primarily to the passing track construction:

- **San Francisco to South San Francisco Subsection**—Construction of Alternative B would require similar construction activities to those described for Alternative A, except that Alternative B would build the West Brisbane LMF approximately 1,500 feet from residences, which is far enough away that residences would not be affected. Nighttime work within this subsection would be required to build the Tunnel Avenue overpass and realign tracks, and residences within 500 feet of nighttime construction near 4th and King Street Station and near the Little Hollywood and Visitacion Valley neighborhoods in San Francisco would be temporarily affected by construction noise.
- **San Bruno to San Mateo Subsection**—There are no differences between Alternative B and Alternative A in this subsection. Construction noise would temporarily affect residences within 500 feet of nighttime track realignment in San Bruno, Millbrae, Burlingame, and San Mateo.
- **San Mateo to Palo Alto Subsection**—Alternative B would build an approximately 6-mile-long passing track from Ninth Street in San Mateo to Whipple Avenue in Redwood City, which would require realignment of tracks, roadway modifications, and station and platform modifications at the existing Hayward Park, Hillsdale, Belmont and San Carlos Stations during a construction period lasting up to 4.5 years. Some of these construction activities would occur at night, and construction noise would temporarily affect residences within 500 feet of nighttime construction in San Mateo, Belmont, San Carlos, and Redwood City. Outside of the passing track area, construction activities under Alternative B would be the same as those described for Alternative A.
- **Mountain View to Santa Clara Subsection**—There are no differences between Alternative B and Alternative A in this subsection. Nighttime track realignment would occur and construction noise would temporarily affect residences within 500 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara.
- **San Jose Diridon Station Approach Subsection**—Alternative B would build an aerial structure that begins at either I-880 (Alternative B [Viaduct to I-880]) or at Scott Boulevard (Alternative B [Viaduct to Scott Boulevard]), aerial platforms and station improvements at the San Jose Diridon Station, track realignments, track crossovers, and would install a radio tower and a new TPSS, resulting in temporary noise impacts. The closest receptors in this subsection would be within 30 to 40 feet of construction areas, particularly between the crossing of I-280 and the crossing of SR 87. For Alternative B (Viaduct to I-880), nighttime construction would be required in some areas for track relocations between West Hedding Street and the San Jose Diridon Station to avoid disruption of passenger rail services, and the closest sensitive receptors in this area would be approximately 200 to 300 feet from the track realignment locations. For Alternative B (Viaduct to Scott Boulevard), nighttime

construction would be required for track relocations between Scott Boulevard and the San Jose Diridon Station to avoid disruption of passenger rail services, and the closest sensitive receptors in this area would be approximately 50 to 100 feet from the track alignments.

The alternatives include project features (IAMFs) to avoid or minimize potential impacts from construction. NV-IAMF#1 would require the contractor to prepare and submit to the Authority prior to construction a noise and vibration technical memorandum documenting how the FRA guidelines for minimizing construction noise and vibration impacts would be employed when work is being conducted within 1,000 feet of sensitive receptors. Typical construction practices contained in the FRA guidance manual for minimizing construction noise and vibration impacts include the following:

- Build noise barriers, such as temporary walls or piles on excavated material, between noisy activities and noise-sensitive resources
- Route truck traffic away from residential streets where possible
- Build walled enclosures around especially noisy activities or around clusters of noisy equipment
- Combine noisy operations so that they occur in the same period
- Phase demolition, earthmoving, and ground-impacting operations so as not to occur in the same period
- Avoid impact pile driving where possible in vibration-sensitive areas

Application of the construction practices identified in the FRA guidelines would minimize temporary construction impacts on sensitive receptors. However, based on the analysis in this section (summarized in Table 3.4-14), there is still the potential for adverse impacts from construction noise on sensitive receptors within 792 feet of HSR nighttime construction activity and within 251 feet of HSR daytime construction activity.

As described in Section 3.4.5.1, Noise, sensitive receptors are in proximity to the project in all five subsections. Numerous residential sensitive receptors are less than 251 feet from locations of daytime construction and less than 792 feet from nighttime construction activity and thus would be affected by construction noise. Sensitive receptors closer to the construction activities than the distances reported in Table 3.4-14 would experience temporary increases in noise levels in exceedance of the FRA noise impact criteria.

CEQA Conclusion

The impact under CEQA would be significant for both project alternatives because construction of the project would substantially temporarily increase ambient noise levels in the noise RSA above levels without construction of the project, and the noise increase would be in exceedance of FRA guidelines. For example, at residences the criteria is 70 dBA for nighttime construction and 80 dBA for daytime construction; these would occur for receptors as close as 24 feet and as far out as 792 feet from nighttime construction activities and as close as 24 feet and as far as 251 feet from daytime earthwork activities for track and roadway realignment work. The alternatives would incorporate NV-IAMF#1 to minimize noise impacts by requiring compliance with FRA guidelines for minimizing construction noise and vibration impacts when work is conducted within 1,000 feet of sensitive receptors. However, even with NV-IAMF#1, some sensitive receptors would be exposed to construction noise levels that exceed FRA guidelines. The mitigation measure to address this impact is identified in Section 3.4.9, CEQA Significance Conclusions. Section 3.4.7, Mitigation Measures, describes the measure in detail.

Operations Impacts

Operations of the project would involve scheduled train travel along the HSR tracks through the RSA between stations and to and from the Brisbane LMF. Operations would generate additional traffic volumes in the vicinity of the stations and the Brisbane LMF associated with passengers and employees.

Impact NV#2: Intermittent Permanent Exposure of Sensitive Receptors to Noise from Operations

Under the 2029 and 2040 No Project conditions, changes in noise levels would be associated with the Caltrain PCEP. The 2029 and 2040 Plus Project conditions evaluate changes in noise associated with combined implementation of the Caltrain PCEP and the HSR project. Table 3.4-4 provides a summary of key operational differences that affect the noise analysis.

Table 3.4-15 shows the results of the 2029 Plus Project condition noise impact assessment. Alternatives A and B would result in zero noise impacts in the San Francisco to South San Francisco Subsection. There is no difference in operations noise impacts between the two project alternatives because the alternatives would have the same alignment and operations.

Table 3.4-15 Summary of 2029 No Project[1] and 2029 Plus Project[2] Noise Impacts

Subsection	Land Use Category[3]	No Project[2]		Alternative A		Alternative B	
		Moderate	Severe	Moderate	Severe	Moderate	Severe
San Francisco 4th and King Street Station and approach	2	0	0	0	0	0	0
	1, 3	0	0	0	0	0	0
Total	**1, 2, 3**	**0**	**0**	**0**	**0**	**0**	**0**

PCEP = Peninsula Corridor Electrification Project
[1] The 2029 No Project condition reflects planned changes in Caltrain operations as part of PCEP for the 4th and King Street Station area only. No Project impacts are provided for comparison purposes and are not used to determine project impact.
[2] The 2029 Plus Project condition reflects future noise conditions for the 4th and King Street Station area only, associated with the project and planned changes in Caltrain operations as part of PCEP.
[3] Federal Railroad Administration Land Use Categories are summarized in Table 3.4-6. Land Use Category 1 = areas where quiet is an essential element to the land use; Category 2 = Residential; Category 3 = Institutional use and passive-use parks.

Table 3.4-16 shows the results of the 2040 No Project and 2040 Plus Project condition noise impact assessments. The 2040 No Project condition would result in 9 severe noise impacts and 42 moderate impacts due to the increase in the number of Caltrain trains from PCEP. Under the 2040 Plus Project condition, both Caltrain and HSR would increase train speeds from 79 mph to 110 mph and operate more trains as summarized in Table 3.4-4. Alternative A would result in 1,758 severe impacts and 4,296 moderate impacts, Alternative B (Viaduct to I-880) would result in 1,648 severe impacts and 4,186 moderate impacts, and Alternative B (Viaduct to Scott Boulevard) would result in 1,628 severe impacts and 4,141 moderate impacts. The most noise impacts would occur under Alternative A, followed by Alternative B (Viaduct to I-880), and Alternative B (Viaduct to Scott Boulevard). The results between alternatives differ in the San Francisco to South San Francisco, San Mateo to Palo Alto, and San Jose Diridon Station Approach Subsections. The passing track under Alternative B result in minor differences in operations noise impacts compared to Alternative A between the relative location of the tracks and train operations and the distances from noise-sensitive receptors. In the San Jose Diridon Station Approach Subsection, there would be more noise impacts under Alternative A than Alternative B because Alternative A has a greater number of existing at-grade crossings at which train horns would sound, whereas Alternative B would be grade separated on viaduct. Further, the viaduct parapets under Alternative B provide some noise shielding from the wheel-rail train noise.

Table 3.4-16 Summary of 2040 No Project[1] and 2040 Plus Project[2] Noise Impacts

Subsection	Land Use Category[3]	No Project		Alternative A		Alternative B[4]	
		Moderate	Severe	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco	2	2	0	182	173	183	168
	1, 3	0	0	4	0	4	0
San Bruno to San Mateo	2	18	7	1,069	496	1,069	496
	1, 3	1	0	10	1	10	1
San Mateo to Palo Alto	2	4	0	1,964	769	1,958	769
	1, 3	6	0	21	2	20	1
Mountain View to Santa Clara	2	11	2	821	193	821	193
	1, 3	0	0	3	0	3	0
San Jose Diridon Station Approach	2	0	0	221	124	117/73	20/0
	1, 3	0	0	1	0	1/0	0/0
Subtotal	**2**	**35**	**9**	**4,257**	**1,755**	**4,148/ 4,104**	**1,646/ 1,626**
	1, 3	**7**	**0**	**39**	**3**	**38/37**	**2/2**
Total	**1, 2, 3**	**42**	**9**	**4,296**	**1,758**	**4,186/ 4,141**	**1,648/ 1,628**

I- = Interstate
PCEP = Peninsula Corridor Electrification Project
[1] The 2040 No Project condition reflects planned changes in Caltrain operations as part of PCEP for all locations other than the 4th and King Street Station area. No Project impacts are provided for comparison purposes and are not used to determine project impact.
[2] The 2040 Plus Project condition reflects future noise conditions for all locations other than the 4th and King Street Station area, associated with the HSR project and planned changes in Caltrain operations as part of PCEP.
[3] Federal Railroad Administration Land Use Categories are summarized in Table 3.4-6. Land Use Category 1 = areas where quiet is an essential element to the land use; Category 2 = Residential; Category 3 = Institutional use and passive-use parks.
[4] Where applicable, values are presented for Alternative B (Viaduct to I-880) first, followed by Alternative B (Viaduct to Scott Boulevard). If only one value is presented, the value would be identical under the two Alternative B options.

Figure 3.4-9 through Figure 3.4-19 illustrate the 2040 Plus Project noise impact locations for each project alternative. Figure 3.4-9 through Figure 3.4-13 illustrate the noise impact locations for Alternative A; Figure 3.4-14 through Figure 3.4-19 illustrate noise impact locations for Alternative B. Each red area indicates a cluster of receptors predicted to have severe impacts and each yellow area indicates a cluster of receptors predicted to have moderate impacts for the 2040 Plus Project condition.

Implementation of the project alternatives would not change the current practices regarding the sounding of train horns and crossing bells in the noise RSA but would change the amount of train horn and crossing bell sounding due to the additional trains. Alternatives A and B would be at grade at the same locations as the existing Caltrain railway, except for Alternative B south of Scott Boulevard. As a result, HSR trains would regularly sound warning horns at all at-grade crossings and Caltrain passenger stations. Project operations may also generate additional noise associated with the installation of additional equipment at PCEP TPFs and the new TPSS (Alternative B only) as noted under Impact NV#7.

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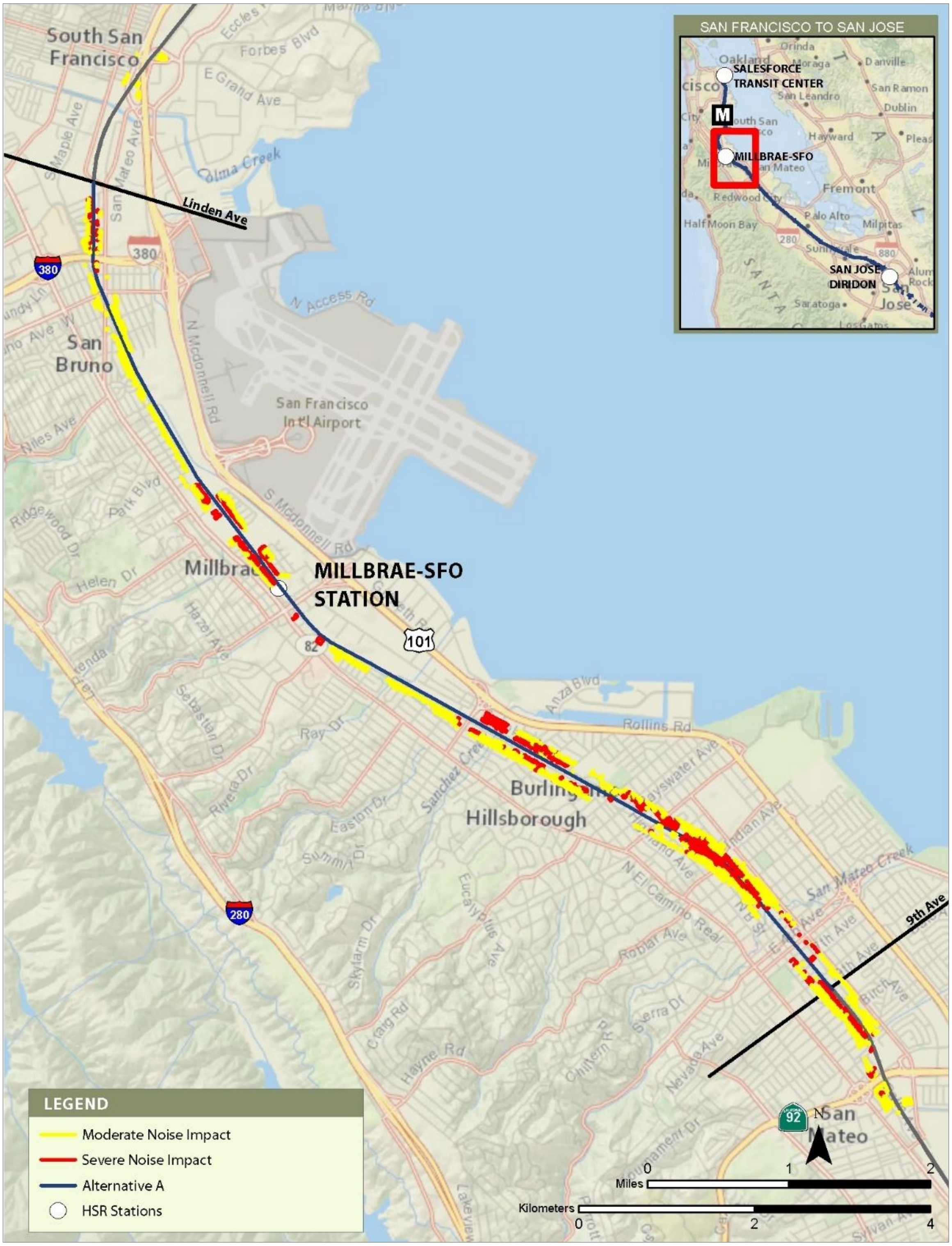
Figure 3.4-9 2040 Plus Project Noise Impacts—Alternative A (San Francisco to South San Francisco Subsection)

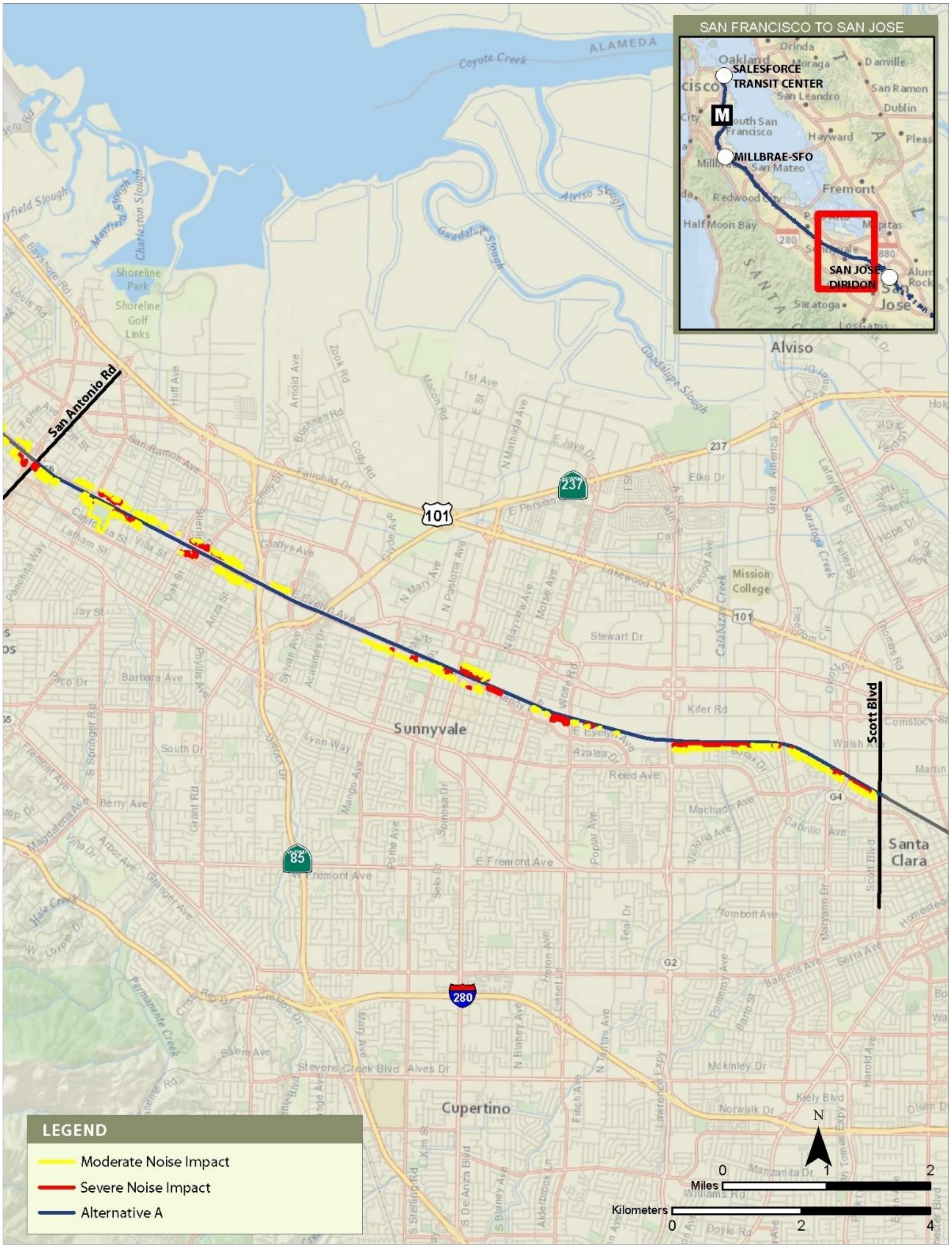


JUNE 2019

Figure 3.4-10 2040 Plus Project Noise Impacts—Alternative A (San Bruno to San Mateo Subsection)

JUNE 2019

Figure 3.4-11 2040 Plus Project Noise Impacts—Alternative A (San Mateo to Palo Alto Subsection)



JUNE 2019

Figure 3.4-12 2040 Plus Project Noise Impacts—Alternative A (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-13 2040 Plus Project Noise Impacts—Alternative A (San Jose Diridon Station Approach Subsection)

JUNE 2019

Figure 3.4-14 2040 Plus Project Noise Impacts—Alternative B (San Francisco to South San Francisco Subsection)

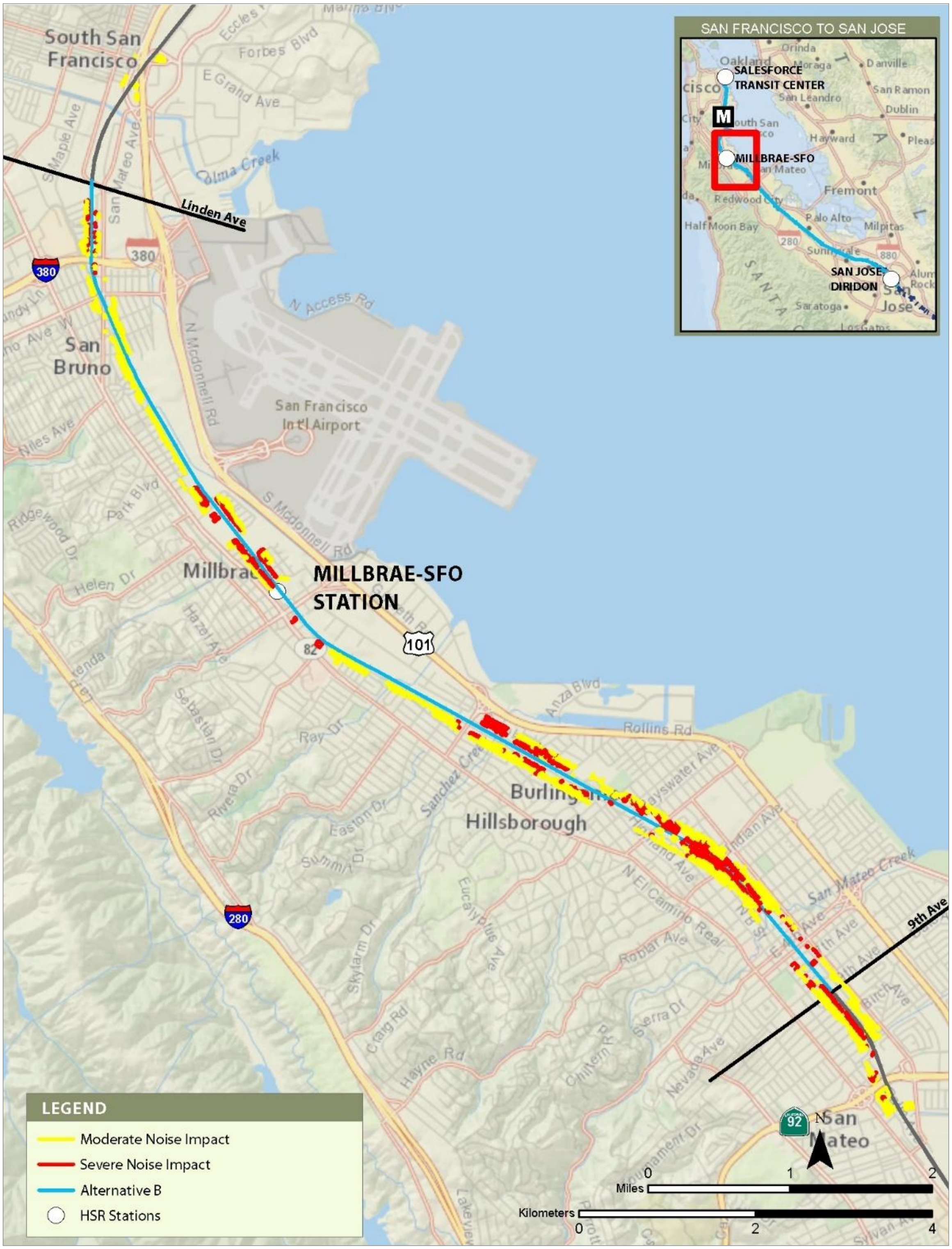


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Figure 3.4-15 2040 Plus Project Noise Impacts—Alternative B (San Bruno to San Mateo Subsection)

JUNE 2019

Figure 3.4-16 2040 Plus Project Noise Impacts—Alternative B (San Mateo to Palo Alto Subsection)

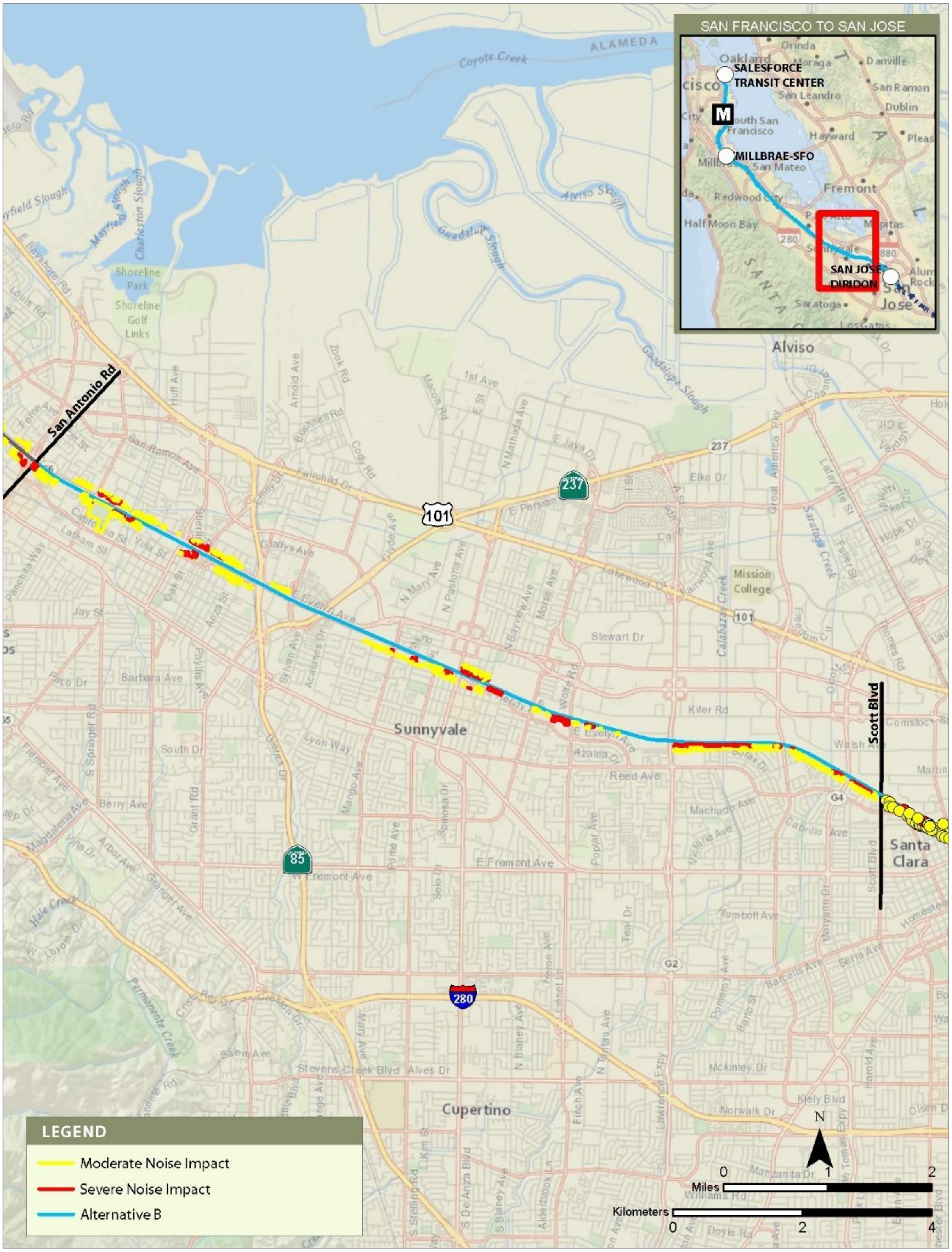

Figure 3.4-17 2040 Plus Project Noise Impacts—Alternative B (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-18 2040 Plus Project Noise Impacts—Alternative B (Viaduct to I-880) (San Jose Diridon Station Approach Subsection)

UNE 2019

Figure 3.4-19 2040 Plus Project Noise Impacts—Alternative B (Viaduct to Scott Boulevard) (San Jose Diridon Station Approach Subsection)

CEQA Conclusion

The impact under CEQA would be significant for both project alternatives because operations would generate noise levels above existing ambient levels and in exceedance of FRA criteria, causing severe noise impacts at sensitive receptors due to train horn sounding and the increase in train service within the corridor. This exceedance would occur under both project alternatives in both the opening year and 2040, with nearly half of the impacts occurring in the San Mateo to Palo Alto Subsection. There would be more operations noise impacts under Alternative A than Alternative B (both viaduct options), particularly within the San Jose Diridon Station Approach Subsection. Mitigation measures to address this impact are identified in Section 3.4.9. Section 3.4.7 describes the measures in detail.

Impact NV#3: Intermittent Permanent Exposure of Sensitive Receptors to Noise from HSR Passenger Station Parking

The project includes the modification of three existing stations to serve as stops for HSR trains—in downtown San Francisco at the existing 4th and King Street Station, in Millbrae at the existing intermodal station, and at the San Jose Diridon Station. No additional parking facilities would be associated with the 4th and King Street Station under either project alternative. The Millbrae Station would have five parking areas with a total of approximately 325 parking spaces; this would be an increase of 37 parking spaces relative to the existing station parking. The analysis assumed that on a typical day during the three AM peak hours and three PM peak hours that all the parking spaces would be filled once and then vacated once. During the non-peak midday and evening hours, the analysis assumed that a percentage of the parking spaces corresponding to the ridership peaking factors would be filled and then vacated each hour (Authority 2008).

At the San Jose Diridon Station neither alternative would result in net new parking spaces. The station layout would be similar for both alternatives, and would relocate approximately 226 parking spaces so that there would be no change in available parking spaces at the station.

The evaluation of the noise generated from the station parking facilities determined that Millbrae Station's parking facilities would result in a maximum L_{dn} contribution of 37 dBA at nearby sensitive receptors. The San Jose Diridon Station parking facilities would result in an L_{dn} contribution of 29 dBA at nearby sensitive receptors. The additional noise from parking facilities would be substantially lower than the projected L_{dn} from HSR train operations. At all nearby receptors, the L_{dn} contribution from the parking facilities at Millbrae Station would be at least 24 dB less than the projected L_{dn} from train operations, and at San Jose Diridon Station would be at least 18 dB less than the projected L_{dn} from train operations.

CEQA Conclusion

The impact under CEQA would be less than significant for both project alternatives because operation of HSR passenger stations would provide only a minor contribution to the overall noise generated by project operations. Noise from HSR passenger station parking is combined with noise from all project sources, including HSR train operations through the stations and train horns sounding when approaching stations, and the total noise is compared to the FRA impact thresholds on Figures 3.4-5 and 3.4-6. Because the dominant noise source at HSR passenger stations would be train operations through the stations and train horns sounding approaching the stations, the minor contribution of traffic within the station parking facilities would not result in the generation of noise levels in excess of standards for a severe impact established by the FRA. Therefore, CEQA does not require any mitigation.

Impact NV#4: Intermittent Permanent Exposure of Sensitive Receptors to Noise from the Brisbane Light Maintenance Facility

One LMF would be located in Brisbane under each project alternative. There are two potential location options for the LMF—the East Brisbane LMF under Alternative A and the West Brisbane LMF under Alternative B. At both locations, the mainline HSR tracks would be directly adjacent to the LMF and the HSR speeds would be approximately 85 to 110 mph. Therefore, the noise from HSR operations would dominate noise from occasional HSR train movements into and out of the LMF.

The Authority used the methods summarized in Volume 2, Appendix 3.4-A, to assess noise impacts from the proposed LMF. Preliminary layouts of the two LMF sites were used to identify the approximate center of noise-producing activities at the facilities. A noise assessment following Section 4.4 of the FTA guidance manual was used to predict noise exposure from the LMF over a 24-hour period. The HSR operations schedule of train movements into and out of the LMF identified 29 planned HSR train movements during the daytime and 7 movements during the nighttime. The L_{dn} contribution from these LMF train movements was then calculated at all nearby noise-sensitive receptors.

The closest identified receptors (residences on Cliff Swallow Court) to the Brisbane LMF sites are approximately 1,900 feet from the East Brisbane LMF and approximately 1,500 feet from the West Brisbane LMF. The L_{dn} contribution from the East Brisbane LMF at the nearest receptor would be 36 dBA, more than 14 dB less than the HSR operations contribution at that receptor. The L_{dn} contribution from the West Brisbane LMF at the nearest receptor would be 40 dBA, more than 11 dB less than the HSR operations contribution at that receptor. As a result, the additional noise from either LMF would not contribute to or cause noise impacts at nearby sensitive receptors.

CEQA Conclusion

The impact under CEQA would be less than significant for both project alternatives. Noise from the LMF is combined with noise from all project sources, including HSR train operations, and the total noise is compared to the FRA impact thresholds illustrated on Figures 3.4-5 and 3.4-6. The operational noise generated by either option for the Brisbane LMF would provide an exceedingly small contribution to the overall noise generated by project operations and would not result in the generation of noise levels in excess of standards for a severe impact established by the FRA. Therefore, CEQA does not require any mitigation.

Impact NV#5: Intermittent Permanent Human Annoyance from Noise Onset of Passing HSR Trains

Onset rate is the average rate of change of increasing sound pressure level measured in dB/sec during a single noise event. Trains for both project alternatives would reach maximum speeds of 110 mph. According to Figure 3.4-7, once the HSR train reaches 110 mph, the onset rate is 30 dB/second when the noise-sensitive receptor is within 23 feet of the train.

Between the 4th and King Street Station and Scott Boulevard in Santa Clara, there is extensive daily train traffic along the Caltrain corridor including Caltrain (92 daily trains) and freight (6 daily trains). Between Scott Boulevard and the San Jose Diridon Station, there is even more extensive daily train traffic along the Caltrain corridor including Caltrain (92 daily trains), ACE (8 daily trains), Capitol Corridor (14 daily trains), Amtrak (2 daily trains), and freight (9 daily trains). Between the San Jose Diridon Station and Tamien Station, there is a moderate amount of daily train traffic along the Caltrain corridor including Caltrain (40 daily trains), ACE (8 daily trains), Amtrak (2 daily trains), and freight (4 daily trains). In these areas, trains operate up to 79 mph at present.

Along the Caltrain corridor, Caltrain trains currently operate up to 79 mph. With the HSR project, HSR trains and Caltrain trains would operate up to 110 mph where track alignments allow operations up to that speed. Where train speeds increase due to the project, operation of the project would result in a sudden increase in noise for receptors within 23 feet of track alignments due to the rapid approach of an HSR train and a quick noise onset rate. To avoid startle impacts at human noise-sensitive receptors because of onset rates, noise-sensitive receptors would need to be more than 23 feet from the track.

At Caltrain and HSR stations, passengers may be on platforms closer than 23 feet from the tracks, but there would be advanced warning of trains approaching with announcements, horns, bells, and signage, so substantial ongoing startle impacts would not occur at stations due to train passage. The same would be true at the at-grade crossings for vehicles, bicyclists and pedestrians, where train horns would sound.

The Authority reviewed the data used for the noise analysis between San Francisco and San Jose indicating distances from proposed tracks to noise-sensitive receptors and found that in most areas (outside of stations and at-grade crossings), noise-sensitive receptors would be more than 23 feet from the proposed track alignments, and no startle impacts would occur. The Authority identified a few noise-sensitive receptors that could be within 23 feet of the nearest track centerline in the following areas (receptors in properties not immediately adjacent to the railroad right-of-way would not be affected):

- San Francisco to South San Francisco Subsection (both alternatives)
  - A number of residences are above the four existing tunnels and are less than 23 feet from the nearest track centerline but residents would not be startled by train noise because the trains would be in a tunnel.
- San Bruno to San Mateo Subsection (both alternatives)
  - One residence east of the existing Caltrain right-of-way along Montgomery Avenue between Walnut Street and I-380 in San Bruno would be less than 23 feet from the northbound track centerline but this residence is anticipated to be acquired because it is within the construction TCE, so no impact is expected to occur due to operations.
- San Mateo to Palo Alto Subsection (Alternative B only)
  - One residence west of the existing Caltrain right-of-way along South B Street in San Mateo is less than 23 feet from the southbound track centerline, but this residence is anticipated to be acquired under Alternative B, so no impact is expected to occur due to operations.

Operation of either project alternative would also result in wayside noise near the four short existing tunnel section portals in the San Francisco to South San Francisco Subsection, which could startle nearby wayside receptors. Wayside noise near the tunnel portals would not cause an adverse impact on sensitive receptors due to the slow train speeds through the tunnels.[11]

CEQA Conclusion

The impact under CEQA would be less than significant for both project alternatives. The potential for startle would only occur where receptors would experience a sudden onset of noise greater than the FTA threshold of 30 dBA/second, which would only occur on this Project Section where a receptor is within 23 feet of the nearest track when a train is travelling up to 110 mph. Ongoing startle impacts would not occur at stations and at-grade crossings within 23 feet of planned track alignments because advance warning would be provided at these locations, which would avoid startling receptors. Outside of stations and at-grade crossings, the only two noise-sensitive receptors (both residences) identified within the area that would experience sudden onset noise in excess of the FTA threshold would be acquired prior to construction due to the need for temporary construction easements or permanent right-of-way acquisition so that operations impacts would not occur at these locations. Accordingly, a temporary or periodic substantial increase in ambient noise levels related to ongoing startle impacts would not occur. Therefore, CEQA does not require any mitigation.

Impact NV#6: Permanent Exposure of Sensitive Receptors to Vehicular Traffic Noise Increases

In addition to noise from HSR operations, noise from changes in vehicle traffic volume due to the project at stations that would provide HSR service and the Brisbane LMF was considered for 2029 and 2040 No Project and Plus Project conditions.

Operation of the project would generate additional traffic and traffic-related noise under the 2029 Plus Project and 2040 Plus Project conditions when compared to the existing conditions. For

[11] Trains exiting a tunnel portal can create additional noise due to the propagating sound wave ahead of the train. The effect would be a rapid rise in sound level as the train leaves the tunnel and portal.

locations north of Scott Boulevard, Volume 2, Appendix 3.4-A, provides the existing total average daily traffic (ADT) volumes for each roadway segment, the 2029 and 2040 No Project ADT, and the 2029 and 2040 Plus Project ADT under each project alternative (2029 analysis is limited to the analysis of the 4th and King Street Station interim terminal operations and approach), and calculates the noise increases over existing noise conditions. The San Jose to Merced Noise and Vibration Technical Report provides the same information for the locations south of Scott Boulevard (Authority 2019a). For context, the 2029 and 2040 Plus Project conditions (described in Section 3.4.4.3) are also compared to the No Project condition and summarized in Volume 2, Appendix 3.4-A.

Table 3.4-17 provides a summary of the number of roadway segments with noise increases greater than or equal to 3 dB over existing conditions by alternative. The two affected segments for the year 2029 would occur in San Francisco on Fourth Street, between Townsend and Bluxome and Bluxome and Brannan. There were no roadway segments where the increases in traffic associated with the Brisbane LMF or Millbrae Station under the 2040 Plus Project condition were anticipated to be greater than or equal to 3 dB. Near the San Jose Diridon Station, there would be four roadway segments under Alternative A where the increases in traffic under the 2040 Plus Project condition were anticipated to be greater than or equal to 3 dB. Under Alternative B (both viaduct options), there would be five roadway segments where the increases in traffic under the 2040 Plus Project condition were anticipated to be greater than or equal to 3 dB.

Table 3.4-17 2029 and 2040 Number of Roadway Segments with Traffic-Related Noise Increases More than 3 dBA above Existing Conditions

Subsection and Roadway Segments	Number of Roadway Segments with Noise Increases ≥ 3 dBA above Existing			
	Alternative A		Alternative B	
	2029	2040[1]	2029	2040[1]
4th and King Street Station vicinity	2	N/A	2	N/A
Brisbane Light Maintenance Facility vicinity	N/A	0	N/A	0
Millbrae Station vicinity	N/A	0	N/A	0
San Jose Diridon Station vicinity	N/A	4	N/A	5
Totals	**2**	**4**	**2**	**5**

dBA = A-weighted decibel
[1] No high-speed rail operations at 4th and King Street Station in 2040.

The project would also require the relocation of a portion of Tunnel Road and a portion of Lagoon Road in Brisbane; however, there are no sensitive receptors along the new road alignments, so there would be no impact relative to permanent road relocation.

CEQA Conclusion

The impact under CEQA would be significant for both project alternatives at two roadway segments in San Francisco and at four to five roadway segments in San Jose because permanent increases in traffic associated with the alternatives would increase ambient noise levels in the project vicinity greater than or equal to 3 dB above levels existing without the project. In 2029, traffic noise level increases greater than or equal to 3 dB above existing levels would occur at two roadway segments near the 4th and King Street Station on Fourth Street between Bluxome and Brannan, and on Fourth Street between Townsend and Bluxome in the San Francisco to South San Francisco Subsection. In San Jose, the affected segments under both alternatives would be Stockton Avenue between Julian Street and The Alameda, The Alameda between Sunol Avenue and Delmas Avenue, Cahill Street between Santa Clara and San Fernando Street, Autumn Street between Santa Clara Street and Park Avenue. Additionally, increases greater than 3 dB would occur at Autumn Street between Julian and Santa Clara under Alternative B (both viaduct options). Mitigation measures to address this impact are identified in Section 3.4.9. Section 3.4.7 describes the measures in detail.

Impact NV#7: Traction Power Facility Noise

Any new equipment required to handle HSR electrical load in the Project Section north of Scott Boulevard would be co-located with TPFs presently being installed as part of the PCEP. The associated facilities, including any necessary additional transformers, cooling fans and pumps, or other electrical equipment would be similar to those for the PCEP and would be in the same location. In addition, Alternative B would include a new TPSS in San Jose near I-880.

HSR train operational noise levels were calculated using the methodology in Section 3.4.4.3 to compare the total project noise levels with the ambient noise at the receptors and to account for both changes from project operations and the new noise source associated with additional equipment at the PCEP TPFs or at the new TPSS. The number of receptors potentially affected by noise is shown in Table 3.4-18. The typical noise levels from additional equipment at the PCEP TPFs would be as high as 67 L_{dn} dBA at 70 feet, which would generate noise impacts. At one residential/mixed-use receptor that would be 5 feet from PS 5, Option 2, the ancillary facility noise level could be as high as 86 L_{dn} and could generate a severe noise impact from the additional equipment alone. However, in combination with HSR train operations, the noise associated with additional equipment at the PCEP TPFs or at the new TPSS would not generate any additional impact beyond those shown in Table 3.4-16. Under both alternatives the L_{dn} contribution from additional equipment at the PCEP TPFs would not generate additional noise impacts beyond the train operations noise impacts.

Table 3.4-18 Traction Power Facility Noise Analysis[1]—Number of Affected Receptors

City	Traction Power Facility	Land Use Category[2]	Alt A		Alt B	
			Moderate	Severe	Moderate	Severe
Palo Alto	PCEP PS 5, Option 2	2	0	1 [3]	0	1 [3]
Sunnyvale	PCEP PS 6, Option 2	2	0	2 [4]	0	2 [4]
Total			**0**	**3**	**0**	**3**

HSR = high-speed rail
PCEP = Peninsula Corridor Electrification Project
PS = paralleling station
TPF = traction power facility
[1] Facilities not listed have no noise-sensitive receptors within 250 feet of the facility per screening distance and no receptors within 100 feet of the facility per screening of PCEP analyses.
[2] Federal Railroad Administration Land Use Categories are summarized in Table 3.4-6. Land Use Category 1 = areas where quiet is an essential element to the land use; Category 2 = Residential; Category 3 = Institutional use and passive-use parks.
[3] TPF generates a severe impact without HSR train noise and other project components.
[4] TPF generates a moderate impact without HSR train noise and other project components.

CEQA Conclusion

The impact under CEQA would be significant for both alternatives when combined with the operational train noise impacts that exceed FRA site-specific noise increase criteria. Additional equipment at the TPFs may generate noise that exceeds the 3.0-dBA severe impact threshold at one home in the San Mateo to Palo Alto Subsection near PS 5, Option 2. Mitigation measures to address this impact are identified in Section 3.4.9. Section 3.4.7 describes the measures in detail.

3.4.6.3 Vibration

Construction and operations of the project alternatives would result in temporary and permanent impacts from vibration. Construction of and modification of tracks, stations, and the LMF could result in vibration impacts from pile driving, vibratory compaction, demolition, or excavation near vibration-sensitive structures. Train movement during operations of the project alternatives could increase vibration levels near the alignment right-of-way and also cause impacts.

No Project Conditions

The conditions describing the No Project Alternative are the same as those described in Section 3.4.6.2, Noise. The same planned development and transportation projects would generally result in increases in ambient vibration levels and could cause localized vibration impacts. Without the project alternatives, the Caltrain PCEP is assumed to use EMU vehicles in place of the current diesel locomotive–hauled coaches. The vibration analysis for the PCEP assumed that the EMU vehicle would be similar to the existing vehicles regarding vibration (PCJPB 2015). Thus, no new vibration impacts are assumed to be associated with PCEP without the HSR project, because although there could be increases in other passenger or freight train operations, those operations would not be expected to cause higher vibration levels than existing conditions.

Project Impacts

Construction Impacts

Construction of the project alternatives would involve demolition of some existing structures near the Brisbane LMF, near station modifications, and near some track relocations or the passing track; clearing and grubbing; handling, storing, hauling, excavating, and placing fill; pile driving; and construction of aerial structures, bridges, road modifications, utility upgrades and relocations, HSR electrical systems, and railbeds. Chapter 2 describes construction activities.

Impact NV#8: Temporary Exposure of Sensitive Receptors and Buildings to Construction Vibration

Construction of project alternatives would require the use of equipment that would generate temporary ground-borne vibration during the 4.5-year construction period. The impacts from construction-related vibration would be similar under both project alternatives, but Alternative B would have more extensive construction activity and would require a greater amount of nighttime construction than Alternative A due to the passing track construction. As a result, construction of Alternative B would expose more receptors to construction vibration.

The potential for vibration impacts would be greatest where vibration-sensitive land uses are close to major construction activities with a long duration (e.g., LMF, passing tracks, viaduct, station modifications) and nighttime construction activities (e.g., passing tracks, parallel tracks and roadway realignment). Alternative A would include the following locations of potential construction vibration impacts and would have fewer impacts than Alternative B:

- **San Francisco to South San Francisco Subsection**—Alternative A would modify platforms and tracks at the 4th and King Street Station and the Bayshore Station, build the East Brisbane LMF with connections from the yard lead tracks to the mainline tracks, build the realigned Tunnel Avenue overpass, install four-quadrant gates and radio towers, and realign track at several locations, including the Sierra Lumber Spur, the South San Francisco Yard area, and the Georgia Pacific Lead. The alternative may also require upgrades to PCEP TPFs. These construction activities, some of which would occur at night and on weekends, would generate temporary construction vibration impacts where they occur near vibration-sensitive land uses. Nighttime work within this subsection, including vibratory compaction, would be required to build the Tunnel Avenue overpass and realign tracks. Nighttime construction vibration would affect residences within 140 feet of nighttime construction in the Little Hollywood neighborhood of San Francisco. Construction activities for the East Brisbane LMF would occur approximately 1,900 feet from the nearest residences, which is far enough that they would not be affected by nighttime construction vibration.
- **San Bruno to San Mateo Subsection**—Alternative A would expand the existing Millbrae Station, modify the existing San Bruno and Broadway Stations, install four-quadrant gates and radio towers, and realign tracks in San Bruno, Millbrae, Burlingame, and San Mateo. Upgrades to PCEP TPFs may also be required. Construction vibration would temporarily affect residences within 140 feet of nighttime construction work in San Bruno, Millbrae, Burlingame, and San Mateo.

- **San Mateo to Palo Alto Subsection**—Alternative A would realign track in San Mateo, Belmont, San Carlos, Menlo Park, and Palo Alto, modify tracks and platforms at the Hayward Park and Atherton Stations, install four-quadrant gates and radio towers, and potentially upgrade PCEP TPFs, all of which would result in some temporary construction vibration impacts. Nighttime construction work associated with track realignments would occur and construction vibration would temporarily affect residences within 140 feet of nighttime construction in San Mateo, Belmont, San Carlos, Atherton, Menlo Park, and Palo Alto.
- **Mountain View to Santa Clara Subsection**—Alternative A would realign tracks in Mountain View, Sunnyvale, and Santa Clara, install four-quadrant gates and radio towers, and potentially upgrade PCEP TPFs, resulting in some temporary construction vibration impacts. Nighttime work would occur, and construction vibration would temporarily affect residences within 140 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara.
- **San Jose Diridon Station Approach Subsection**—Alternative A would modify the San Jose Diridon Station, realign tracks, install new tracks, install four-quadrant gates and a radio tower, and potentially install additional equipment at the PCEP TPS-2 facility, resulting in temporary construction vibration impacts. Nighttime track realignment would occur, potentially in areas near residences to minimize disruption with existing passenger rail services.

Alternative B would include the following locations of potential construction vibration impacts and would have greater impacts than Alternative A due primarily to the passing track construction:

- **San Francisco to South San Francisco Subsection**—Construction of Alternative B would require similar construction activities to those described for Alternative A, except that Alternative B would build the West Brisbane LMF approximately 1,500 feet from residences, which is far enough away that residences would not be affected. Nighttime work within this subsection would be required to build the Tunnel Avenue overpass and realign tracks, and construction vibration would temporarily affect residences within 140 feet of nighttime construction in the Little Hollywood neighborhood of San Francisco.
- **San Bruno to San Mateo Subsection**—There are no differences between Alternative B and Alternative A in this subsection. Construction vibration would temporarily affect residences within 140 feet of nighttime construction work in San Bruno, Millbrae, Burlingame, and San Mateo.
- **San Mateo to Palo Alto Subsection**—Alternative B would build an approximately 6-mile-long passing track from Ninth Street in San Mateo to Whipple Avenue in Redwood City, which would require realignment of tracks, roadway modifications, and station and platform modifications at the existing Hayward Park, Hillsdale, Belmont and San Carlos Stations during a construction period lasting up to 4.5 years. Some of these construction activities would occur at night, and construction vibration would temporarily affect residences within 140 feet of nighttime construction in San Mateo, Belmont, San Carlos, and Redwood City. Outside of the passing track area, construction activities under Alternative B would be the same as those described for Alternative A.
- **Mountain View to Santa Clara Subsection**—There are no differences between Alternative B and Alternative A in this subsection. Nighttime work would occur and construction vibration would temporarily affect residences within 140 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara.
- **San Jose Diridon Station Approach Subsection**—Alternative B would include construction of an aerial station at the San Jose Diridon Station, build an aerial structure beginning at either I-880 (Alternative B [Viaduct to I-880]) or at Scott Boulevard (Alternative B [Viaduct to Scott Boulevard]), install new tracks, relocate tracks, install a radio tower, and install a new TPSS. Nighttime construction activities would occur, potentially within 500 feet of residences in San Jose. Nighttime track realignment would occur, potentially in areas near residences to minimize disruption with existing passenger rail services.

Construction vibration could result in human annoyance and building damage. Human annoyance occurs when construction vibration rises above the threshold of human perception for extended periods of time. A threshold of 80 VdB has been used to evaluate nighttime annoyance for infrequent events at residential land use. This threshold is typically applied to most HSR construction work. For sources such as pile driving, vibratory compaction and ongoing demolition work with jackhammers or hoe-rams, the frequent event criterion of 72 VdB has been used. Nighttime annoyance would potentially occur as far out as 300 feet from pile-driving activities, 140 feet from vibratory compaction, and as close as 50 feet from short-duration, transient events.

Building damage occurs when construction activities produce vibration in the ground strong enough to potentially cause cosmetic or structural damage. Pile driving very close to buildings (within 55 feet) would potentially exceed the 0.2 in/sec PPV threshold and cause building damage at wood-framed residential buildings with plaster. For modern, reinforced concrete buildings, building damage would potentially exceed the 0.5 in/sec PPV threshold within 30 feet. Pile driving would be used in limited portions of the Caltrain right-of-way, including for the LMF building foundations as well as for expansion of existing bridges where additional piles are necessary due to either track realignment or due to additional passing tracks (under Alternative B only).

CEQA Conclusion

The impact under CEQA would be significant for both project alternatives because construction of the alternatives could expose persons to annoyance at locations where track modifications requiring vibration compaction would occur within 140 feet of vibration-sensitive receptors, and could expose buildings to excessive ground-borne vibration if pile driving would occur within 55 feet of any building near foundations required for the East or West Brisbane LMF, the Tunnel Avenue overpass, or bridge and structure modifications required to accommodate track realignments or aerial structures. The alternatives would include NV-IAMF#1 to minimize construction vibration and the potential for it to cause damage to buildings and human annoyance. However, even with NV-IAMF#1, some sensitive receptors and buildings would be exposed to ground-borne vibration that could result in annoyance or building damage. The mitigation measure to address this impact is identified in Section 3.4.9. Section 3.4.7 describes the measure in detail.

Operations Impacts

Operations of the project alternatives would include trains along the Caltrain corridor servicing passengers at the 4th and King Street, Millbrae, and San Jose Diridon Stations. Trains would also run regularly to the LMF for maintenance. Chapter 2 describes operations and maintenance activities.

Impact NV#9: Intermittent Permanent Exposure of Sensitive Receptors to Vibration from Operations

Potential vibration impacts due to annoyance as a result of HSR operations were assessed for 2029 and 2040. HSR operations would be different for each year, as noted in Table 3.4-4. The 2029 analysis was conducted for the 4th and King Street Station, from just south of Mission Bay Drive to Fourth and King Street. The 2040 analysis was conducted for the alignment south of Mission Bay Drive in San Francisco to West Alma Avenue in San Jose.

Under the No Project Alternative, the Caltrain PCEP is assumed to use EMU vehicles in place of the current diesel locomotive–hauled coaches. The vibration analysis for the PCEP EIR assumed that the EMU vehicle would generate vibration similar to the existing vehicle (PCJPB 2015). Thus, no new vibration impacts are assumed associated with PCEP.

No vibration impacts are predicted in the 4th and King Street Station area in 2029 because the projected vibration levels would not exceed applicable criteria described in Section 3.4.4.3. Table 3.4-19 summarizes the results of the 2040 vibration impact assessment with the project alternatives. The vibration impacts are separated between ground-borne vibration impacts and ground-borne noise impacts. The ground-borne noise impacts are limited to the short existing tunnel sections in the RSA. Alternative A would result in 2,493 ground-borne vibration impacts and 18 ground-borne noise impacts. Alternative B (Viaduct to I-880) would result in 2,307 ground-borne vibration impacts and 18 ground-borne noise impacts. Alternative B (Viaduct to Scott Boulevard) would result in 2,366 ground-borne vibration impacts and 18 ground-borne noise impacts. The vibration impacts would occur in all five subsections. Alternative B would have slightly fewer ground-borne vibration impacts in the passing track segments because the alignments would be slightly closer to receptors, necessitating some receptors to be acquired. In San Jose, the aerial viaduct configuration under Alternative B would generate fewer vibration impacts than the at-grade track configuration under Alternative A.

Table 3.4-19 2040 Plus Project Potential Vibration Impacts

Subsection	Land Use Category[1]	Number of Vibration Impacts			
		Alternative A		Alternative B[2]	
		GBV	GBN	GBV	GBN
San Francisco to South San Francisco	2	68	17	67	17
	1, 3	8	1	8	1
San Bruno to San Mateo	2	647	0	647	0
	1, 3	5	0	5	0
San Mateo to Palo Alto	2	1,137	0	1,137	0
	1, 3	13	0	12	0
Mountain View to Santa Clara	2	409	0	409	0
	1, 3	3	0	3	0
San Jose Diridon Station Approach	2	201	0	19/78	0
	1,3	2	0	0	0
Subtotal	**2**	**2,462**	**17**	**2,279/2,338**	**17**
	1, 3	**31**	**1**	**28**	**1**
Total	**1, 2, 3**	**2,493**	**18**	**2,307/ 2,366**	**18**

GBN = ground-borne noise
GBV = ground-borne vibration
I- = Interstate
[1] Federal Railroad Administration Land Use Categories are summarized in Table 3.4-6. Land Use Category 1 = Areas where vibration would interfere with operations; Category 2 = Residential; Category 3 = Institutional use.
[2] Where applicable, values are presented for Alternative B (Viaduct to I-880) first, followed by Alternative B (Viaduct to Scott Boulevard). If only one value is presented, the value would be identical under the two Alternative B options.

Figure 3.4-20 through Figure 3.4-30 illustrate the potential vibration annoyance impacts for each project alternative. Figure 3.4-20 through Figure 3.4-24 illustrate the Alternative A vibration impact locations. Figure 3.4-25 through Figure 3.4-30 illustrate the Alternative B vibration impact locations. Each red area indicates a cluster of receptors predicted to exceed FRA vibration impact thresholds. Each yellow area indicates a cluster of receptors predicted to exceed FRA ground-borne noise impact thresholds.

In each of the five subsections, there are many vibration-sensitive locations where the existing levels exceed the residential criterion of 72 VdB. Caltrain trains are the dominant existing rail source of vibration in the RSA, because Caltrain speeds exceed those of freight trains and vibration levels increase with speed. The entire project is categorized as a heavily used rail corridor. The project alternatives would more than double the number of train passby events per day.

Caltrain trains create similar ground-borne vibration levels to those from HSR trains in the RSA, even though the current maximum speeds are generally lower. In some areas, the project alternatives would cause the existing tracks to be shifted or for new passing tracks to be added with Alternative B. The analysis accounts for locations where the project would shift existing vibration rail sources closer to sensitive locations.

These vibration impacts are caused by both HSR train operations and also in some cases by Caltrain operations. Where the HSR project would cause Caltrain and freight tracks to be shifted closer to vibration-sensitive receptors, the train operations on those closer tracks are treated as project vibration sources and compared to the impact criteria. Under both alternatives, the project also would cause Caltrain trains to operate at increased maximum speeds to accommodate blended service, and those Caltrain operations at higher speeds are treated as project vibration sources and compared to impact criteria.

Figure 3.4-20 2040 Plus Project Vibration Impacts—Alternative A (San Francisco to South San Francisco Subsection)

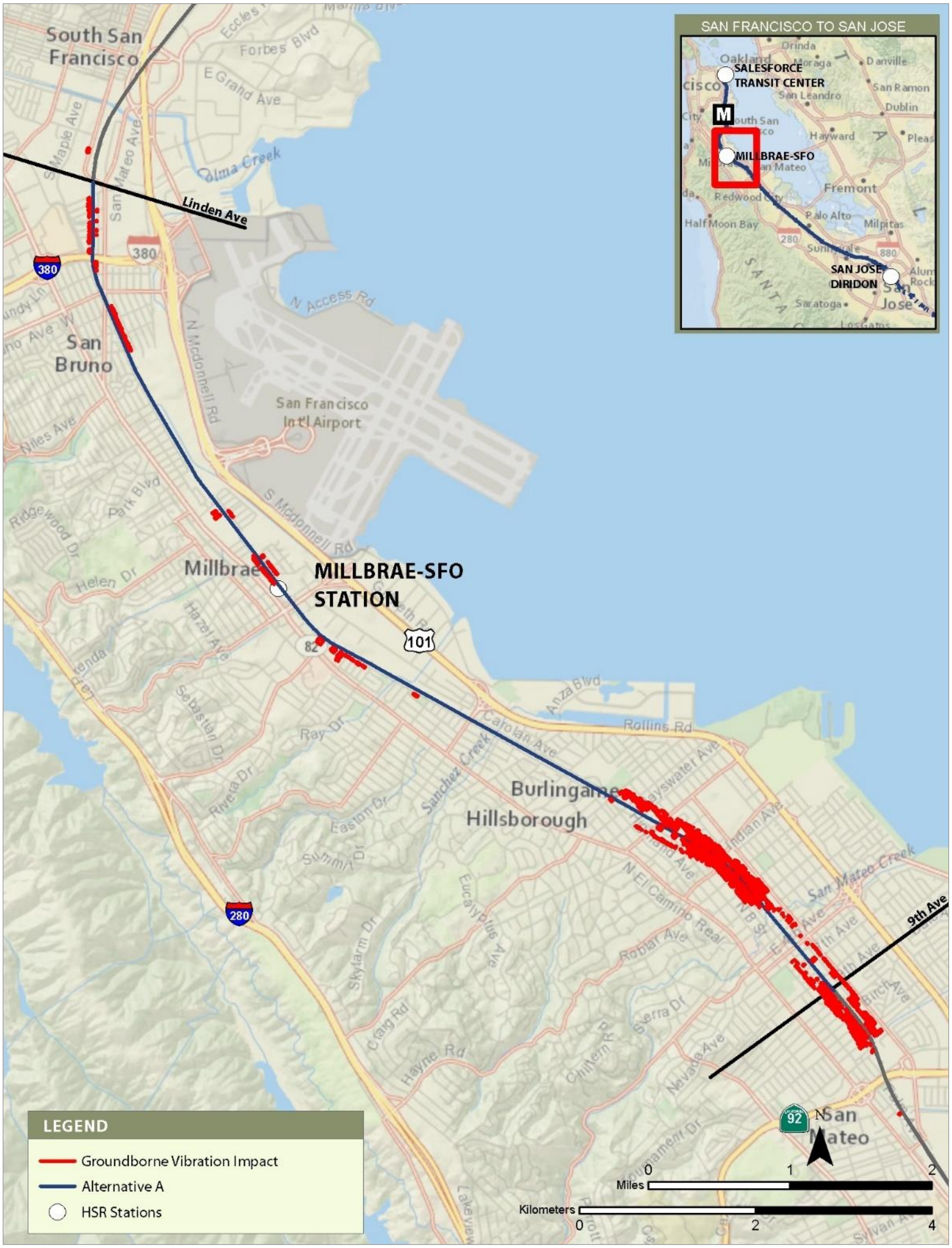

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Figure 3.4-21 2040 Plus Project Vibration Impacts—Alternative A (San Bruno to San Mateo Subsection)

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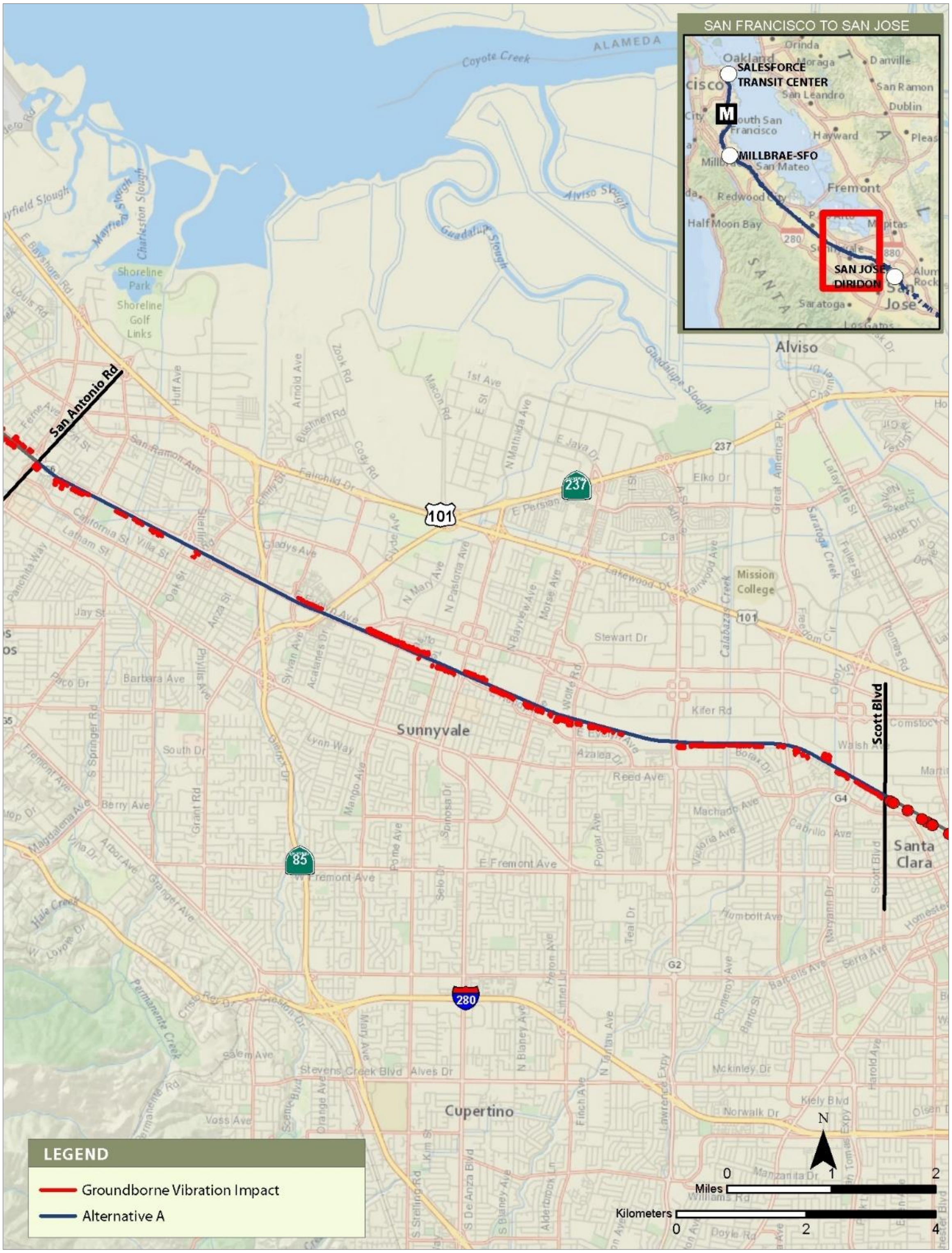
Figure 3.4-22 2040 Plus Project Vibration Impacts—Alternative A (San Mateo to Palo Alto Subsection)



JUNE 2019

Figure 3.4-23 2040 Plus Project Vibration Impacts—Alternative A (Mountain View to Santa Clara Subsection)

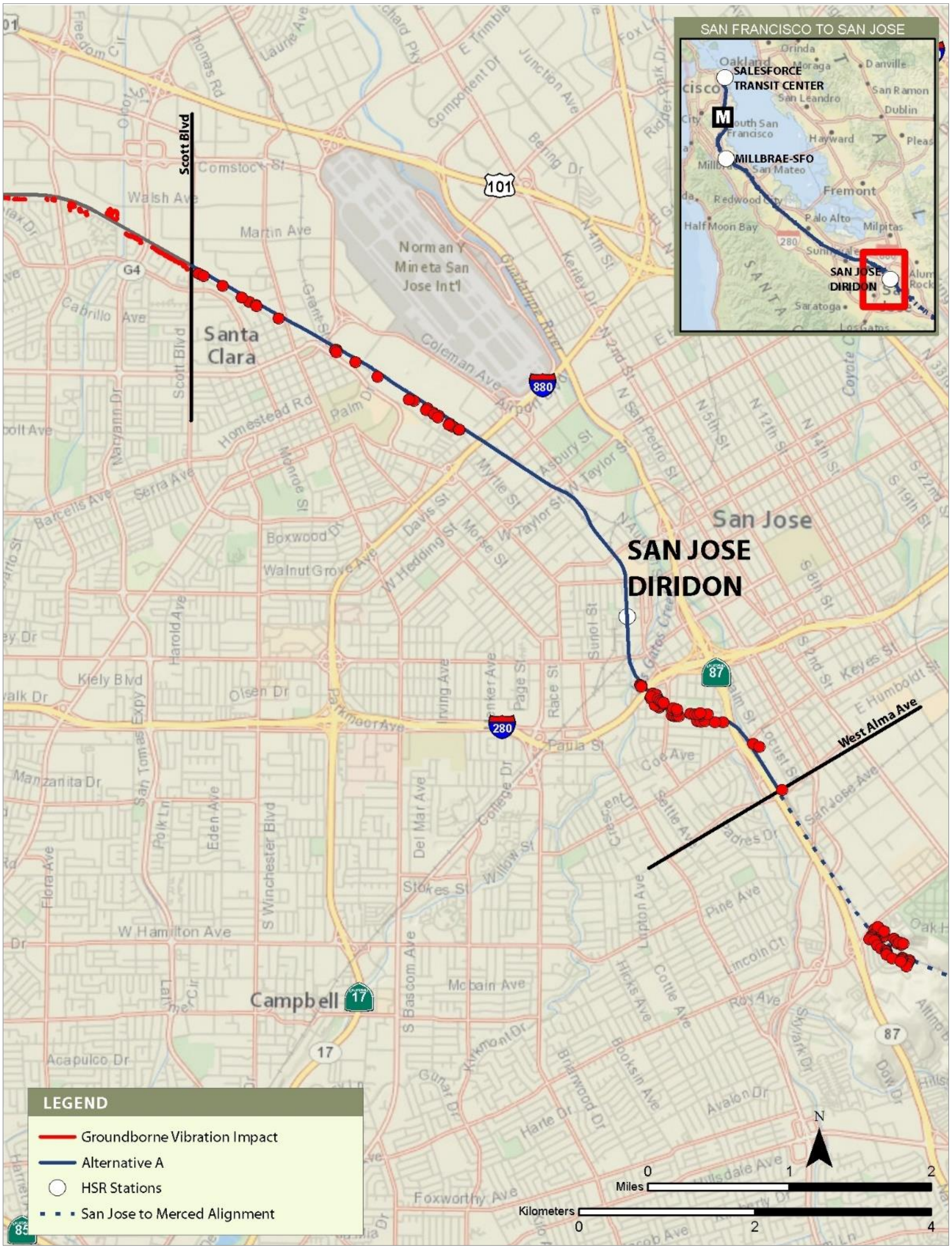


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Figure 3.4-24 2040 Plus Project Vibration Impacts—Alternative A (San Jose Diridon Station Approach Subsection)

JUNE 2019

Figure 3.4-25 2040 Plus Project Vibration Impacts—Alternative B (San Francisco to South San Francisco Subsection)

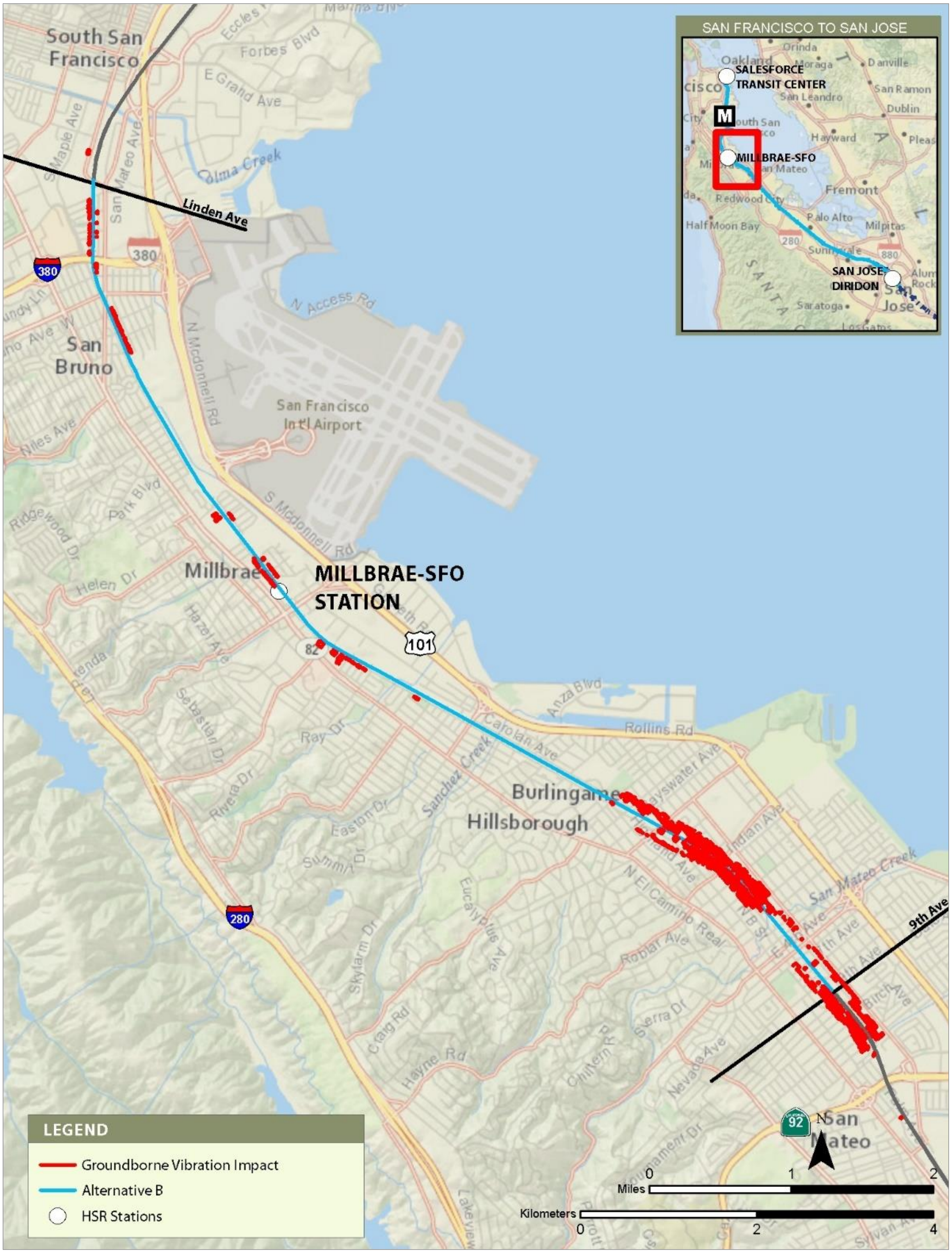

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Figure 3.4-26 2040 Plus Project Vibration Impacts—Alternative B (San Bruno to San Mateo Subsection)

JUNE 2019

Figure 3.4-27 2040 Plus Project Vibration Impacts—Alternative B (San Mateo to Palo Alto Subsection)

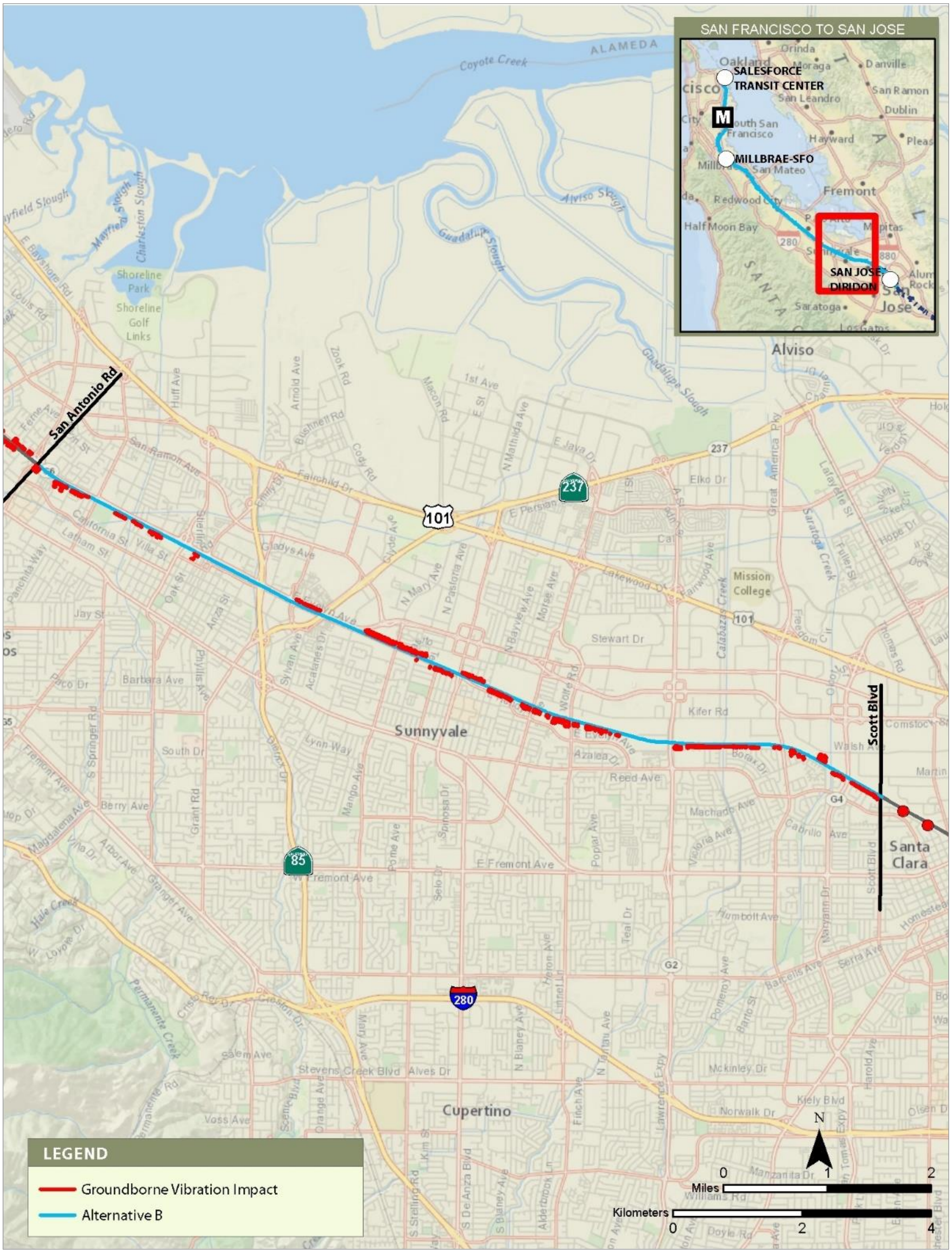

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Figure 3.4-28 2040 Plus Project Vibration Impacts—Alternative B (Mountain View to Santa Clara Subsection)

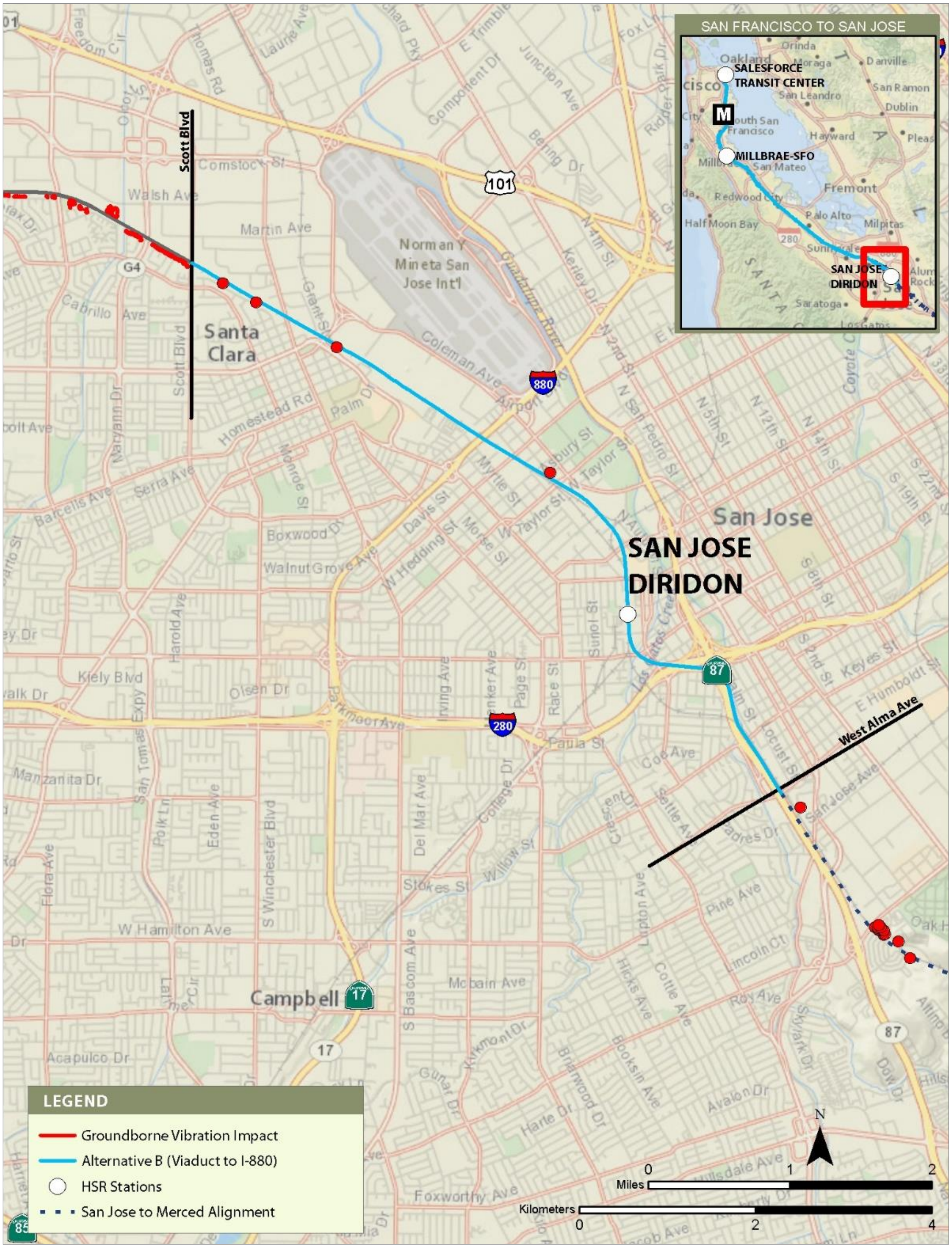

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Figure 3.4-29 2040 Plus Project Vibration Impacts—Alternative B (Viaduct to I-880) (San Jose Diridon Station Approach Subsection)

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Figure 3.4-30 2040 Plus Project Vibration Impacts—Alternative B (Viaduct to Scott Boulevard) (San Jose Diridon Station Approach Subsection)

The projected vibration levels from HSR trains would exceed the annoyance impact criterion at some nearby locations in all subsections. Even though the HSR train speeds would be slightly higher than conventional-speed commuter rail such as Caltrain in the RSA, the ground-borne vibration levels are often comparable or lower, likely because of the relatively low input forces from the HSR trains (the force density level).[12] To operate trains at high speeds, the rails and wheels typically have to be in very good condition, resulting in lower vibration levels relative to train speed on conventional passenger trains.

There are four short existing tunnel sections in the San Francisco to South San Francisco Subsection. Ground-borne noise was assessed from the project alternatives in these tunnel sections. Volume 2, Appendix 3.4-A provides more details.

CEQA Conclusion

The impact under CEQA would be significant for both project alternatives because operations would generate excessive ground-borne vibration and ground-borne noise impacts at sensitive receptors that exceed the FRA criteria of 72 VdB for residential use, 65 VdB for lab facilities and 75 VdB for institutional use; ground-borne noise criteria are 35 dBA for residences and 40 dBA for institutions. Alternative A would result in 2,493 ground-borne vibration impacts and 18 ground-borne noise impacts. Alternative B (Viaduct to I-880) would result in 2,307 ground-borne vibration impacts and 18 ground-borne noise impacts. Alternative B (Viaduct to Scott Boulevard) would result in 2,366 ground-borne vibration impacts and 18 ground-borne noise impacts. These impacts would be spread over all five subsections, with approximately half of the impacts occurring in the San Mateo to Palo Alto Subsection. The mitigation measure to address this impact is identified in Section 3.4.9. Section 3.4.7 describes the measure in detail.

3.4.7 Mitigation Measures

Significant impacts under CEQA would be associated with project construction and operation activities, including noise impacts from construction activity, noise impacts from project operations, noise impacts from increased project-related vehicle traffic, exposure of buildings and sensitive receptors to vibration impacts from construction, and exposure of buildings and sensitive receptors to increased vibration levels from HSR operations. The Authority has developed standardized mitigation measures that would be implemented to address impacts from noise and vibration generated by construction and operation of the project alternatives. As described in this section, the construction noise and vibration mitigation measures would reduce impacts on sensitive receptors but would not completely avoid impacts. The operational measures would minimize operations impacts on sensitive receptors, but would not completely avoid impacts.

NV-MM#1: Construction Noise Mitigation Measures

Prior to construction (any ground-disturbing activities), the contractor would prepare a noise monitoring program for Authority approval. The noise monitoring program would describe how during construction the contractor would monitor construction noise to reduce noise levels to the noise limits (an 8-hour L_{eq}, dBA of 80 during the day and 70 at night for residential land use, 85 for both day and night for commercial land use, and 90 for both day and night for industrial land use) where a noise-sensitive receptor is present and wherever feasible. The contractor would be given the flexibility to reduce noise in the most efficient and cost-effective manner. This can be done by prohibiting certain noise-generating activities during nighttime hours or providing additional noise control measures to meet the noise limits. In addition, the noise monitoring program would describe the actions required of the contractor to meet required noise limits. These actions would include the following nighttime and daytime noise control mitigation measures, as necessary, and as feasible within the constraints of working in an active rail corridor:

- Install a temporary construction site noise barrier near a noise source.
- Avoid nighttime construction in residential neighborhoods.

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[12] The force density level is the vibration excitation force transmitted by the train into the rails, track, and ground.

- Locate stationary construction equipment as far as possible from noise-sensitive sites.
- Reroute construction truck traffic along roadways that would cause the least disturbance to residents.
- During nighttime work, use smart back-up alarms, which automatically adjust the alarm level based on the background noise level, use broadband alarms, or switch off back-up alarms and replace with spotters.
- Use low-noise emission equipment.
- Implement noise-deadening measures for truck loading and operations.
- Monitor and maintain equipment to meet noise limits.
- Line or cover storage bins, conveyors, and chutes with sound-deadening material.
- Use acoustic enclosures, shields, or shrouds for equipment and facilities.
- Use high-grade engine exhaust silencers and engine-casing sound insulation.
- Prohibit aboveground jackhammering and impact pile driving during nighttime hours.
- Minimize the use of generators to power equipment.
- Limit use of public address systems.
- Grade surface irregularities on construction sites.
- Use moveable noise barriers at the source of the construction activity.
- Limit or avoid certain noisy activities during nighttime hours.
- To mitigate noise related to pile driving, use an auger to install the piles instead of an impact or vibratory pile driver would reduce noise levels substantially. If pile driving is necessary, limit the time of day that the activity can occur.
- The Authority would establish and maintain in operation until completion of construction a toll-free "hotline" regarding the project construction activities. The Authority would arrange for all incoming messages to be logged (with summaries of the contents of each message) and for a designated representative of the Authority to respond to hotline messages within 24 hours (excluding weekends and holidays). The Authority would make a reasonable good-faith effort to address all concerns and answer all questions, and would include on the log its responses to all callers. The Authority would make a log of the incoming messages and the Authority's responsive actions publicly available via request on its website.

The contractor would provide the Authority with an annual report by January 31st of the following year documenting how it implemented the noise-monitoring program.

This measure would have limited to no secondary environmental impacts because the temporary measures are limited to the construction zone itself and would not exacerbate any other environmental effects of construction. Temporary noise barriers would temporarily change visual aesthetics, but in addition to shielding receptors from noise, would also partially shield views of construction, which would not be an adverse aesthetic impact.

NV-MM#2: Construction Vibration Mitigation Measures

Prior to construction involving impact pile driving within 50 feet of any building the contractor would provide the Authority with a vibration technical memorandum documenting how project pile driving criteria would be met. Upon approval of the technical memorandum by the Authority, and where a vibration-sensitive receptor is present, the contractor would comply with the vibration reduction methods described in that memorandum. Potential construction vibration building damage is only anticipated from impact pile driving at very close distances to buildings. If pile driving occurs more than 25 to 50 feet from buildings, or if alternative methods such as push piling or auger piling are used, damage from construction vibration is not expected to occur. When a construction scenario has been established, the contractor would conduct pre-construction surveys at locations within 50 feet of pile driving to document the existing condition of buildings in case damage is reported during or after construction. The contractor would arrange for the repair of damaged buildings or would pay compensation to the property owner.

This measure would have limited to no secondary environmental impacts because the temporary measures are limited to the construction zone itself and would not exacerbate any other environmental effects of construction.

NV-MM#3: Implement Proposed California High-Speed Rail Project Noise Mitigation Guidelines

Various options exist to address the potentially severe noise effects from HSR operations. The Authority has developed Noise and Vibration Mitigation Guidelines for the statewide HSR system that sets forth three categories of mitigation measures to reduce or offset severe noise impacts from HSR operations: noise barriers, sound insulation, and noise easements. The guidelines also set forth an implementation approach that considers multiple factors for determining the reasonableness of noise barriers as mitigation for severe noise impacts, including structural and seismic safety, cost, number of affected receptors, and effectiveness. Noise barrier mitigation would be designed to reduce the exterior noise level from HSR operations from severe to moderate, according to the provisions of the FRA noise and vibration manual (FRA 2012). The Noise and Vibration Mitigation Guidelines, included as Volume 2, Appendix 3.4-B, describe the mitigation measures and approach in further detail. Noise barriers, sound insulation, and noise easement measures are described below.

Noise Barriers

Prior to operation of the HSR, the Authority would install noise barriers where they can achieve between 5 and 15 dB of exterior noise reduction, depending on their height and location relative to the tracks. The primary requirements for an effective noise barrier are that the barrier must (1) be high enough and long enough to break the line-of-sight between the sound source and the receptor, (2) be of an impervious material with a minimum surface density of 4 pounds per square foot, and (3) not have any gaps or holes between the panels or at the bottom. Because many materials meet these requirements, aesthetics, durability, cost, and maintenance considerations usually determine the selection of materials for noise barriers.

Depending on the situation, noise barriers can become visually intrusive. Typically, the noise barrier style would be selected with input from the local jurisdiction to reduce the visual effect of barriers on adjacent lands uses, refer to *Aesthetic Options for Non-Station Structures* (Authority 2017). For example, noise barriers could be solid or transparent, and made of various colors, materials, and surface treatments.

Pursuant to the Authority’s Noise and Vibration Mitigation Guidelines, recommended noise barriers must meet the following criteria to be considered a reasonable and feasible mitigation measure:

- Achieve a minimum of 5 dB of noise reduction; which is then defined as a benefited receptor
- The minimum number of receptors should be at least 10
- The length should be at least 800 feet
- Must be cost-effective; defined as mitigation not exceeding $95,000 per benefited receptor

The maximum noise barrier height would be 14 feet for at-grade sections. Berm and berm/wall combinations are the preferred types of noise barriers where space and other environmental constraints permit. On aerial structures, the maximum noise barrier height would also be 14 feet, but barrier material would be limited by engineering weight restrictions for barriers on the structure. All noise barriers would be designed to be as low as possible to achieve a substantial noise reduction.

Noise barriers on both aerial structures and at-grade structures could consist of solid, semitransparent, or transparent materials as defined in *Aesthetic Options for Non-Station Structures* (Authority 2017). Figure 3.4-31 illustrates an example of a noise barrier that meets the Authority's typical requirements. Volume 2, Appendix 3.4-B, provides more details.

Source: Authority 2019b MAY 2019

Figure 3.4-31 Example of a Typical Noise Barrier

Install Building Sound Insulation

If noise barriers are not proposed for receptors with severe impacts, or if proposed noise barriers would not reduce exterior sound levels to below a severe impact level, the Authority would consider providing sound insulation as a potential additional mitigation measure on a case-by-case basis. Sound insulation of residences and institutional buildings to improve outdoor-to-indoor noise reduction is a mitigation measure that can be considered when the use of noise barriers is not feasible in providing a reasonable level (5 to 7 dBA) of noise reduction. Although this approach has no effect on noise in exterior areas, it may be the best choice for sites where noise barriers are not feasible or desirable and for buildings where indoor sensitivity is of most concern. Substantial improvements in building sound insulation (on the order of 5 to 10 dBA) can often be achieved by adding an extra layer of glazing to windows, by sealing holes in exterior surfaces that act as sound leaks, and by providing forced ventilation and air conditioning so that windows do not need to be opened.

Noise Easements

If a substantial noise reduction cannot be completed through installation of noise barriers or installing sound insulation, the Authority would consider acquiring a noise easement on properties with a severe impact on a case-by-case basis. An agreement between the Authority and the property owner can be established wherein the property owner releases the right to petition the Authority regarding the noise level and subsequent disruptions. This would take the form of an easement that would encompass the property boundaries to the right-of-way of the rail line. The Authority would consider this mitigation measure only in isolated cases where other mitigation is ineffective or infeasible.

Secondary Impacts of Implementing Noise Barriers and Sound Insulation

Noise barriers could have secondary impacts on visual aesthetics and require tree or vegetation removal. Depending on their design, height, and location, noise barriers can become visually intrusive, blocking views or creating places for unwanted graffiti. Within this Project Section, noise barriers would be installed within the fenced areas of the existing Caltrain right-of-way, which is often shielded from view by fencing or landscaping (described in Section 3.15, Aesthetics and Visual Quality). In accordance with Mitigation Measure AVQ-MM#6 as part of the final design and construction management plan, the Authority would work with local jurisdictions to develop the appropriate noise barrier style and treatments for visually sensitive areas, to reduce the visual effect of barriers on adjacent land uses. For example, noise barriers could be solid or transparent, made of various colors, materials, and surface treatments, screened with vegetation, or treated with surface coatings to facilitate cleaning and removal of graffiti.

The installation of noise barriers would not result in secondary impacts on wildlife movement, because noise barriers would be built within fenced areas of the existing Caltrain right-of-way. Noise barriers would not introduce new barriers to wildlife movement nor would they block culverts that currently facilitate wildlife movement. Similarly, there would be no secondary impacts on community cohesion, because noise barriers would be constructed within an existing transportation corridor and would not physically divide established communities or disrupt community circulation to the extent that community character or cohesion would be affected. The final design of noise barriers would take into consideration drainage requirements such that no secondary impacts on stormwater drainage would result.

Providing sound insulation would involve modest building retrofit activity similar to routine residential or commercial window modifications or insulation replacement and would not result in significant secondary effects.

NV-MM#4: Support Potential Implementation of Quiet Zones by Local Jurisdictions

Trains sound the warning horns approaching at-grade crossings because it is required by the FRA as a safety precaution (49 C.F.R. Parts 222 and 229). FRA does allow for the possibility of establishing horn-free quiet zones, which would eliminate the requirement for all trains to routinely sound their warning horns when approaching at-grade highway/rail crossings. Establishing quiet zones can only be legally undertaken by local jurisdictions; the Authority cannot legally establish or require a quiet zone. However, the Authority would assist local communities with this process through the installation of four-quadrant gates and channelization at all at-grade crossings without them presently on the Project Section, which would help cities to implement quiet zones, should they choose to do so. Establishing quiet zones would eliminate train warning horns for all trains approaching at-grade highway/rail crossings under normal, non-emergency situations.

NV-MM#5: Vehicle Noise Specification

During HSR vehicle technology procurement, the Authority would require bidders to meet the federal regulations (40 C.F.R. § 201.12/13) at the time of procurement for locomotives (currently a 90-dB-level standard) operating at speeds faster than 45 mph. This measure would have no secondary environmental impacts.

NV-MM#6: Special Trackwork at Crossovers, Turnouts, and Insulated Joints

Prior to construction, the contractor would provide the Authority with an HSR operation noise technical report for review and approval. The report would address the minimization/elimination of rail gaps at crossovers and turnouts. Because the impacts of HSR wheels over rail gaps at turnouts increases HSR noise by approximately 6 dB over typical operations, turnouts can be a major source of noise impact. If the turnouts cannot be moved from sensitive areas, the noise technical report would recommend the use of special types of trackwork that eliminate the gap. The Authority would require the project design to follow the recommendations in the approved noise technical report.

Special trackwork would occur within the construction footprint and would not require additional right-of-way. Trackwork would require additional construction equipment activity using equipment similar to that for proposed trackwork for the project and would result in similar construction period temporary aesthetic, air quality, and noise impacts.

NV-MM#7: Additional Noise Analysis during Final Design

Prior to construction, the contactor would provide the Authority with an HSR operation noise technical report for review and approval. If final design or final vehicle specifications result in changes to the assumptions underlying the noise technical report, the Authority would prepare necessary environmental documentation, as required by CEQA and NEPA, to reassess noise impacts and mitigation.

It would be premature to assess the specific potential secondary impacts of final design measures. However, measures adopted pursuant to this measure are likely to be similar to the other noise mitigation measures and thus likely result in similar secondary environmental impacts during their construction, and may be significant.

NV-MM#8: Project Vibration Mitigation Measures

Mitigation for operations vibration impacts can take place at the source, at the sensitive receptor, or along the propagation path from the source to the sensitive receptor. Measures could include those listed in Table 3.4-20.

Table 3.4-20 Vibration Mitigation Procedures and Descriptions

Mitigation Procedure	Location of Mitigation	Description
Location and design of special trackwork	Source	Careful review of crossover, turnout, and insulated joint locations during the preliminary engineering stage. When feasible, relocate special trackwork to a less vibration-sensitive area. Install spring frogs and other non-gap trackwork to eliminate gaps and help reduce vibration levels.
Vehicle suspension	Source	Employ rail vehicle with low unsprung weight, soft primary suspension, minimum metal-on-metal contact between moving parts of the truck, and smooth wheels that are perfectly round.
Special track support systems	Source	Use floating slabs, resiliently supported ties, high-resilience fasteners, and ballast mats to help reduce vibration levels from track support system.
Building modifications	Receptor	For existing buildings, if vibration-sensitive equipment is affected by train vibration, stiffen the floor upon which the vibration-sensitive equipment is located, isolate it from the remainder of the building, or both. For new buildings, support and effectively isolate the building foundation with vibration-isolating components such as springs and elastomer pads.
Buffer zones	Receptor	Negotiate a vibration easement from the affected property owners or expand rail right-of-way.

It would be premature to assess the specific potential secondary impacts of vibration measures at this time. However, special trackwork, building modifications, or other effective measures adopted pursuant to this measure are likely to be similar to the other noise mitigation measures and thus likely result in similar secondary environmental impacts during their construction, and may be significant.

3.4.7.1 Noise Mitigation Analysis

The Authority has provided guidance regarding the implementation of noise barrier mitigation measures in Volume 2, Appendix 3.4-B. The Authority used this guidance to conduct a noise mitigation analysis to evaluate the use of noise barriers as specified in NV-MM#3 and the potential effectiveness of horn-free quiet zones that may be adopted by local jurisdictions in combination with noise barrier mitigation as specified in NV-MM#4.

The noise mitigation analysis has been conducted for two scenarios. The first mitigation scenario applies NV-MM#3 and noise barriers only as mitigation, with all trains continuing to sound warning horns approaching at-grade crossings and passenger stations. The second mitigation scenario applies both NV-MM#3 (installing noise barriers) and NV-MM#4 (installing four-quadrant gates and channelization for at-grade crossings) and assumes that quiet zones are established to eliminate horn noise at the at-grade crossings. Both of these noise mitigation scenarios are discussed below.

Noise Barriers

NV-MM#3 identifies noise barriers as a potential mitigation measure to avoid severe noise impacts from HSR operations. The Authority assessed the feasibility and cost-effectiveness of using noise barriers to mitigate severe impacts from operations of the project alternatives based on the following criteria listed in the Authority's Noise and Vibration Mitigation Guidelines (Volume 2, Appendix 3.4-B).

The Authority would examine alternatives to avoid, minimize, or mitigate severe noise impacts. If severe noise impacts cannot be avoided, then the Authority would take steps to reduce severe noise impacts substantially through mitigation measures that are reasonable, physically feasible, practical, and cost-effective. The minimum number of receptors should be at least 10, and the length of a noise barrier should be at least 800 feet. Barrier heights up to a maximum of 14 feet ATOR for at-grade and aerial structure sections would be considered. Mitigation options for areas that require barriers over 14 feet would be studied on a case-by-case basis. The community should approve of implementation of the recommended noise barriers (75 percent of all affected parties).

The cost for constructing a noise barrier along the at-grade portion of the alignment is estimated to be $70 per square foot, and the cost to build a noise barrier along the elevated portion of the alignment is $65 per square foot. The total cost of mitigation cannot exceed $95,000 per benefited receptor. This cost is determined by dividing the total cost of the mitigation measure by the number of noise-sensitive buildings that receive a substantial (i.e., 5 dBA or greater) outdoor noise reduction. This calculation would generally limit the use of mitigation by barriers in areas that have few or isolated residential buildings. If the density of residential dwellings is insufficient to make the measure cost-effective, then other noise abatement measures, such as sound insulation, would be considered on a case-by-case basis. If sound insulation is identified as an alternative mitigation measure, the treatment must provide a substantial increase in noise reduction (i.e., 5 dBA or greater) between the outside and inside noise levels for interior habitable rooms. Receptors that receive at least a 5 dBA noise reduction from a noise barrier are described as benefited receptors.

Following these noise barrier guidelines, a noise barrier analysis was conducted for both project alternatives to evaluate the effects of noise barriers. Table 3.4-21 shows the proposed noise barriers found to be acoustically feasible and cost-effective for Alternatives A and B.

North of Scott Boulevard in Santa Clara, all but one of the proposed noise barriers are the same for both alternatives. Proposed barrier number 17 would need to be a different length for Alternatives A and B. In the San Jose Diridon Station Approach Subsection, five noise barriers were found to be acoustically feasible and cost-effective for Alternative A. Under Alternative B (Viaduct to I-880), two noise barriers were found to be acoustically feasible and cost-effective. No potential noise barriers were found to be acoustically feasible and cost-effective in the San Jose Diridon Station Approach Subsection under Alternative B (Viaduct to Scott Boulevard).

The table includes the approximate start and end locations of the barriers, the length, height, area, and side of track. The table shows the number of severe and moderate noise-affected receptors that would benefit with each barrier (i.e., the number of buildings, not dwelling units). The table also shows the number of residual noise impacts (the number of buildings, not dwelling units) that would remain, even though they would be behind the proposed noise barriers.

Potential noise barriers are not recommended at existing Caltrain passenger stations because they could restrict access. It may be possible to consider noise barriers as a mitigation measure for residual noise impacts at passenger stations during final design, depending on design specifics and coordination with Caltrain. The extents and heights of potential noise barriers included herein are approximate based on information currently available.

The Authority found 61 potential noise barriers to be cost-effective for Alternative A, 58 potential noise barriers to be cost-effective for Alternative B (Viaduct to I-880), and 56 potential noise barriers to be cost-effective for Alternative B (Viaduct to Scott Boulevard). The proposed noise barriers under Alternative A would benefit 1,253 severe impacts and 1,854 moderate impacts. The proposed noise barriers under Alternative B (Viaduct to I-880) would benefit 1,171 severe impacts and 1,953 moderate impacts. The proposed noise barriers under Alternative B (Viaduct to Scott Boulevard) would benefit 1,154 severe impacts and 1,848 moderate impacts. The proposed noise barriers would be in the San Bruno to San Mateo, San Mateo to Palo Alto, Mountain View to Santa Clara, and San Jose Diridon Station Approach Subsections. The proposed barrier heights would range from 6 to 12 feet ATOR.

Figure 3.4-32 through Figure 3.4-43 illustrate the approximate locations of the potential noise barriers for Alternatives A and B. Figure 3.4-32 through Figure 3.4-36 illustrate Alternative A noise barriers. Figure 3.4-37 through Figure 3.4-43 illustrate Alternative B noise barriers. Figures illustrating where noise barriers are different between Alternative B (Viaduct to I-880) and Alternative B (Viaduct to Scott Boulevard) are noted. Noise barriers are indicated in aqua, and noise barrier labels are included and shown on the side of the alignment where they are located. These figures also illustrate the residual noise-affected receptors that would remain with the potential noise barriers.

Table 3.4-21 Proposed Noise Barriers without Quiet Zones—Alternatives A and B

Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
#1	San Francisco & Brisbane	0357+70	0373+25	1,555	12	18,660	SB	4	1	0
#2	South SF & San Bruno	0650+25	0664+25	1,400	11	15,400	SB	17	1	0
#3	Millbrae	0764+95	0777+50	1,255	9	11,295	SB	20	23	0
#4	Millbrae	0779+20	0795+00	1,580	9	14,220	NB	26	21	0
#5	Millbrae	0791+45	0806+80	1,535	10	15,350	SB	28	35	0
#6	Millbrae	0799+40	0817+55	1,815	8	14,520	NB	25	25	0
#7	Millbrae	0807+25	0817+95	1,070	8	8,560	SB	15	0	0
#8	Burlingame	0906+40	0920+70	1,430	10	14,300	NB	10	0	0
#9	Burlingame	0912+45	0945+60	3,315	12	39,780	SB	8	116	0
#10	Burlingame	0920+70	0945+55	2,485	9	22,365	NB	61	50	0
#11	Burlingame	0947+10	0961+10	1,400	10	14,000	SB	11	23	0
#12	San Mateo	0986+75	0998+30	1,155	11	12,705	NB	12	18	0
#13	San Mateo	1007+70	1037+10	2,940	11	32,340	SB	45	79	0
#14	San Mateo	1007+70	1037+10	2,940	9	26,460	NB	48	106	0
#15	San Mateo	1058+95	1069+20	1,025	9	9,225	NB	10	13	0
#16	San Mateo	1071+05	1107+05	3,600	10	36,000	SB	51 (Alt A) 52 (Alt B)[3]	97 (Alt A) 93 (Alt B)[3]	0
#17 A[1]	San Mateo & Belmont	1214+30	1235+60	2,130	6	12,780	NB	8	26	0
#17 B[2]	San Mateo & Belmont	1214+30	1231+15	1,685	6	10,110	NB	5	27	0
#18	San Carlos	1308+20	1326+70	1,850	8	14,800	NB	12 (Alt A) 14 (Alt B)[3]	51 (Alt A) 49 (Alt B)[3]	0

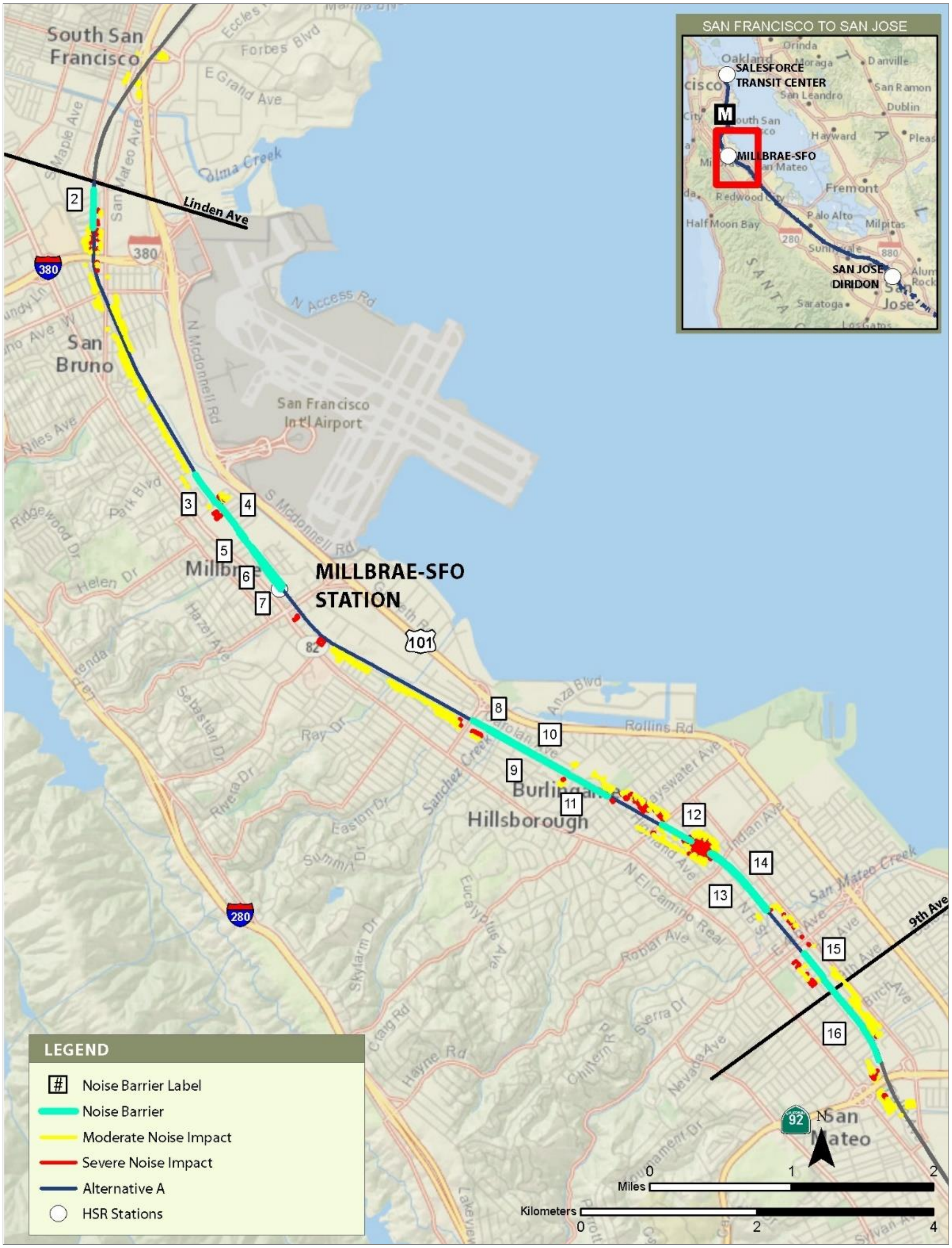
Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
#19	San Carlos & Redwood City	1396+40	1420+85	2,445	10	24,450	NB	15	58	0
#20	Redwood City	1423+20	1437+65	1,445	9	13,005	NB	17	30	0
#21	Redwood City	1459+95	1470+00	1,005	9	9,045	SB	5	0	0
#22	Redwood City	1484+00	1492+65	865	11	9,515	NB	8	16	0
#23	Redwood City	1511+65	1545+40	3,375	6	20,250	SB	69	66	0
#24	Redwood City	1520+60	1553+30	3,270	6	19,620	NB	37	73	0
#25	Atherton	1551+95	1573+50	2,155	10	21,550	SB	23	24	0
#26	Menlo Park	1591+25	1606+50	1,525	11	16,775	SB	48	51	0
#27	Menlo Park	1595+35	1606+50	1,115	11	12,265	NB	12	22	0
#28	Menlo Park	1608+00	1617+65	965	11	10,615	NB	15	22	0
#29	Menlo Park	1608+00	1617+65	965	10	9,650	SB	21	5	0
#30	Menlo Park	1619+30	1628+35	905	10	9,050	NB	15	16	0
#31	Menlo Park	1629+75	1638+85	910	9	8,190	NB	11	7	0
#32	Menlo Park & Palo Alto	1656+45	1680+00	2,355	11	25,905	NB	13	27	0
#33	Palo Alto	1681+60	1695+85	1,425	9	12,825	NB	13	16	0
#34	Palo Alto	1703+35	1721+25	1,790	8	14,320	SB	4	1	0
#35	Palo Alto	1721+75	1745+90	2,415	9	21,735	NB	31	56	0
#36	Palo Alto	1747+50	1782+75	3,525	9	31,725	NB	31	87	0
#37	Palo Alto	1747+50	1763+85	1,635	10	16,350	SB	22	22	0
#38	Palo Alto	1763+85	1782+75	1,890	8	15,120	SB	6	18	0
#39	Palo Alto	1811+45	1836+90	2,545	6	15,270	SB	28	52	0
#40	Palo Alto	1835+60	1850+90	1,530	12	18,360	SB	19	36	0

Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
#41	Palo Alto	1852+65	1868+25	1,560	12	18,720	SB	46	14	0
#42	Palo Alto	1852+65	1868+25	1,560	12	18,720	NB	33	36	0
#43	Palo Alto	1870+10	1887+65	1,755	11	19,305	NB	8	35	0
#44	Palo Alto & Mountain View	1870+10	1894+05	2,395	10	23,950	SB	20	51	0
#45	Mountain View	1894+05	1906+80	1,275	9	11,475	SB	2	3	0
#46	Mountain View	1944+85	1960+65	1,580	12	18,960	NB	6	34	0
#47	Mountain View	1952+85	1972+50	1,965	7	13,755	SB	5	20	0
#48	Mountain View	1993+10	2006+25	1,315	10	13,150	NB	15	13	0
#49	Mountain View	1993+10	2006+25	1,315	9	11,835	SB	7	3	0
#50	Sunnyvale	2132+85	2149+90	1,705	9	15,345	SB	9	43	0
#51	Sunnyvale	2147+50	2163+90	1,640	8	13,120	NB	29	53	0
#52	Sunnyvale	2165+45	2174+75	930	8	7,440	SB	2	0	0
#53	Sunnyvale	2199+20	2209+75	1,055	8	8,440	SB	3	0	0
#54	Sunnyvale	2210+60	2236+55	2,595	9	23,355	SB	4	9	0
#55	Sunnyvale & Santa Clara	2262+80	2319+50	5,670	10	56,700	SB	63	113	0
#56	Santa Clara	2345+55	2374+60	2,905	10	29,050	SB	28	36	0
SJ #1 A[4]	San Jose	2963+00	2973+00	1,000	9	9,000	SB	4	0	0
SJ #2 A[4]	San Jose	3105+00	3114+00	900	12	10,800	SB	23	0	0
SJ #3 A[4]	San Jose	3114+00	3120+00	600	10	6,000	SB	11	1	0/2
SJ #4 A[4]	San Jose	3120+00	3137+00	1,700	12	20,400	SB	41	0	0
SJ #5 A[4]	San Jose	3123+00	3138+00	1,500	12	18,000	NB	20	0	0

Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
SJ #1 B (I-880)[5]	San Jose	2261+00	2302+00	4,100	8	32,800	SB	13	98	0
SJ #2 B (I-880)[5]	San Jose	2351+00	2361+00	1,000	9	9,000	SB	4	7	0
Total—Alternative A								**1,253**	**1,854**	**0/2**
Total—Alternative B (Viaduct to I-880)								**1,171**	**1,953**	**0**
Total—Alternative B (Viaduct to Scott Boulevard)								**1,154**	**1,848**	**0**

I- = Interstate
NB = northbound
SB = southbound
[1] Proposed noise barrier #17A applies to Alternative A.
[2] Proposed noise barrier #17B applies to Alternative B.
[3] Noise barriers #16 and #18 are the same for both Alternatives A and B, but the number of impacts mitigated differs as noted.
[4] Proposed noise barriers SJ #1A through SJ #5A are located in the San Jose Diridon Station Approach Subsection and apply to Alternative A.
[5] Proposed noise barriers SJ #1B and SJ #2B are located in the San Jose Diridon Station Approach Subsection and apply only to Alternative B (Viaduct to I-880).

Figure 3.4-32 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative A (San Francisco to South San Francisco Subsection)

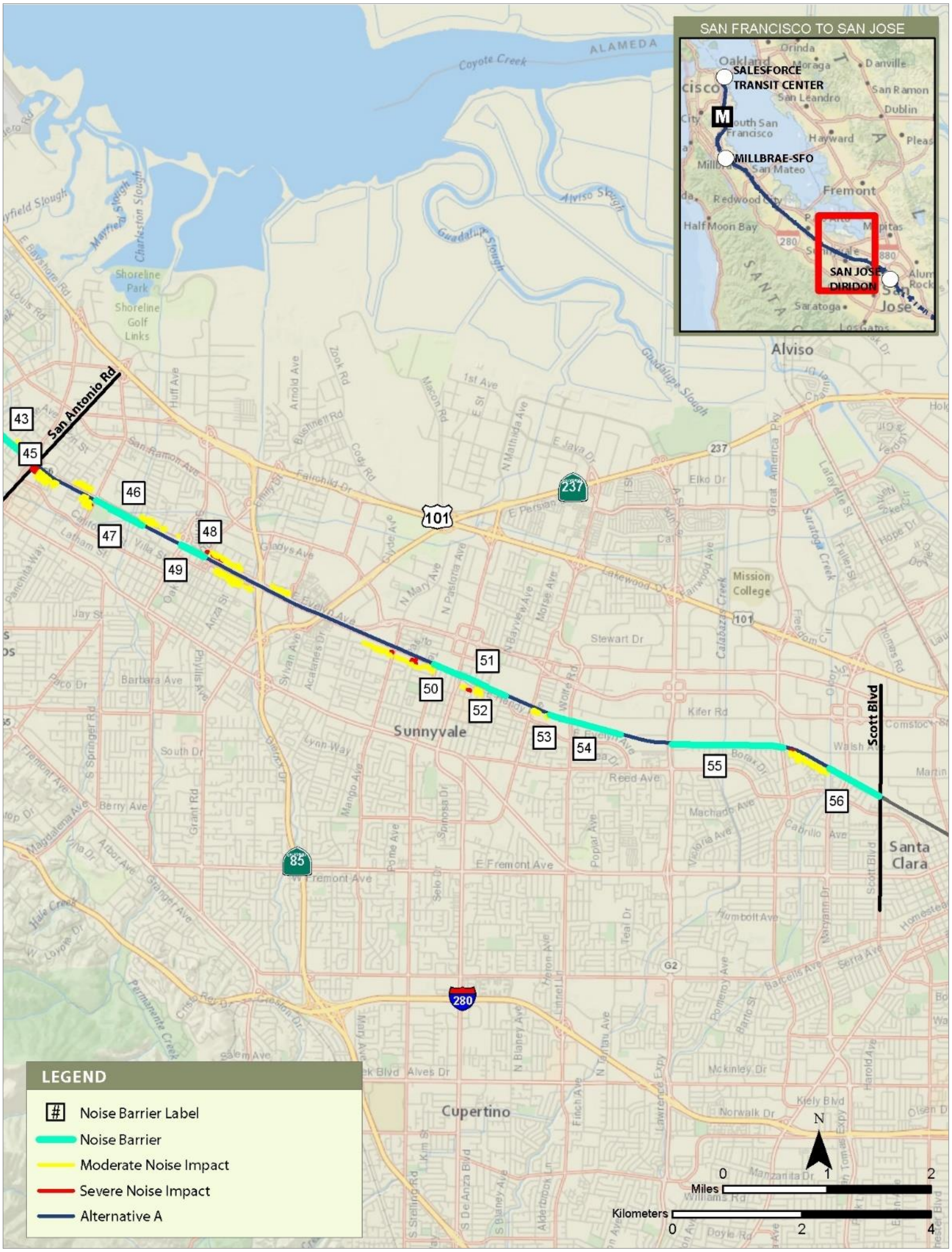


JUNE 2019

Figure 3.4-33 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative A (San Bruno to San Mateo Subsection)

JUNE 2019

Figure 3.4-34 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative A (San Mateo to Palo Alto Subsection)



JUNE 2019

Figure 3.4-35 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative A (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-36 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative A (San Jose Diridon Station Approach Subsection)

JUNE 2019

Figure 3.4-37 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (San Francisco to South San Francisco Subsection)

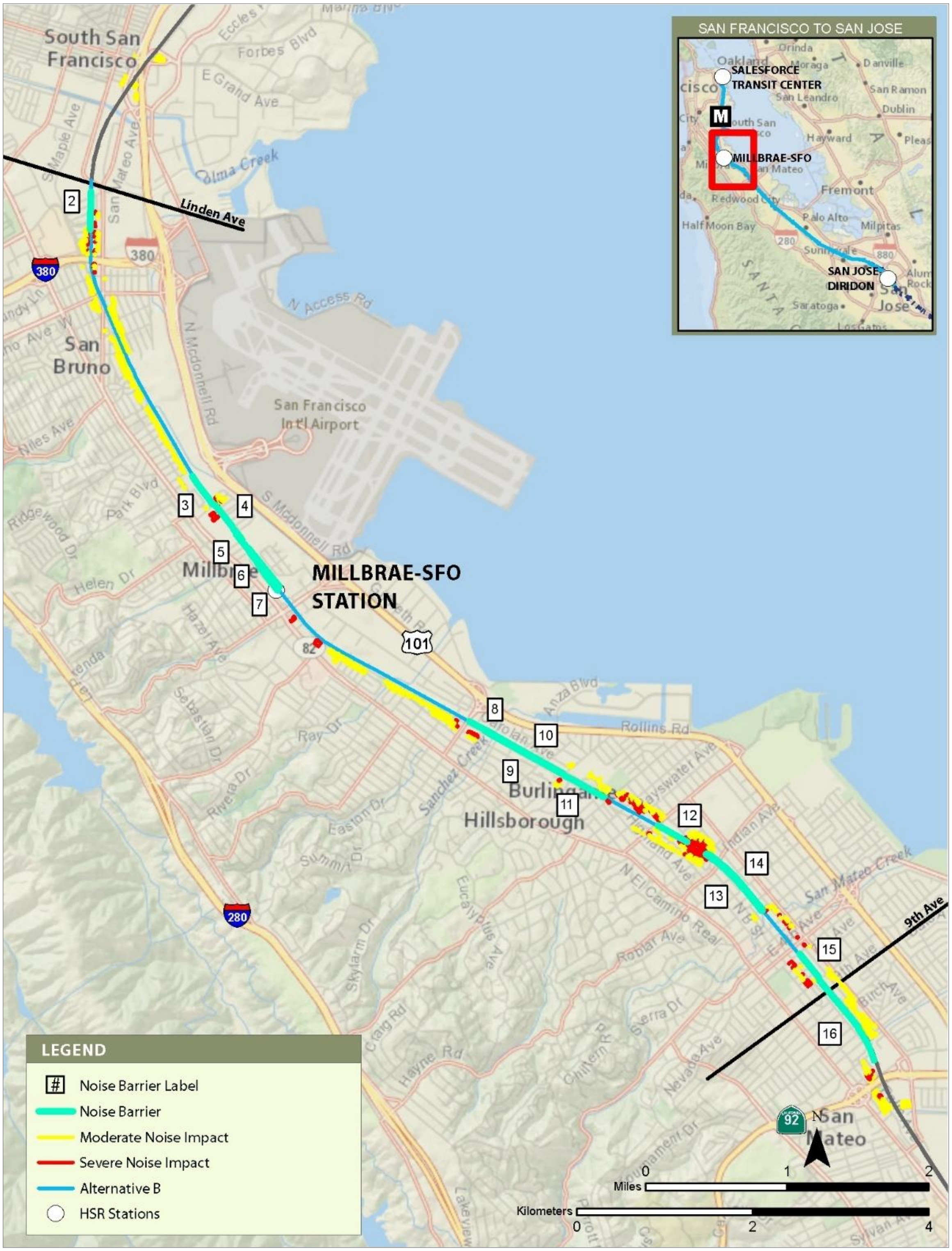


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Figure 3.4-38 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (San Bruno to San Mateo Subsection)

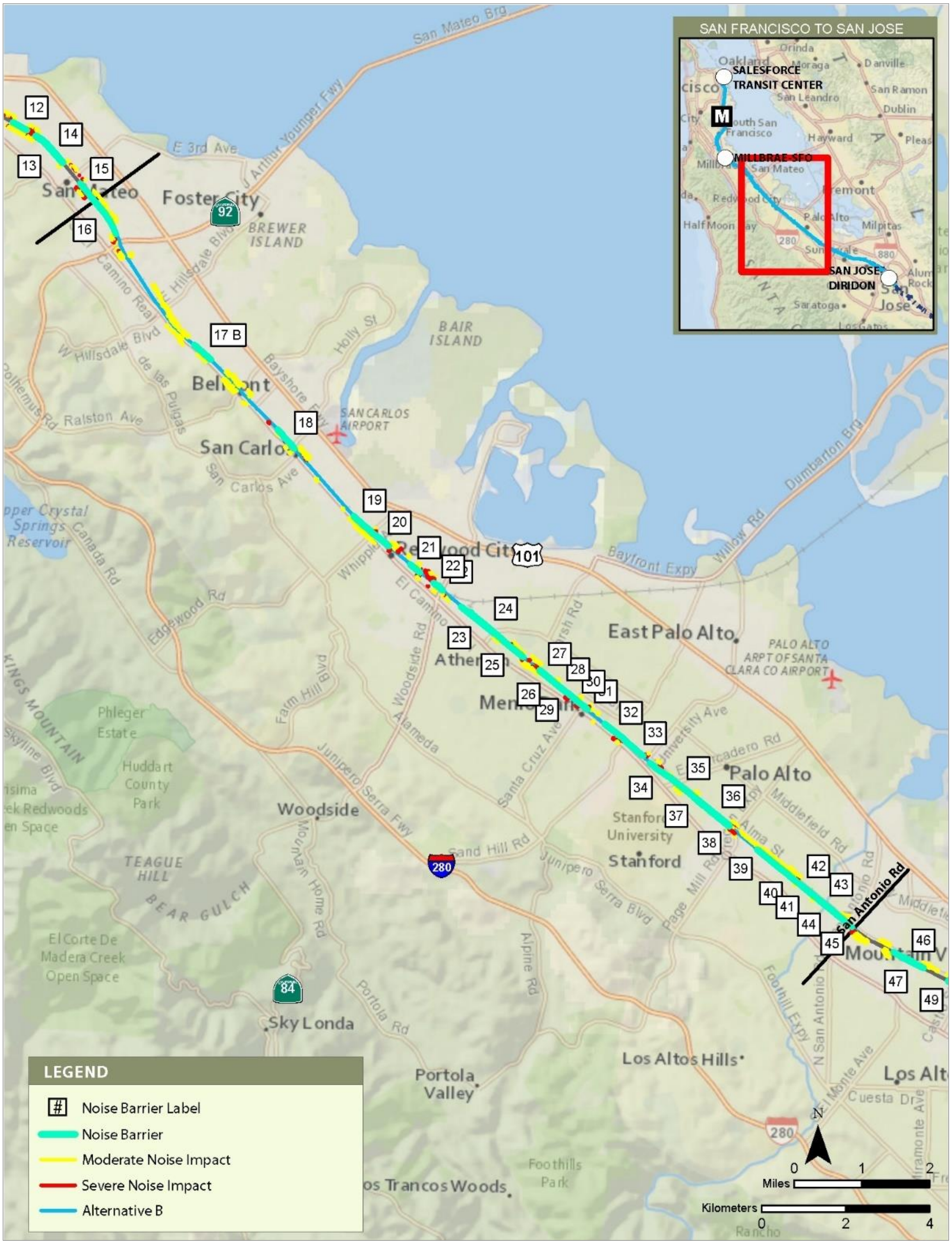

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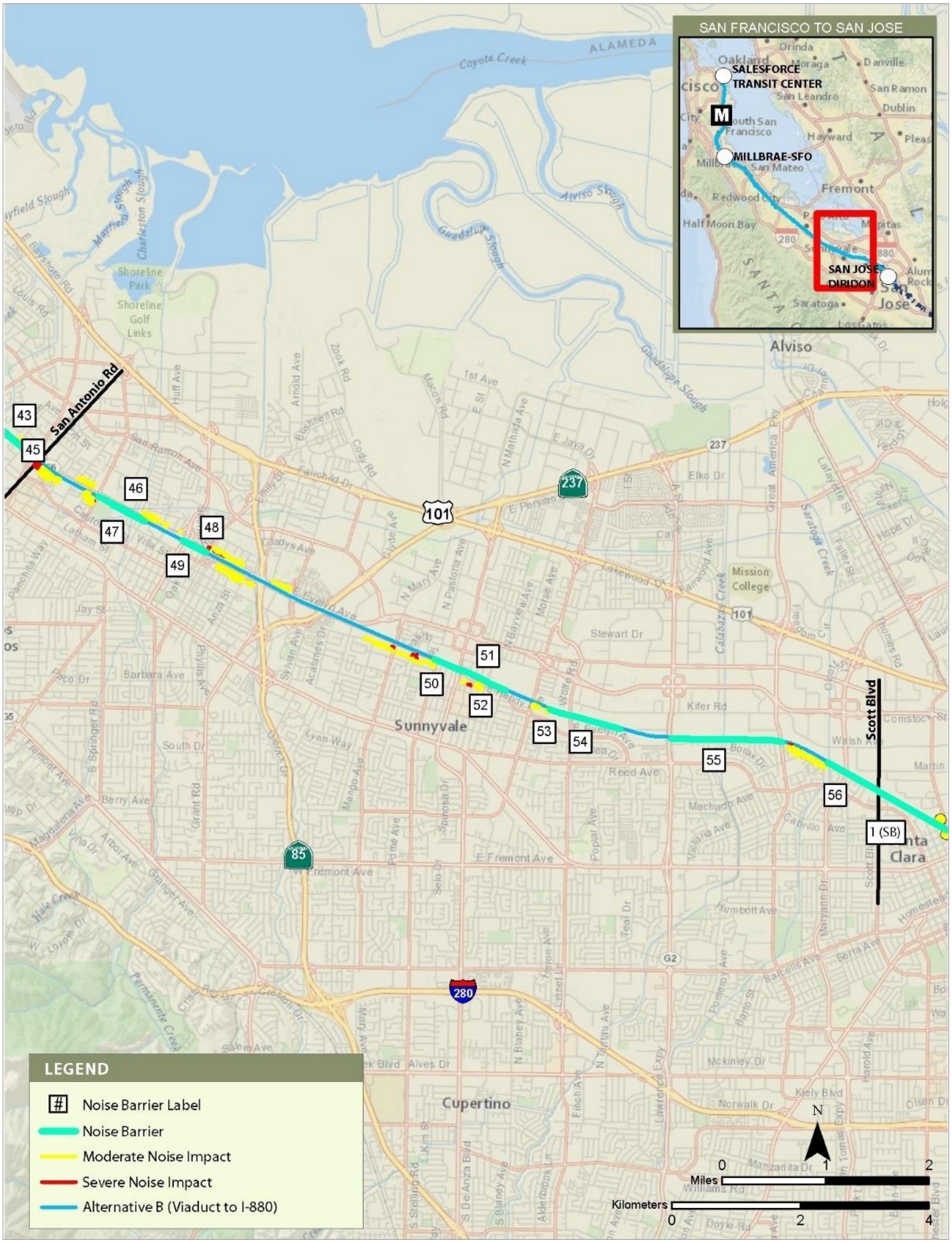
Figure 3.4-39 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (San Mateo to Palo Alto Subsection)

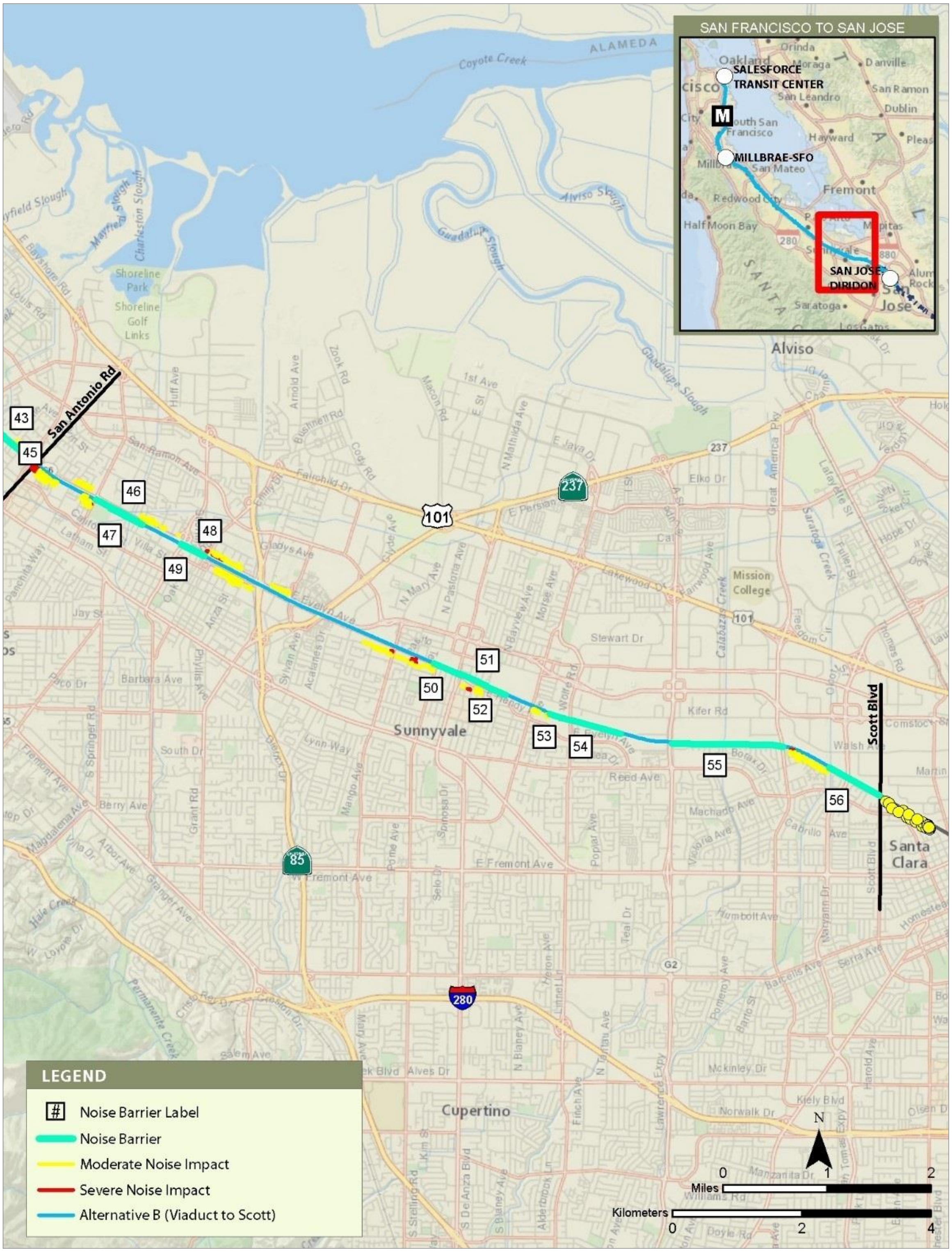


JUNE 2019

Figure 3.4-40 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (Viaduct to I-880) (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-41 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (Viaduct to I-880) (San Jose Diridon Station Approach Subsection)



JUNE 2019

Figure 3.4-42 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (Viaduct to Scott Boulevard) (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-43 Noise Barriers and Residual Noise Impacts without Quiet Zones—Alternative B (Viaduct to Scott Boulevard) (San Jose Diridon Station Approach Subsection)

Horn Noise

NV-MM#4 identifies quiet zones as a method to reduce horn noise in the corridor. Many of the projected noise impacts under both alternatives would occur because of train warning horn noise in the RSA. Caltrain, freight, and HSR trains all sound warning horns as they approach at-grade roadway crossings and passenger stations. Trains sound horns while approaching Caltrain stations following Caltrain operating policy. Trains sound the warning horns approaching at-grade crossings because it is required by the FRA as a safety precaution.

The FRA does allow for the possibility of establishing quiet zones, which would eliminate the requirement for all trains to routinely sound their warning horns when approaching at-grade highway/rail crossings. Establishing quiet zones is a measure that can only be undertaken by local communities per the FRA regulations. HSR cannot impose a quiet zone by its own initiative. The project includes the installation of four-quadrant gates at all at-grade crossings presently without them on the Project Section, which would help cities to implement quiet zones, should they choose to do so.

A noise analysis was conducted for both project alternatives to examine the use of quiet zones in the RSA in conjunction with noise barriers. The Authority evaluated the benefit of eliminating train horn noise for all trains approaching at-grade crossings and then analyzed potential noise barriers. This analysis assumed that all trains would continue to sound warning horns approaching passenger stations consistent with Caltrain operating policy.

As shown in Table 3.4-22, with quiet zones, 25 potential noise barriers would be cost-effective for Alternative A, 26 potential noise barriers to be cost-effective for Alternative B (Viaduct to I-880), and 24 potential noise barriers to be cost-effective for Alternative B (Viaduct to Scott Boulevard). With quiet zones in place, the proposed noise barriers would mitigate an additional 478 severe impacts and 805 moderate impacts under Alternative A, 491 severe impacts and 905 moderate impacts under Alternative B (Viaduct to I-880), and 474 severe impacts and 800 moderate impacts under Alternative B (Viaduct to Scott Boulevard). The noise barriers would be in the San Bruno to San Mateo, San Mateo to Palo Alto, Mountain View to Santa Clara, and San Jose Diridon Station Approach Subsections. The barrier heights would range from 6 to 12 feet ATOR.

Figure 3.4-44 through Figure 3.4-55 illustrate the approximate locations of the potential noise barriers with quiet zones for Alternatives A and B. Figure 3.4-44 through Figure 3.4-48 illustrate Alternative A noise barriers. Figure 3.4-49 through Figure 3.4-55 illustrate Alternative B noise barriers. Figures illustrating where noise barriers are different between Alternative B (Viaduct to I-880) and Alternative B (Viaduct to Scott Boulevard) are noted. Noise barriers are indicated in aqua, and noise barrier labels are included and shown on the side of the alignment where they would be. These figures also illustrate the residual noise-affected receptors that would remain with the quiet zones and potential noise barriers.

Table 3.4-22 Proposed Noise Barriers with Quiet Zones—Alternatives A and B

Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
#1	San Francisco & Brisbane	0357+70	0373+25	1,555	12	18,660	SB	4	1	0
#Q5	Millbrae	0799+30	0806+80	750	7	5,250	SB	15	28	0
#6	Millbrae	0799+40	0817+55	1,815	8	14,520	NB	25	25	0
#7	Millbrae	0806+80	0817+95	1,115	8	8,920	SB	15	0	0
#8	Burlingame	0906+40	0920+70	1,430	10	14,300	NB	10	0	0
#Q13	San Mateo	1018+75	1037+10	1,835	9	16,515	SB	23	34	0
#Q14	San Mateo	1018+75	1037+10	1,835	9	16,515	NB	29	89	0
#Q16[3]	San Mateo	1082+30	1107+05	2,475	9	22,275	SB	26 (Alt A) 27 (Alt B)[3]	59 (Alt A) 55 (Alt B)[3]	0
#17 A[1]	San Mateo & Belmont	1214+30	1235+60	2,130	6	12,780	NB	8	26	0
#17 B[2]	San Mateo & Belmont	1214+30	1231+15	1,685	6	10,110	NB	5	27	0
#18[3]	San Carlos	1308+20	1326+70	1,850	8	14,800	NB	12 (Alt A) 14 (Alt B)[3]	51 (Alt A) 49 (Alt B)[3]	0
#23	Redwood City	1511+65	1545+40	3,375	6	20,250	SB	69	66	0
#24	Redwood City	1520+60	1553+30	3,270	6	19,620	NB	37	73	0
#25	Atherton	1551+95	1573+50	2,155	10	21,550	SB	23	24	0
#34	Palo Alto	1703+35	1721+25	1,790	8	14,320	SB	4	1	0
#38	Palo Alto	1763+85	1782+75	1,890	8	15,120	SB	26	18	0
#39	Palo Alto	1811+45	1840+05	2,860	6	17,160	SB	28	53	0
#45	Mountain View	1894+05	1906+80	1,275	9	11,475	SB	2	3	0
#50	Sunnyvale	2132+85	2149+90	1,705	9	15,345	SB	9	43	0

Barrier	City	Start Stationing	End Stationing	Length (feet)	Height (feet)	Noise Barrier Coverage (square feet)	Side of Track	Number of Severe Impacts Benefitted	Number of Moderate Impacts Benefitted	Number of Residual Impacts (Severe/ Moderate)
#51	Sunnyvale	2147+50	2163+90	1,640	8	13,120	NB	29	53	0
#52	Sunnyvale	2165+45	2174+75	930	8	7,440	SB	2	0	0
#53	Sunnyvale	2199+20	2209+75	1,055	8	8,440	SB	3	0	0
#54	Sunnyvale	2210+60	2236+55	2,595	9	23,355	SB	4	9	0
#55	Sunnyvale & Santa Clara	2262+80	2319+50	5,670	10	56,700	SB	63	113	0
#56	Santa Clara	2345+55	2374+60	2,905	10	29,050	SB	28	36	0
SJ #1 A[4]	San Jose	2963+00	2973+00	1,000	9	9,000	SB	4	0	0
SJ #1 B (I-880)[5]	San Jose	2261+00	2302+00	4,100	8	32,800	SB	13	98	0
SJ #2 B (I-880)[5]	San Jose	2351+00	2361+00	1,000	9	9,000	SB	4	7	0
Total – Alternative A								**478**	**805**	**0**
Total – Alternative B (Viaduct to I-880)								**491**	**905**	**0**
Total – Alternative B (Viaduct to Scott Boulevard)								**474**	**800**	**0**

NB = northbound
SB = southbound
[1] Proposed noise barrier #16 A applies to Alternative A.
[2] Proposed noise barrier #16 B applies to Alternative B.
[3] Noise barriers #15 and #17 are the same for Alternatives A and B, but the number of impacts mitigated differs as noted.
[4] Proposed noise barrier SJ #1A is located in the San Jose Diridon Station Approach Subsection and applies to Alternative A.
[5] Proposed noise barriers SJ #1B and SJ #2B are located in the San Jose Diridon Station Approach Subsection and apply only to Alternative B (Viaduct to I-880).

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Figure 3.4-44 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative A (San Francisco to South San Francisco Subsection)

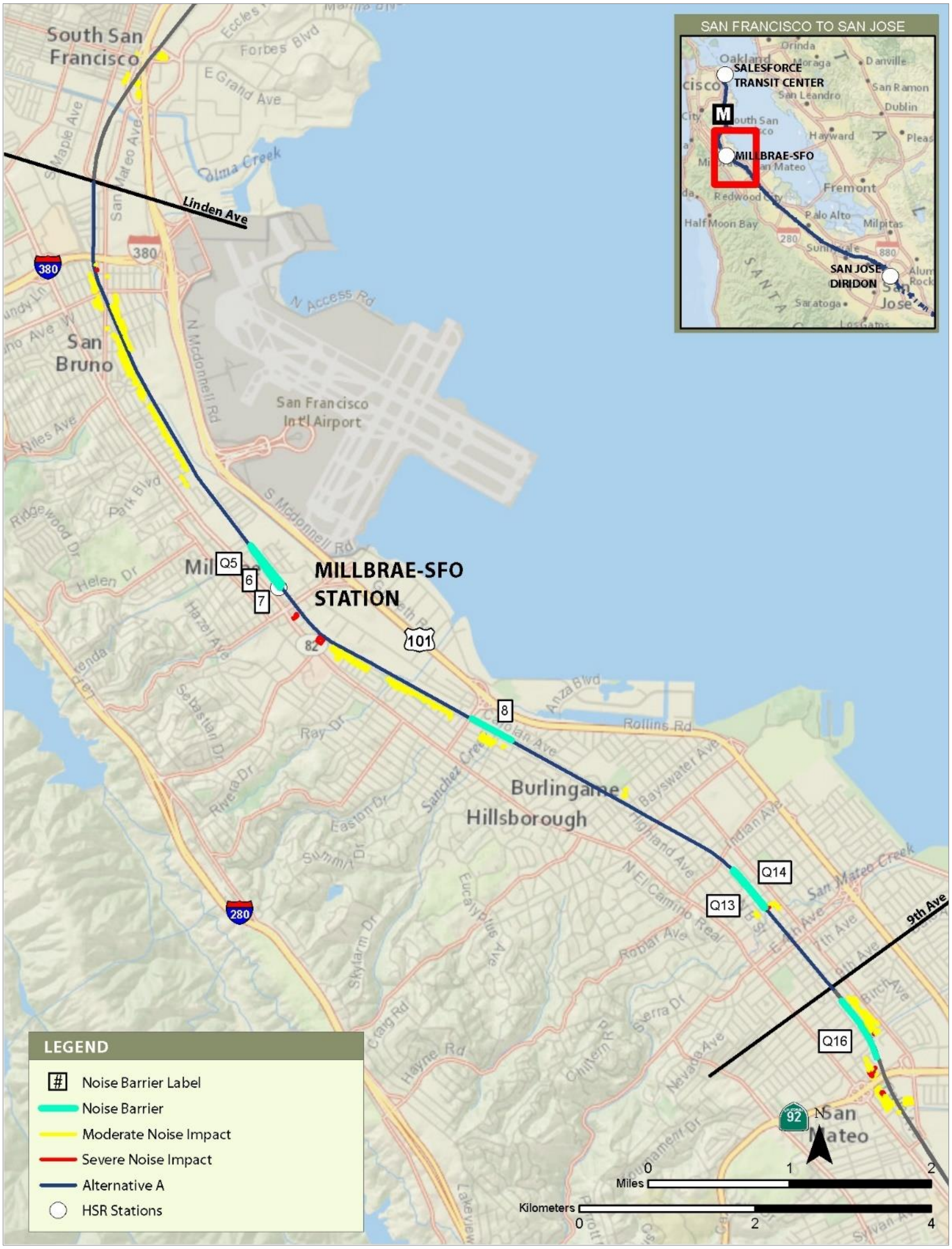

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Figure 3.4-45 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative A (San Bruno to San Mateo Subsection)

Figure 3.4-46 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative A (San Mateo to Palo Alto Subsection)

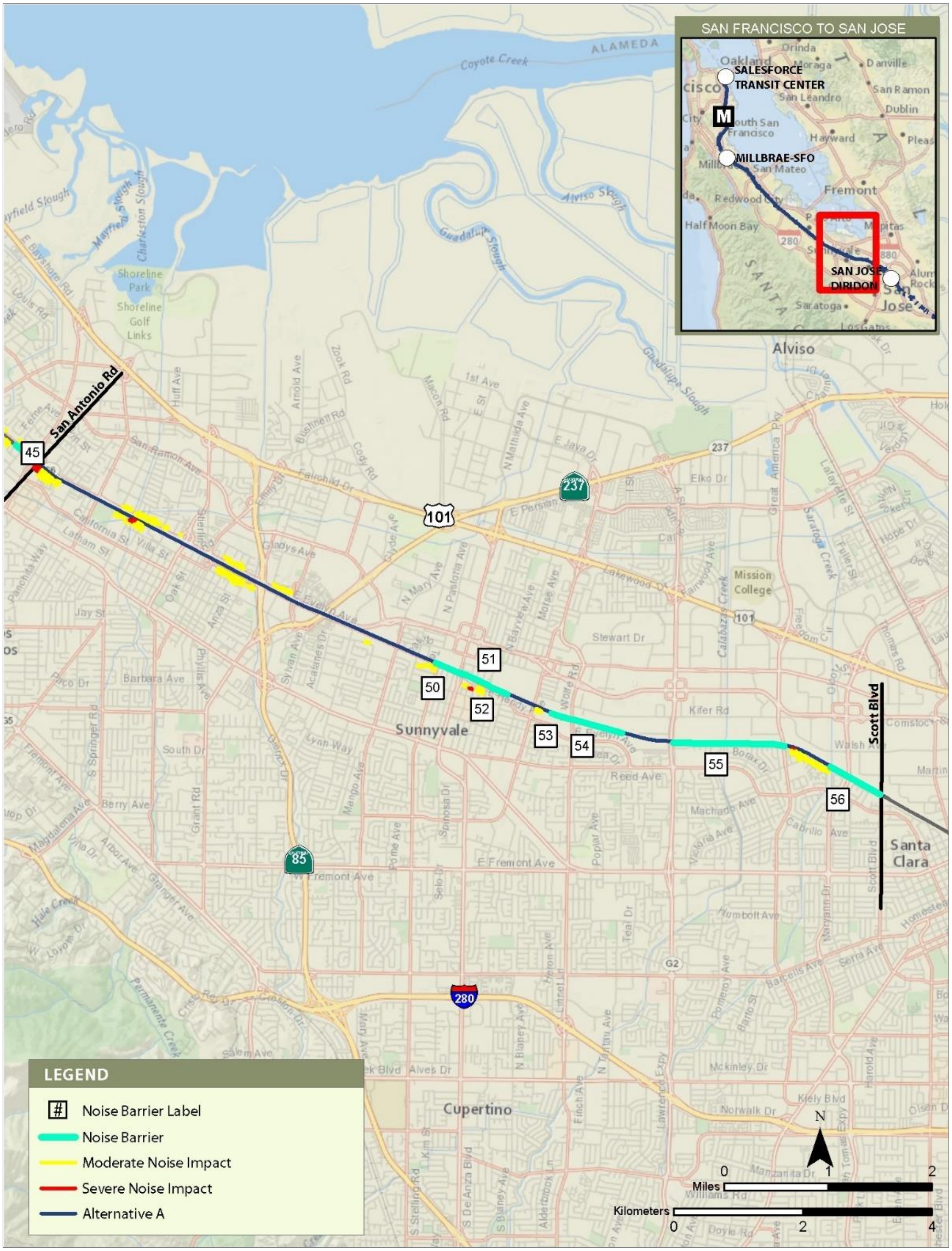

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Figure 3.4-47 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative A (Mountain View to Santa Clara Subsection)

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Figure 3.4-48 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative A (San Jose Diridon Station Approach Subsection)

Figure 3.4-49 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (San Francisco to South San Francisco Subsection)

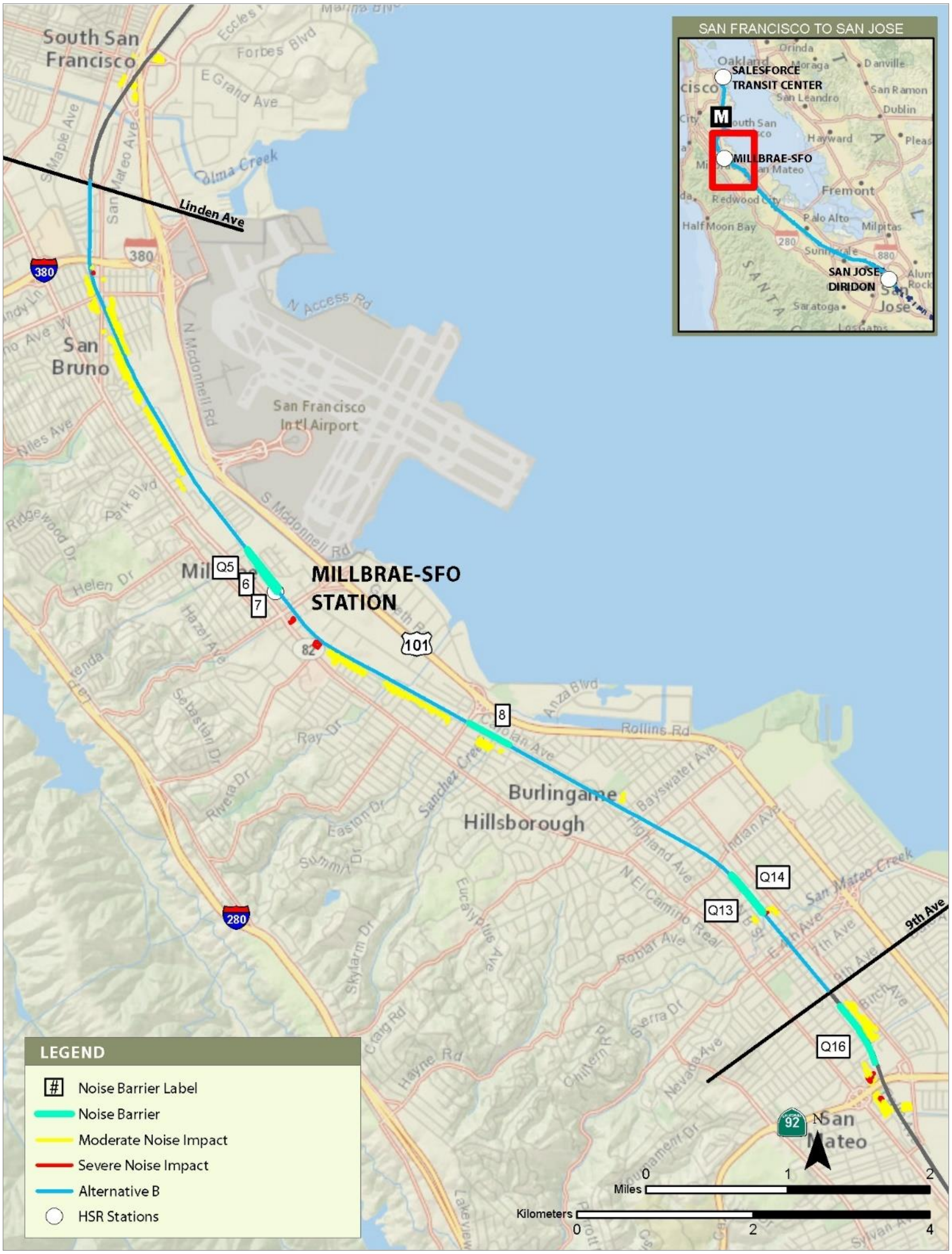

Figure 3.4-50 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (San Bruno to San Mateo Subsection)

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Figure 3.4-51 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (San Mateo to Palo Alto Subsection)

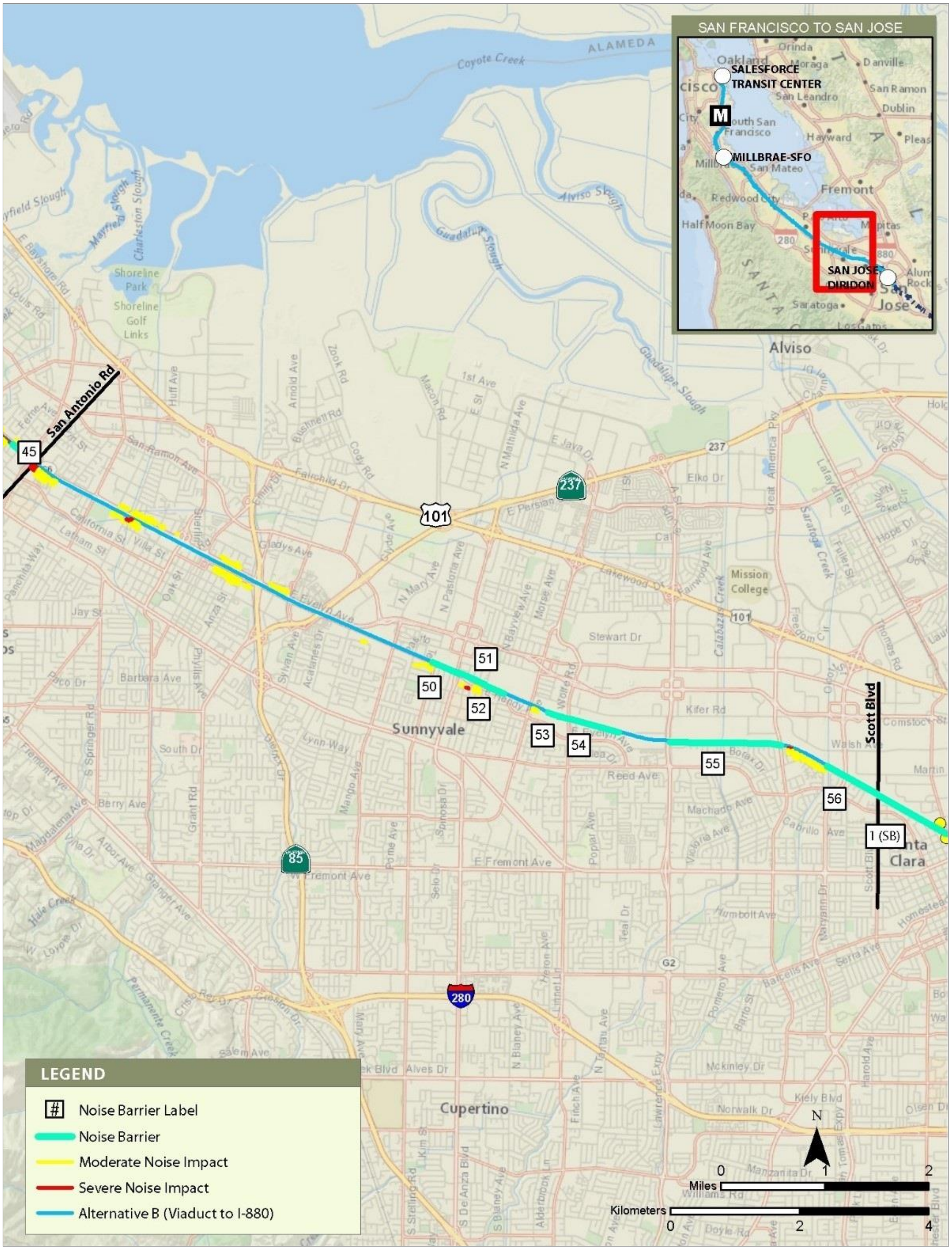

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Figure 3.4-52 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (Viaduct to I-880) (Mountain View to Santa Clara Subsection)

JUNE 2019

Figure 3.4-53 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (Viaduct to I-880) (San Jose Diridon Station Approach Subsection)

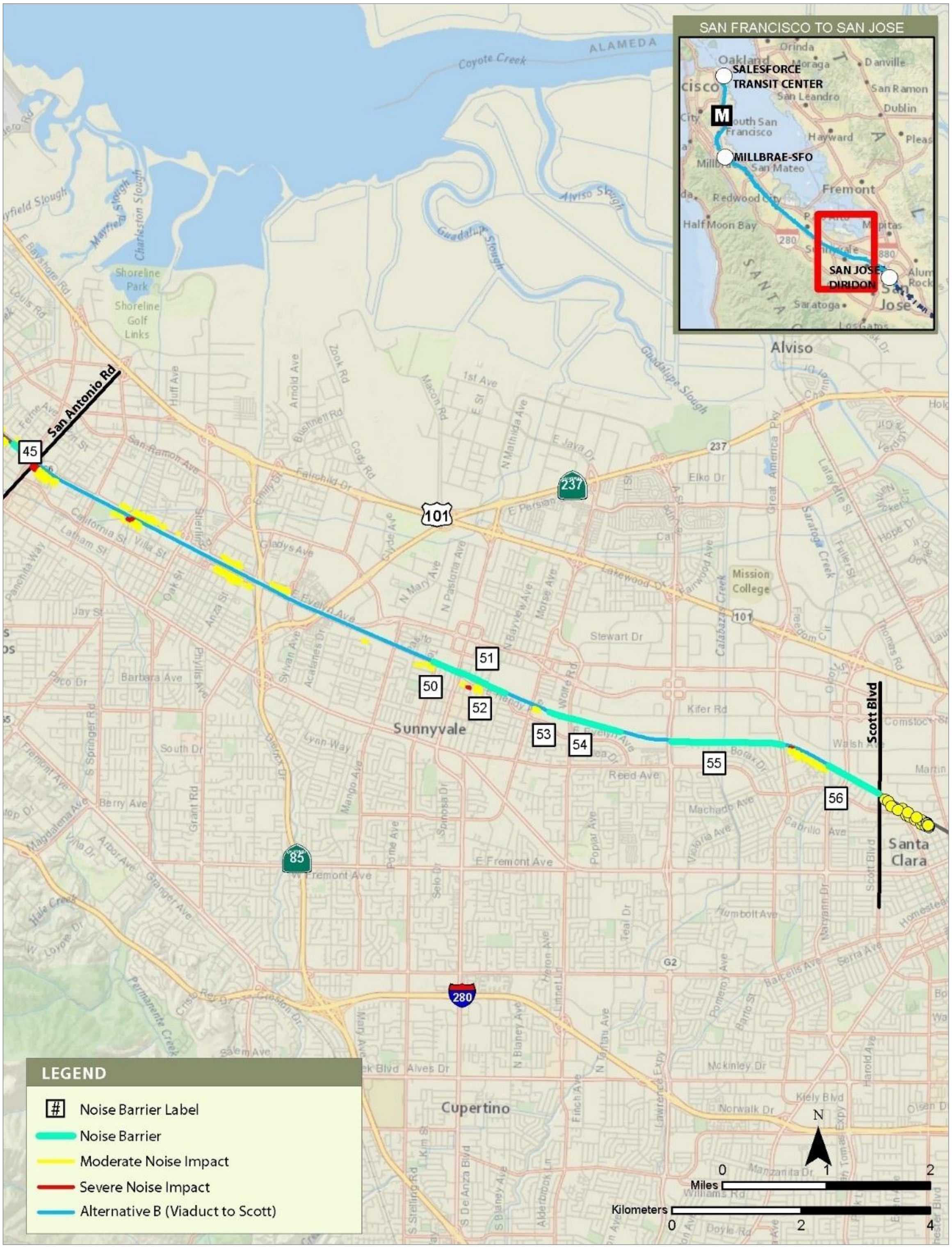

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Figure 3.4-54 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (Viaduct to Scott Boulevard) (Mountain View to Santa Clara Subsection)

Figure 3.4-55 Noise Barriers and Residual Noise Impacts with Quiet Zones—Alternative B (Viaduct to Scott Boulevard) (San Jose Diridon Station Approach Subsection)

Summary

Table 3.4-23 summarizes the results of the noise mitigation analysis for Alternative A for the year 2040 for three cases: noise impacts without mitigation, residual noise impacts with noise barriers, and residual noise impacts with quiet zones and noise barriers. The results are shown for each subsection. Under Alternative A, the total number of projected noise impacts without mitigation would be 6,054. With noise barriers as a mitigation measure, 3,183 noise impacts would be mitigated. With the implementation of quiet zones and noise barriers as mitigation measures, 3,707 noise impacts would be mitigated.

Table 3.4-23 Noise Mitigation Effectiveness—Alternative A

Subsection	Alternative A Moderate and Severe Noise Impacts					
	Noise Impacts Without Mitigation		Residual Noise Impacts With Noise Barriers		Residual Noise Impacts With Quiet Zones and Noise Barriers	
	Moderate	Severe	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco	186	173	185	169	176	166
San Bruno to San Mateo	1,079	497	555	144	351	5
San Mateo to Palo Alto	1,985	771	945	124	933	60
Mountain View to Santa Clara	824	193	482	21	417	9
San Jose Diridon Station Approach	222	124	222	24	216	14
Total[1]	**4,296**	**1,758**	**2,389**	**482**	**2,093**	**254**

[1] The total numbers of impacts shown as benefited in Table 3.4-21 are not the same as the difference between the numbers in this table with and without mitigation because, while mitigation would reduce noise effects, it might not eliminate them entirely. Thus a reduced impact may still qualify as a residual moderate or severe impact.

Table 3.4-24 summarizes the results of the noise mitigation analysis for Alternative B for the year 2040 for three cases: noise impacts without mitigation, residual noise impacts with noise barriers, and residual noise impacts with quiet zones and noise barriers. The results are shown for each subsection. Under Alternative B (Viaduct to I-880), the total number of projected noise impacts without mitigation would be 5,834. With noise barriers as a mitigation measure, 3,202 noise impacts would be mitigated. With the implementation of quiet zones and noise barriers as mitigation measures, 3,710 noise impacts would be mitigated. Under Alternative B (Viaduct to Scott Boulevard), the total number of projected noise impacts without mitigation would be 5,769. With noise barriers as a mitigation measure, 3,080 noise impacts would be mitigated. With the implementation of quiet zones and noise barriers as mitigation measures, 3,588 noise impacts would be mitigated.

Table 3.4-24 Noise Mitigation Effectiveness—Alternative B

Subsection	Alternative B Moderate and Severe Noise Impacts					
	Noise Impacts Without Mitigation		Residual Noise Impacts With Noise Barriers		Residual Noise Impacts With Quiet Zones Noise Barriers	
	Moderate	Severe	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco	187	168	186	164	177	161
San Bruno to San Mateo	1,079	497	555	144	351	5
San Mateo to Palo Alto	1,978	770	941	123	929	59

Subsection		Alternative B Moderate and Severe Noise Impacts					
		Noise Impacts Without Mitigation		Residual Noise Impacts With Noise Barriers		Residual Noise Impacts With Quiet Zones Noise Barriers	
		Moderate	Severe	Moderate	Severe	Moderate	Severe
Mountain View to Santa Clara		824	193	482	21	417	9
San Jose Diridon Station Approach	Viaduct to I-880	118	20	13	3	13	3
	Viaduct to Scott Boulevard	73	0	73	0	73	0
Total[1]	**Viaduct to I-880**	**4,186**	**1,648**	**2,177**	**455**	**1,887**	**237**
	Viaduct to Scott Boulevard	**4,141**	**1,628**	**2,237**	**452**	**1,947**	**234**

[1] The total numbers of impacts shown as benefited in Table 3.4-21 are not the same as the difference between the numbers in this table with and without mitigation because, while mitigation would reduce noise effects, it might not eliminate them entirely. Thus a reduced impact may still qualify as a residual moderate or severe impact.

3.4.7.2 Vibration Mitigation Analysis

Operations vibration impacts would be mitigated with NV-MM#8. This mitigation measure includes various options to reduce train vibration. The specific design and implementation of this mitigation measure would be identified during final design.

Because there are site-specific factors to consider, such as the speed, presence of special trackwork, soil type and vibration propagation characteristics, further studies during the subsequent engineering phases of the project should evaluate these site-specific conditions where vibration mitigation is indicated to determine the mitigation design requirements. Such studies would include additional vibration propagation tests to narrow down the site-specific vibration estimates, and engineering evaluation of the special track support options. Vibration impacts less than 10 dB over the thresholds would be reduced to less-than-significant levels with mitigation. It may not be possible to fully mitigate vibration impacts that are more than 10 dB over the threshold; as a result, some vibration impacts would be potentially significant and unavoidable with mitigation.

3.4.8 Impact Summary for NEPA Comparison of Alternatives

As described in Section 3.1.5.4, the impacts of project actions under NEPA are compared to the No Project Alternative when evaluating the impact of the project alternatives on the resource. The determination of impact is based on the context and intensity of the change that would be generated by construction and operation of the project. Table 3.4-25 compares the project impacts by alternative, followed by a summary of the impacts.

Table 3.4-25 Comparison of Project Alternative Impacts for Noise and Vibration

	Alternative A	Alternative B
Noise		
Impact NV#1: Temporary Exposure of Sensitive Receptors to Construction Noise	Temporary noise impacts at noise-sensitive locations would exceed the residential nighttime 8-hour L_{eq} criterion of 70 dBA for typical track construction activities up to 500 feet from excavation work, 792 feet from earthwork and retaining wall work, and as far as 706 feet from at-grade track construction. For stations and ancillary structures, excavation and foundation work would generate temporary nighttime impacts at residential areas out to 446 feet for non-pile-driving work; impacts from pile driving would extend out to 706 feet. Superstructure, building shell and landscaping work would cause impacts out to 354 feet.	Temporary noise impacts at noise-sensitive locations would be similar to Alternative A with exception of the passing track area, where construction would require more and longer durations of nighttime construction activity near noise-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City. The duration of construction would also be greater in the San Jose Diridon Station Approach Subsection, where viaduct structures and an aerial station would be built for Alternative B. Temporary noise impacts at noise-sensitive locations would exceed the residential nighttime 8-hour L_{eq} criterion of 70 dBA for typical track construction activities up to 774 feet for viaduct construction.
Impact NV#2: Intermittent Permanent Exposure of Sensitive Receptors to Noise from Operations	Permanent noise impacts from 2029 Plus Project condition at 4th and King Street Station and approach: ▪ none Permanent noise impacts from 2040 Plus Project condition: ▪ 4,296 moderate noise impacts ▪ 1,758 severe noise impacts	Permanent noise impacts from 2029 Plus Project condition at 4th and King Street Station and approach: ▪ none Permanent noise impacts from 2040 Plus Project condition: Viaduct to I-880: ▪ 4,186 moderate noise impacts ▪ 1,648 severe noise impacts Viaduct to Scott Boulevard: ▪ 4,141 moderate noise impacts ▪ 1,628 severe noise impacts
Impact NV#3: Intermittent Permanent Exposure of Sensitive Receptors to Noise from HSR Passenger Station Parking	Noise contribution from parking facilities: ▪ No new parking at 4th and King Street Station ▪ 37 dBA L_{dn} at the Millbrae Station ▪ 29 dBA L_{dn} at the San Jose Diridon Station This additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.	Same as Alternative A

	Alternative A	Alternative B
Impact NV#4: Intermittent Permanent Exposure of Sensitive Receptors to Noise from the Brisbane Light Maintenance Facility	Noise contribution from LMF: ▪ 36 dBA L_{dn} contribution from train movements at the East Brisbane LMF This additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.	Noise contribution from LMF: ▪ 40 dBA L_{dn} contribution from train movements at the West Brisbane LMF This additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.
Impact NV#5: Intermittent Permanent Human Annoyance from Onset of Passing HSR Trains	Advance warnings of trains would be provided at stations and at-grade crossings to avoid startling receptors. No sensitive receptors outside of these areas were identified within the distance where rapid onset noise exposure would exceed the FTA threshold.	Same as Alternative A
Impact NV#6: Permanent Exposure of Sensitive Receptors to Vehicular Traffic Noise Increases	Roadway segments with an anticipated increase in traffic noise of ≥3 dB compared to existing conditions include: 2029 Plus Project conditions at 4th and King Street Station and approach: ▪ 2 segments near 4th and King Street Station 2040 Plus Project conditions: ▪ 4 segments near Diridon Station	Similar to Alternative A 2029 Plus Project conditions at 4th and King Street Station and approach: ▪ 2 segments near 4th and King Street Station 2040 Plus Project conditions: ▪ 5 segments near Diridon Station
Impact NV#7: Traction Power Facility Noise	The installation of additional equipment at PCEP TPFs would generate noise, but would not cause additional noise impacts beyond those from trains and horns.	Same as Alternative A in regard to the addition of equipment at PCEP TPFs. Regarding the new TPSS, for Alternative B, no noise-sensitive receptors lie within the screening distance and no noise impacts were determined.
Vibration		
Impact NV#8: Temporary Exposure of Sensitive Receptors and Buildings to Construction Vibration	During nighttime work, potential human annoyance to construction vibration within 140 feet of mechanical equipment for infrequent construction activities, and within 300 feet of frequent, repetitive equipment such as pile driving, vibratory compaction, and ongoing demolition work with jackhammers or hoe-rams. Potential building damage from impact pile driving within 55 feet of structures.	Temporary vibration impacts at vibration-sensitive locations would be the same as Alternative A with the exception of the passing track area, where construction would require more and longer durations of nighttime construction activity near vibration-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City. Additionally, there would be differences in construction duration and nighttime construction in the San Jose Diridon Station Approach Subsection.

	Alternative A	Alternative B
Impact NV#9: Intermittent Permanent Exposure of Sensitive Receptors to Vibration from Operations	Permanent vibration impacts from 2029 Plus Project conditions at 4th and King Street Station and approach: ▪ none Permanent vibration impacts from 2040 Plus Project: ▪ 2,493 ground-borne vibration impacts Permanent ground-borne noise impacts from 2029 Plus Project conditions at 4th and King Street Station and approach: ▪ none Permanent ground-borne noise impacts from 2040 Plus Project: ▪ 18 ground-borne noise impacts	Permanent vibration impacts from 2029 Plus Project conditions at 4th and King Street Station and approach: ▪ none Permanent vibration impacts from 2040 Plus Project: Viaduct to I-880: ▪ 2,307 ground-borne vibration impacts Viaduct to Scott Boulevard: ▪ 2,366 ground-borne vibration impacts Same as Alternative A with respect to ground-borne noise impacts.

dB = decibel
dBA = A-weighted decibel
HSR = high-speed rail
I- = Interstate
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
LMF = light maintenance facility
PCEP = Peninsula Corridor Electrification Project
TPF = traction power facility
TPSS = traction power substation

3.4.8.1 Construction Noise

Construction of the project would require the use of mechanical equipment that would generate temporary increases in noise and result in temporary construction impacts at noise-sensitive locations. For typical track construction scenarios, the residential nighttime 8-hour L_{eq} criterion of 70 dBA would potentially be exceeded up to 500 feet from excavation work, 792 feet from the earthwork and retaining wall work, and as far as 706 feet from at-grade track construction or 774 feet from viaduct construction. For stations and ancillary structures, excavation and foundation work would potentially generate temporary nighttime impacts at residential areas out to 446 feet for non-pile-driving work; impacts from pile driving would extend out to 706 feet. Superstructure, building shell and landscaping work would potentially generate impacts out to 354 feet. These distances would be applicable to both project alternatives, however construction of the passing track under Alternative B would require greater amounts and longer durations (up to 4.5 years) of nighttime construction activity near noise-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City, and in San Jose, Alternative B would also include construction of new viaduct structures.

The Authority and its contractors would comply with FRA guidelines for minimizing noise at sensitive receptors during project construction (NV-IAMF#1), but construction noise effects would remain. These impacts would be reduced through implementation of NV-MM#1. This mitigation would require the contractor to provide a noise monitoring program. The measure provides contractors with the flexibility to implement different tools to meet FRA standards for limiting both daytime and nighttime noise during construction.

Construction of the project would result in temporary changes in the local roadway network that would require some diversion and rerouting of traffic. The diversion of traffic is not expected to affect noise levels because traffic on local roadways provides only a minor contribution to overall noise levels.

3.4.8.2 Operational Noise

Operation of the project would permanently increase noise levels above the FRA's noise impact thresholds at sensitive receptors. Under the 2029 Plus Project condition at the 4th and King Street Station and approach, there would be zero noise impacts under both alternatives. Under the 2040 Plus Project condition, there would be 1,758 severe noise impacts and 4,296 moderate impacts under Alternative A, 1,648 severe noise impacts and 4,186 moderate noise impacts under Alternative B (Viaduct to I-880), and 1,628 severe noise impacts and 4,141 moderate noise impacts under Alternative B (Viaduct to Scott Boulevard). The Authority has identified multiple mitigation measures that would reduce the number of sensitive receptors subject to moderate and severe impacts from train operations: NV-MM#3, NV-MM#4, NV-MM#5, NV-MM#6, and NV-MM#7, as described in Section 3.4.7.

With the implementation of noise barriers as a mitigation measure, a total of 1,276 severe noise impacts would be mitigated for Alternative A, 1,193 severe noise impacts would be mitigated for Alternative B (Viaduct to I-880), and 1,176 severe noise impacts would be mitigated for Alternative B (Viaduct to Scott Boulevard). By implementing quiet zones and noise barriers, a total of 1,504 severe noise impacts would be mitigated for Alternative A, 1,411 severe noise impacts would be mitigated for Alternative B (Viaduct to I-880), and 1,394 severe noise impacts would be mitigated for Alternative B (Viaduct to Scott Boulevard).

Operation of the project would generate traffic and associated noise at stations providing HSR service. No new parking facilities are associated with the 4th and King Street Station. Near the Millbrae Station, the L_{dn} contribution from the parking facilities would be 37 dBA at the closest noise receptors. Near the San Jose Diridon Station, the L_{dn} contribution from the relocated parking spaces would be 29 dBA at the closest noise receptors. The additional noise from parking facilities would be substantially lower (at least 17 dB less) than the projected L_{dn} from HSR operations. Therefore, no additional noise impacts are anticipated due to parking facilities.

Operation of the project would also generate additional noise associated with train movements in and out of the Brisbane LMF. Under Alternatives A, the L_{dn} contribution from the East Brisbane LMF at that nearest receptor would be 36 dBA (more than 14 dBA less than HSR operations). Under Alternative B, the L_{dn} contribution from the West Brisbane LMF at that nearest receptor would be 40 dBA (more than 11 dBA less than HSR operations). Therefore, no additional noise impacts are anticipated due to the LMF.

Construction of the project would result in permanent changes in the local roadway network that would require some diversion and rerouting of traffic. The diversion of traffic is not expected to affect noise levels because traffic on local roadways provides only a minor contribution to overall noise levels.

Operation of the project would generate additional traffic and traffic-related noise under the 2029 Plus Project and 2040 Plus Project conditions. Permanent increases in traffic-related noise would be similar for both alternatives and would occur at roadways segments near the 4th and King Street Station, Millbrae Station, and near the Brisbane LMF. In 2029 at the 4th and King Street Station and approach, two roadway segments under both alternatives would have the potential for noise level increases greater than or equal to 3 dB compared to existing noise conditions. In 2040, operation of each project alternative would result in no roadway segments near Millbrae Station or the Brisbane LMF with the potential for noise level increases greater than or equal to 3 dB; four segments would be affected near the San Jose Diridon Station under Alternative A and five segments would be affected under Alternative B. NV-MM#3 and NV-MM#7 would be available to address these impacts.

Advance warnings of passing trains would be provided at stations and at-grade crossings where receptors may be within the distance where rapid onset noise exposure could exceed the FTA threshold. These advance warnings would avoid startling of sensitive receptors at stations and at-grade crossings. No sensitive receptors outside of these areas were identified within the distance where rapid onset noise exposure would exceed the FTA threshold.

Under both alternatives the L_{dn} contribution from the additional equipment that may be installed at PCEP TPFs would not generate additional noise impact beyond the train operations noise impacts. The TPF impacts may occur at one single-family residence in the San Mateo to Palo Alto Subsection near PS5 Option 2. NV-MM#3 and NV-MM#7 would be available to address these impacts.

3.4.8.3 Construction Vibration

Construction of the project alternatives could cause temporary exposure of sensitive receptors and buildings to construction vibration. Building damage could occur within approximately 50 feet of pile-driving activity. Incorporation of NV-IAMF#1 would minimize construction vibration and the potential for it to cause damage to buildings. However, even with NV-IAMF#1, some sensitive buildings within 55 feet of the construction activity would still be exposed to ground-borne vibration that could result in building damage. Construction of the passing track under Alternative B would require greater amounts and longer durations (up to 4.5 years) of nighttime construction activity near vibration-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City, and in San Jose, Alternative B would also include construction of new viaduct structures. The residual impact would be addressed with NV-MM#2.

Using the frequent event criterion, annoyance from nighttime vibratory construction activities could occur as far out as 300 feet from pile-driving activity or 140 feet from vibratory compaction activity. Incorporation of NV-IAMF#1 would minimize construction vibration and the potential for it to cause annoyance to occupants at vibration-sensitive land use. However, even with NV-IAMF#1, some sensitive receptors would still be exposed to ground-borne vibration that could result in annoyance. The residual impact would be addressed with NV-MM#2.

3.4.8.4 Operational Vibration

Operation of the project alternatives could cause permanent vibration impacts at sensitive receptors. Under the 2029 Plus Project condition at the 4th and King Street Station and approach, no vibration impacts are predicted. Under the 2040 Plus Project condition, Alternative A would result in 2,493 ground-borne vibration impacts, Alternative B (Viaduct to I-880) would result in 2,307 ground-borne vibration impacts, and Alternative B (Viaduct to Scott Boulevard) would result in a nearly identical 2,366 ground-borne vibration impacts. Under the 2040 Plus Project condition, both alternatives would result in 18 ground-borne noise impacts. The vibration impacts would occur in all five subsections, although nearly half would occur in the San Mateo to Palo Alto Subsection. NV-MM#8 would be available to address this impact.

3.4.9 CEQA Significance Conclusions

As described in Section 3.4.4.5, Methods for Determining Significance under CEQA, the impacts of project actions under CEQA are evaluated against thresholds to determine whether a project action would result in no impact, a less-than-significant impact, or a significant impact. Table 3.4-26 identifies the CEQA significance conclusions for each impact discussed in Sections 3.4.6.2 and 3.4.6.3, Vibration. A summary of the significant impacts, mitigation measures, and factors supporting the significance conclusions after mitigation follows the table.

Alternatives A and B would have similar significant noise and vibration impacts with the exception of differences in impacts related to construction of the passing track. Alternative B would have greater construction noise and vibration impacts due to the additional construction of passing tracks. Both alternatives would have similar significant operational noise and vibration impacts.

Table 3.4-26 CEQA Significance Conclusions and Mitigation Measures for Noise and Vibration

CEQA Impacts	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure(s)	CEQA Level of Significance after Mitigation
Noise			
Impact NV#1: Temporary Exposure of Sensitive Receptors to Construction Noise	Significant for both project alternatives. Construction activity noise would exceed FRA standards at sensitive receptors.	NV-MM#1: Construction Noise Mitigation Measures	Significant and unavoidable for both project alternatives
Impact NV#2: Intermittent Permanent Exposure of Sensitive Receptors to Noise from Operations	Significant for both project alternatives. Operations noise would exceed FRA standards at sensitive receptors.	NV-MM#3: Implement Proposed California High-Speed Rail Project Noise Mitigation Guidelines NV-MM#4: Implement Quiet Zones NV-MM#5: Vehicle Noise Specification NV-MM#6: Special Trackwork at Crossovers, Turnouts, and Insulated Joints NV-MM#7: Additional Noise Analysis during Final Design	Significant and unavoidable for all alternatives
Impact NV#3: Intermittent Permanent Exposure of Sensitive Receptors to Noise from HSR Passenger Stations	Less than significant for both alternatives. Additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.	No mitigation measures are required	N/A
Impact NV#4: Intermittent Permanent Exposure of Sensitive Receptors to Noise from the Brisbane Light Maintenance Facility	Less than significant for both alternatives. Additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.	No mitigation measures are required	N/A
Impact NV#5: Intermittent Permanent Human Annoyance from Onset Noise of Passing HSR Trains	Less than significant for both alternatives. Startle would be avoided at stations and at-grade crossings through advance warnings. No sensitive receptors outside of these areas were identified within the distance where rapid onset noise exposure would exceed the FTA threshold.	No mitigation measures are required	N/A

CEQA Impacts	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure(s)	CEQA Level of Significance after Mitigation
Impact NV#6: Permanent Exposure of Sensitive Receptors to Vehicular Traffic Noise Increases	Significant for both project alternatives. Additional vehicular traffic near the 4th and King Street Station would increase ambient noise levels in the project vicinity above levels existing without the project.	NV-MM#3: Implement Proposed California High-Speed Rail Project Noise Mitigation Guidelines NV-MM#7: Additional Noise Analysis during Final Design	Significant and unavoidable for both alternatives
Impact NV#8: Traction Power Facility Noise	Significant for both project alternatives. The additional equipment at PCEP TPFs would not affect new receptors beyond those identified in NV#2.	NV-MM#3: Implement Proposed California High-Speed Rail Project Noise Mitigation Guidelines NV-MM#7: Additional Noise Analysis during Final Design	Less than Significant with mitigation for both alternatives
Vibration			
Impact NV#8: Temporary Exposure of Sensitive Receptors and Buildings to Construction Vibration	Significant for both project alternatives. Construction of the project alternatives could expose buildings to excessive ground-borne vibration and exceed nighttime annoyance ground-borne vibration criterion for residential building occupants.	NV-MM#2: Construction Vibration Mitigation Measures	Less than Significant for both alternatives
Impact NV#9: Intermittent Permanent Exposure of Sensitive Receptors to Vibration from Operations	Significant for both project alternatives. HSR operations would generate excessive ground-borne vibration and ground-borne noise impacts at sensitive receptors.	NV-MM#8: Project Vibration Mitigation Measures	Significant and unavoidable for both alternatives

FRA = Federal Railroad Administration
HSR = high-speed rail
PCEP = Peninsula Corridor Electrification Project
TPF = traction power facility
TPSS = traction power substation

Impact NV#1: Temporary Exposure of Sensitive Receptors to Construction Noise

There would be a significant impact under CEQA for all project alternatives because construction activities would affect sensitive receptors by temporarily and periodically substantially increasing ambient noise levels in the project vicinity. The alternatives would incorporate NV-IAMF#1 to minimize noise impacts by requiring compliance with FRA guidelines for minimizing construction noise and vibration impacts when work is conducted within 1,000 feet of sensitive receptors. However, even with NV-IAMF#1, some sensitive receptors would be exposed to construction noise that exceeds FRA guidelines. The Authority would implement NV-MM#1, which would require the contractor to prepare a noise monitoring program and noise control plan prior to construction to comply with the FRA construction noise limits wherever feasible. The monitoring program would describe the actions the contractor would use to reduce noise, such as installing temporary noise barriers, avoiding nighttime construction near residential areas, and using low-noise emission equipment. Implementation of this mitigation measure would reduce construction noise levels but may not always reduce the noise below the FRA noise standards for residences of 70 dBA for nighttime work and 80 dBA for daytime work, particularly for activities that must occur at night such as track relocation greater than 10 feet, and due to pile driving. Therefore, the impact would be significant and unavoidable for both project alternatives.

Impact NV#2: Intermittent Permanent Exposure of Sensitive Receptors to Noise from Operations

There would be a significant impact under CEQA for all project alternatives because HSR operations would increase noise levels above existing ambient levels and in exceedance of FRA criteria, causing severe noise impacts at sensitive receptors. The number of severe impacts would be the similar for both alternatives, as summarized in Table 3.4-27, with more noise impacts occurring under Alternative A. In some instances where buildings are not acquired, there are more impacts under Alternative B due to the tracks being closer to buildings. In the San Jose Diridon Station Approach Subsection, there are more noise impacts under Alternative A due to the at-grade, blended alignment and train horns sounding approaching at-grade crossings. The noise impacts would be greater for Alternative B (Viaduct to I-880) than Alternative B (Viaduct to Scott Boulevard) due to being at grade for a greater distance.

Table 3.4-27 Noise Mitigation Effectiveness

Project Alternative	2040 Noise Impacts without Mitigation		Residual Noise Impacts with Noise Barriers		Residual Noise Impacts with Quiet Zones and Noise Barriers	
	Moderate	Severe	Moderate	Severe	Moderate	Severe
Alternative A	4,296	1,758	2,389	482	2,093	254
Alternative B[1]	4,186/ 4,141	1,648/ 1,628	2,177/ 2,237	455/ 452	1,887/ 1,947	237/ 234

[1] Values are presented for Alternative B (Viaduct to I-880) first, followed by Alternative B (Viaduct to Scott Boulevard).

The Authority would implement mitigation measures to minimize operations noise impacts. As part of NV-MM#3, the Authority would consider building noise barriers, supporting City implementation of quiet zones where cities decide to implement them, installing sound insulation, or acquiring easements on properties severely affected by noise, based on criteria in the Authority's Noise and Vibration Mitigation Guidelines (Volume 2, Appendix 3.4-B). Implementing measures would reduce or compensate for severe noise impacts from operations by mitigating noise impacts through the installation of noise barriers and the other options.

As part of NV-MM#4, the Authority would assist local communities in establishing quiet zones in order to reduce noise impacts from train warning horns. NV-MM#5 would require HSR vehicles to meet federal regulations for noise (40 C.F.R. § 201.12) at the time of procurement. NV-MM#6 would require the contractor to document how they minimized or eliminated rail gaps related to special trackwork, which can be a major source of noise during operations. These mitigation measures would all be effective at reducing the number of severe noise impacts in the RSA; however, they would not mitigate all noise impacts because noise barriers are not cost-effective or acoustically feasible in all areas with predicted noise impacts. As part of NV-MM#7, should any changes to final design or vehicle specifications change any assumptions underlying the noise analysis, the Authority would be required to prepare the necessary environmental documentation as required by NEPA and CEQA to reassess potential impacts and mitigation. Table 3.4-27 summarizes the noise impacts that could be mitigated with noise barriers alone, and with a combination of quiet zones and noise barriers. As specified in the noise mitigation guidelines (Volume 2, Appendix 3.4-B), installation of noise barriers requires approval of 75 percent of affected parties in a community. Additionally, quiet zones can only be established at the initiative of a local jurisdiction. Therefore, quiet zones cannot be advanced where local jurisdictions do not want them to be established.

Because severe noise impacts would remain following mitigation and because the implementation of noise barriers and quiet zones is constrained by approval of affected parties and local jurisdictions, the impact would be significant and unavoidable under CEQA.

Impact NV#6: Permanent Exposure of Sensitive Receptors to Vehicular Traffic Noise Increases

There would be a significant impact under CEQA for both project alternatives because HSR operations would permanently expose sensitive receptors to traffic noise increases from additional traffic near the 4th and King Street Station in San Francisco. A total of two roadway segments (Fourth Street between Bluxome and Brannan and the other on Fourth Street between Townsend and Bluxome) under both alternatives would have the potential for noise level increases greater than or equal to 3 dB compared to existing noise conditions in 2029. In 2040 under Alternative A, in San Jose near Diridon Station, four roadway segments would have the potential for noise level increases greater than or equal to 3 dB for Alternative A (Stockton Avenue between Julian Street and The Alameda, The Alameda between Sunol Avenue and Delmas Avenue, Cahill Street between Santa Clara and San Fernando Street, Autumn Street between Santa Clara Street and Park Avenue). Additionally, increases greater than 3 dB would occur at Autumn Street between Julian and Santa Clara under Alternative B.

The Authority would implement mitigation measures to minimize impacts from traffic noise increases. As part of NV-MM#3, the Authority would investigate the traffic noise impacts and ways to mitigate them by means such as noise barriers. As part of NV-MM#7, should any changes to final design change any assumptions underlying the noise analysis, the Authority would be required to prepare the necessary environmental documentation as required by NEPA and CEQA to reassess impacts and mitigation. These mitigation measures would be effective at reducing the traffic noise impacts, but would not mitigate all traffic noise impacts because line-of-sight and safety concerns typically limit the application of effective noise barriers in an urban area. Therefore, the impact would be significant and unavoidable.

Impact NV#7: Permanent Exposure of Sensitive Receptors to Traction Power Facility Noise

There would be a significant impact under CEQA because project operations would permanently expose sensitive receptors to severe noise increase from PS5 Option 2 in Palo Alto (both alternatives). Relative to PS5 Option 2, one residential building would be exposed to a noise increase that exceeds the 3-dB severe impact threshold for the TPF and the HSR trains. The Authority would implement mitigation measures to minimize impacts from TPF noise. As part of NV-MM#3, the Authority would investigate the TPF noise impacts and ways to mitigate them by means such as noise barriers around the facility. As part of NV-MM#7, additional design considerations such as equipment selection and siting would be evaluated during final design if needed to mitigate the noise. These mitigation measures would mitigate all severe noise impacts from TPF. Therefore, the impact would be less than significant with mitigation.

Impact NV#8: Temporary Exposure of Sensitive Receptors and Buildings to Construction Vibration

There would be a significant impact under CEQA for both project alternatives because construction activities could expose persons or buildings to excessive ground-borne vibration from pile driving for the LMF foundation and foundations for bridge structures, and other vibration-intensive construction activities such as vibratory compaction and demolition. Incorporation of NV-IAMF#1 would minimize construction vibration and its potential to cause damage to buildings and human annoyance. However, even with NV-IAMF#1, some sensitive receptors would be exposed to ground-borne vibration that could result in annoyance during, and buildings could be exposed to vibration that exceeds damage criteria.

The Authority would implement NV-MM#2 to minimize vibration impacts from construction. As part of this mitigation measure, the contractor would develop and implement vibration reduction methods when impact pile driving and other high-vibration-producing activity would occur within 55 feet of any building to meet FRA vibration impact criteria. Prior to starting pile driving and other high-vibration activity, the contractor would conduct pre-construction surveys within 55 feet of the activity to document the existing condition of buildings in case damage is reported during or after construction. The contractor would arrange for the repair of damaged buildings or would pay compensation to the property owner. These measures would effectively avoid or offset vibration impacts from construction. Therefore, the impact would be less than significant with mitigation for both project alternatives.

Impact NV#9: Intermittent Permanent Exposure of Sensitive Receptors to Vibration from Operations

There would be a significant impact under CEQA for both project alternatives because HSR operations would generate excessive ground-borne vibration impacts at sensitive receptors in all five subsections. Alternative A would result in 2,493 ground-borne vibration impacts, Alternative B (Viaduct to I-880) would result in 2,307 ground-borne vibration impacts, and Alternative B (Viaduct to Scott Boulevard) would result in 2,366 ground-borne vibration impacts. Both alternatives would result in 18 ground-borne noise impacts. The Authority would implement NV-MM#8, which would require vibration mitigation measures that would minimize vibration impacts from operations. There are various options to reduce train vibration, though it may not be possible in all instances to mitigate all vibration impacts because it may not be cost-effective or feasible. The specific design and implementation of this mitigation measure would be identified during final design. Therefore, the impact would be significant and unavoidable.