APPENDIX 3.4-A: NOISE AND VIBRATION TECHNICAL REPORT

California High-Speed Rail Authority

San Francisco to San Jose Project Section

Noise and Vibration Technical Report

June 2022

CALIFORNIA
High-Speed Rail Authority

The environmental review, consultation, and other actions required by applicable federal environmental laws for this project are being or have been carried out by the State of California pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated July 23, 2019, and executed by the Federal Railroad Administration and the State of California.

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ACRONYMS AND ABBREVIATIONS

μin/sec	microinch per second
ADT	average daily traffic
ATOR	above-top-of-rail
Authority	California High-Speed Rail Authority
BART	Bay Area Rapid Transit
Bay Area	San Francisco Bay Area
C.F.R.	Code of Federal Regulations
Caltrans	California Department of Transportation
CNEL	community noise equivalent level
CP	control point
dB	decibel
dBA	A-weighted decibel
DTX	Downtown Extension
EIR	environmental impact report
EIS	environmental impact statement
EMU	electric multiple unit
FDL	force density level
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FRA guidance manual	*High-Speed Ground Transportation Noise and Vibration Impact Assessment*
FTA	Federal Transit Administration
FTA guidance manual	*Transit Noise and Vibration Impact Assessment Manual*
HSR	high-speed rail
Hz	Hertz, cycles per second
I-	Interstate
IAMF	impact avoidance and minimization feature
L_{dn}	day-night sound level, dBA
L_{eq}	equivalent sound level, dBA
L_{eq}(h)	hourly equivalent sound level, dBA
L_{max}	maximum sound level
LMF	light maintenance facility
L_{min}	minimum sound level
LSR	line source response
L_v	velocity level

mph	miles per hour
MT	mainline track
MUNI	San Francisco Municipal Railway
NAC	noise abatement criteria
OCS	overhead contact system
PCEP	Peninsula Corridor Electrification Project
PPV	peak particle velocity
Project Section, or project	San Francisco to San Jose Project Section
PS	paralleling station
PTC	positive train control
RMS	root-mean-square
RSA	resource study area
SamTrans	San Mateo County Transit District
SEL	sound exposure level
SFO	San Francisco International Airport
SFTC	Salesforce Transit Center
SR	State Route
S_{ref}	speed reference
TPF	traction power facility
TPSS	traction power substation
U.S.C.	United States Code
US	U.S. Highway
USEPA	U.S. Environmental Protection Agency
VdB	vibration decibel
VHS	very high-speed

EXECUTIVE SUMMARY

The California High-Speed Rail Authority (Authority) has prepared this San Francisco to San Jose Project Section Noise and Vibration Technical Report to support the *San Francisco to San Jose Project Section Final Environmental Impact Report (EIR)/Environmental Impact Statement (EIS)*. This technical report characterizes existing conditions and analyzes noise and vibration effects[1] of two project alternatives.

This technical report addresses effects resulting from construction and operation of the San Francisco to San Jose Project Section (Project Section, or project). It describes relevant federal, state, regional, and local regulations and requirements; methods used for the analysis of effects; the affected environment; impact avoidance and minimization features (IAMF) incorporated into the project design that would avoid or minimize specific environmental effects; and the potential effects of noise and vibration in the resource study area that could result from construction and operation of the project alternatives. Project noise and vibration effects consist of construction-related noise and vibration effects, high-speed rail (HSR) operational noise and vibration effects, including noise from stations and maintenance facilities, and operational traffic noise effects.

Summary of Effects

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)[2] and positive train control. With the HSR project, there would be a blended service operating in the Caltrain corridor with both intercity HSR trains and commuter Caltrain trains sharing the same rail corridor between San Jose and San Francisco. This analysis evaluates noise and vibration effects associated with the two project alternatives for both the construction and operational phases.

Noise

Construction

Additional improvements beyond the Caltrain Modernization Program would be required to accommodate HSR services. 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 a light maintenance facility (LMF); and build communication radio towers located at approximately 2.5-mile intervals. Additional passing tracks would be built under Alternative B.

Construction of the project would require the use of mechanical equipment that would generate temporary increases in noise and ground-borne vibration and result in temporary construction effects at noise-sensitive locations. Where nighttime construction would be required, the residential nighttime 8-hour equivalent sound level criterion of 70 A-weighted decibel (dBA) would potentially be exceeded up to 792 feet from construction areas. The Authority and its contractors would comply with Federal Railroad Administration (FRA) and Federal Transit Administration guidelines for minimizing noise and vibration impacts at sensitive receptors during project construction (NV-IAMF#1: Noise and Vibration), but construction noise and vibration effects would remain.

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[1] The terms *impact* and *effect* have the same meaning in this document and relate to exceedance of a relevant Federal Railroad Administration or Federal Transit Administration impact criteria level, rather than significance conclusions under the National Environmental Policy Act and the California Environmental Quality Act.

[2] The Peninsula Corridor Electrification Project (PCEP) will provide electrification infrastructure and electrical multiple units (EMU) 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 (mph). In addition, the PCEP will increase Caltrain daily service from 92 to 112 trains per day. The construction and operational effects of the PCEP on noise and vibration compared to existing conditions were evaluated by Caltrain in the PCEP Environmental Impact Report (PCJPB 2015a).

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

Operations

The project would be within an existing rail corridor that presently has passenger service consisting of 92 Caltrain trains per day between San Francisco and Santa Clara and approximately 6 freight trains per day. The HSR project would result in the following changes to rail operations within the Caltrain corridor:

- **Increase in the number of passenger trains**—The HSR project would add an estimated 122 revenue trains and 12 to 22 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 units (EMU) 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 in certain locations for both Caltrain and HSR service.

Operation of HSR trains would permanently increase noise levels above the noise impact thresholds at some sensitive receptors. Both alternatives would generate similar numbers of severe and moderate operations noise impacts under the 2029 and 2040 Plus Project conditions. Under the 2029 Plus Project condition, there would be zero noise impacts in the San Francisco to South San Francisco Subsection under Alternatives A and B; under the 2040 Plus Project condition, there would be 1,634 severe noise impacts and 4,074 moderate impacts under Alternative A and 1,628 severe noise impacts and 4,068 moderate impacts under Alternative B.

Project operations would generate traffic and associated noise at HSR stations. Near the Millbrae Station, the largest day-night sound level (L_{dn}) contribution from the parking facilities at the nearby noise receptors would be 37 dBA. This additional noise from parking facilities would be substantially lower (at least 24 decibels [dB] less) than the projected L_{dn} from HSR operations. No new parking facilities that have the potential to generate additional noise would be provided at the 4th and King Street Station.

Project operations would also generate noise associated with train movements in and out of the LMF in Brisbane. Under Alternative A, the L_{dn} contribution from the East Brisbane LMF at the nearest receptor would be 36 dBA (10 dBA or more below HSR operations noise). Under Alternative B, the L_{dn} contribution from the West Brisbane LMF at the nearest receptor would be 40 dBA (also 10 dBA or more below HSR operations noise).

The potential for passing HSR train noise to startle or surprise humans near the HSR track and result in human annoyance is included in this analysis for informational purposes only consistent with FRA guidance (FRA 2012). Annoyance and startle effects for humans would be primarily limited to areas within the project's proposed right-of-way. Noise effects on wildlife are evaluated separately in the *San Francisco to San Jose Project Section Biological and Aquatic Resources Technical Report* (Authority 2020).

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 project alternatives and would occur at roadway segments near the 4th and King Street Station, Millbrae Station, and the Brisbane LMF. In 2029, two roadway segments under Alternatives A and B would have the potential for noise level increases of 3 dB or more compared to existing noise conditions. In 2040, operation of either project alternative would not result in noise level increases greater than 3 dB on any roadway segments.

Vibration

Construction

Construction of the project would require the use of mechanical equipment that would generate temporary increases in ground-borne vibration which could result in human annoyance and could result in building damage at buildings within 50 feet. Construction activities, such as pile driving, would have the potential to cause structural damage to buildings in close proximity to these activities (within 50 feet). Most construction activities would only have the potential to cause annoyance from vibration within 140 feet of the mechanical equipment. Some equipment, such as pile driving or ongoing demolition work would have the potential to cause annoyance from vibration within 300 feet of these construction activities.

Operations

Project operations would have the potential to result in permanent increases in vibration levels at sensitive receptors and exceed vibration impact thresholds under both alternatives. The evaluation of potential vibration impacts for the project alternatives indicates that both alternatives would generate similar numbers of vibration impacts. Under the 2029 Plus Project condition, there would be zero vibration impacts in the San Francisco to South San Francisco Subsection under Alternatives A and B. Under the 2040 Plus Project condition, there would be 2,290 ground-borne vibration impacts and 18 ground-borne noise impacts under Alternative A; under Alternative B there would be 2,288 ground-borne vibration impacts and 18 ground-borne noise impacts.

1 INTRODUCTION

Since publication of the Draft Environmental Impact Report (EIR)/Environmental Impact Statement (EIS), the following substantive changes have been made to this appendix:

- Where appropriate, the verb "would," when used specifically to describe impact avoidance and minimization features (IAMF) or mitigation measures, as well as their directly related activities, was changed to "will," indicating their integration into project design.
- Analysis of a lead track design change for the East Brisbane Light Maintenance Facility (LMF) under Alternative A was incorporated. The southbound lead track shifting westward did not change the noise or vibration impact assessment results. Figures 2-12 and 2-21 were updated accordingly.
- Section 3.3, Consistency and Local, was updated to reflect the adoption of an updated general plan for the Town of Atherton.

This report presents a noise and vibration technical evaluation for the California High-Speed Rail (HSR) San Francisco to San Jose Project Section (Project Section, or project). It was prepared in support of environmental reviews required under the National Environmental Policy Act and California Environmental Quality Act.

1.1 Background of the HSR Program

The California High-Speed Rail Authority (Authority) proposes to build, operate, and maintain an electric-powered HSR system in California, connecting the San Francisco Bay Area (Bay Area) and Central Valley to Southern California. When completed, the nearly 800-mile train system would provide new passenger rail service to more than 90 percent of the state's population. More than 200 weekday trains would serve the statewide intercity travel market. The system would be capable of operating speeds up to 220 miles per hour (mph) in certain HSR sections, with an automatic train control system. The HSR system would connect and serve the state's major metropolitan areas, extending from San Francisco to Los Angeles and Anaheim in Phase 1, with extensions to Sacramento and San Diego in Phase 2.

The Authority and Federal Railroad Administration (FRA) commenced the tiered environmental planning process with the 2005 *Final Program Environmental Impact Report /Environmental Impact Statement (EIR/EIS) for the Proposed California High-Speed Train System* (Statewide Program EIR/EIS) (Authority and FRA 2005). After completion of the first- tier programmatic environmental documents,[3] the Authority and FRA began preparing second-tier project environmental evaluations for sections of the statewide HSR system. Chapter 2, San Francisco to San Jose Project Section, of this technical report provides details of the Project Section and the two project alternatives under consideration.

1.2 Organization of this Technical Report

This technical report comprises the following chapter in addition to this introductory chapter:

- Chapter 2 describes the project alternatives as currently proposed.
- Chapter 3, Laws, Regulations, and Orders, describes federal, state, and regional and local laws, regulations, and policies relevant to noise and vibration.
- Chapter 4, Methods for Evaluating Effects, provides an overview of noise and vibration descriptors, describes the noise and vibration resource study area (RSA), the impact

[3] Two program-level environmental documents were prepared: the Statewide Program EIR/EIS (Authority and FRA 2005) and the *Final Bay Area to Central Valley High-Speed Train (HST) Program Environmental Impact Report/Environmental Impact Statement (EIR/EIS)* (Authority and FRA 2008). These documents evaluated the impacts of proposed HSR corridors and selected the HSR sections comprising the California statewide system.

assessment criteria, and the noise and vibration prediction methodology used in the assessment.

- Chapter 5, Existing Conditions and Effects Analysis, describes the environmental setting and assesses the construction and operations effects related to noise and vibration.
- Chapter 6, References, provides complete reference information for the published, online, agency, institutional, and individual sources consulted in preparation of this report.
- Chapter 7, Preparer Qualifications, presents the credentials of the staff who oversaw the preparation of this report.
- Supporting information is provided in the following appendices:
  - Appendix A, Measurement Site Photographs
  - Appendix B, Noise Measurement Data
  - Appendix C, Vibration Propagation Measurement Data

2 SAN FRANCISCO TO SAN JOSE PROJECT SECTION

The Project Section would provide HSR service between San Francisco and San Jose as part of the statewide HSR system. HSR stations would be located at 4th and King Street[4] in San Francisco and at Millbrae. HSR service would share tracks with Caltrain along approximately 43 miles of blended system infrastructure primarily within the existing Caltrain right-of-way. The Project Section would include a light maintenance facility (LMF) in Brisbane. Two project alternatives are evaluated in this technical report—Alternative A and Alternative B. This chapter describes the common design features of the two project alternatives, followed by descriptions of each alternative.

What does "blended" mean?

Blended refers to operating the high-speed rail trains with existing intercity and commuter and regional rail trains on common infrastructure.

2.1 Common Design Features

The project would extend along the existing Caltrain right-of-way through urban cities and communities in San Francisco, San Mateo, and Santa Clara Counties, including San Francisco, Brisbane, South San Francisco, San Bruno, Millbrae, Burlingame, San Mateo, Belmont, San Carlos, Redwood City, North Fair Oaks, Atherton, Menlo Park, Palo Alto, Mountain View, Sunnyvale, and Santa Clara. The Project Section would be comprised of the following four geographic subsections: San Francisco to South San Francisco, San Bruno to San Mateo, San Mateo to Palo Alto, and Mountain View to Santa Clara (Figure 2-1).

San Francisco to San Jose Project Subsections

- San Francisco to South San Francisco—10 miles from 4th and King Street Station in San Francisco to Linden Avenue in South San Francisco
- San Bruno to San Mateo—8 miles from Linden Avenue in South San Francisco to 9th Avenue in San Mateo
- San Mateo to Palo Alto—16 miles from 9th Avenue in San Mateo to San Antonio Road in Palo Alto
- Mountain View to Santa Clara—9 miles from San Antonio Road in Palo Alto to Scott Boulevard

Operating on the two-track system primarily within the existing Caltrain right-of-way, the project would use existing and in-progress infrastructure improvements developed by Caltrain for its Caltrain Modernization Program, including electrification of the Caltrain corridor between San Francisco and San Jose as part of the Peninsula Corridor Electrification Project (PCEP) and positive train control (PTC). These improvements would provide consistent and predictable travel between San Francisco and San Jose. The blended system would accommodate operating speeds of up to 110 mph for up to four HSR trains and six Caltrain trains per hour per direction in the peak period.

Operation of the blended system would require additional infrastructure improvements and project elements beyond the Caltrain Modernization Program to accommodate HSR service. Design elements common to both alternatives include track modifications to support higher speeds while maintaining passenger comfort; station and platform modifications to accommodate HSR trains passing through or stopping at existing stations; and modifications to the overhead contact system (OCS) (a series of wires strung above the tracks by poles) and traction power facilities (TPF) installed by Caltrain as part of the PCEP. The project alternatives would implement safety improvements at existing at-grade roadway crossings and at Caltrain stations and platforms, as well as security modifications such as the installation of perimeter fencing along the right-of-way. The project would also include an LMF to accommodate planned operational needs for high-capacity rail movement and communication radio towers located at approximately 2.5-mile intervals.

[4] The 4th and King Street Station would serve as an interim station until completion of the Transbay Joint Powers Authority's proposed Downtown Extension Project (DTX). The DTX would extend the electrified peninsula rail corridor in San Francisco from the 4th and King Street Station to the Salesforce Transit Center (SFTC). HSR would utilize the track constructed for the DTX to reach the SFTC.

Source: Authority 2019 MAY 2019

Figure 2-1 Proposed San Francisco to San Jose Project Section

2.1.1 Track and Station Modifications

Definition of Hold-Out Rule

Hold-Out Rule is the rule enforced at Caltrain stations that requires passengers to board and alight the train from between the active tracks. An oncoming train is stopped outside of the station until the passengers are clear of the active tracks.

Depending on the alternative selected, between 7 and 10 of the existing 23 Caltrain stations between 4th and King Street in San Francisco and Scott Boulevard in Santa Clara would require varying degrees of modifications to accommodate HSR trains passing through or stopping at the stations. HSR trains would stop at the 4th and King Street and Millbrae Stations, requiring dedicated HSR platforms and associated passenger services to be provided at these stations. Other stations would also be modified to accommodate track adjustments, remove the hold-out rule, and build project features such as the Brisbane LMF and passing track.

The blended system would require curve straightening, track center modifications, and superelevation[5] of existing Caltrain tracks along approximately 33 percent of the project corridor to support higher speeds of up to 110 mph. These track modifications are described under Section 2.2, Alternative A, and Section 2.3, Alternative B, and illustrated on Figures 2-8, 2-13, 2-17, 2-18, 2-19, 2-20, and 2-22. Where horizontal track modifications would be greater than 1 foot, the OCS poles and wires would require relocation. Where track modifications would occur at existing Caltrain stations, adjustments to existing platforms would be required. Track modifications at San Bruno Station and Hayward Park Station under Alternatives A and B would require modifying or realigning the existing station platforms.

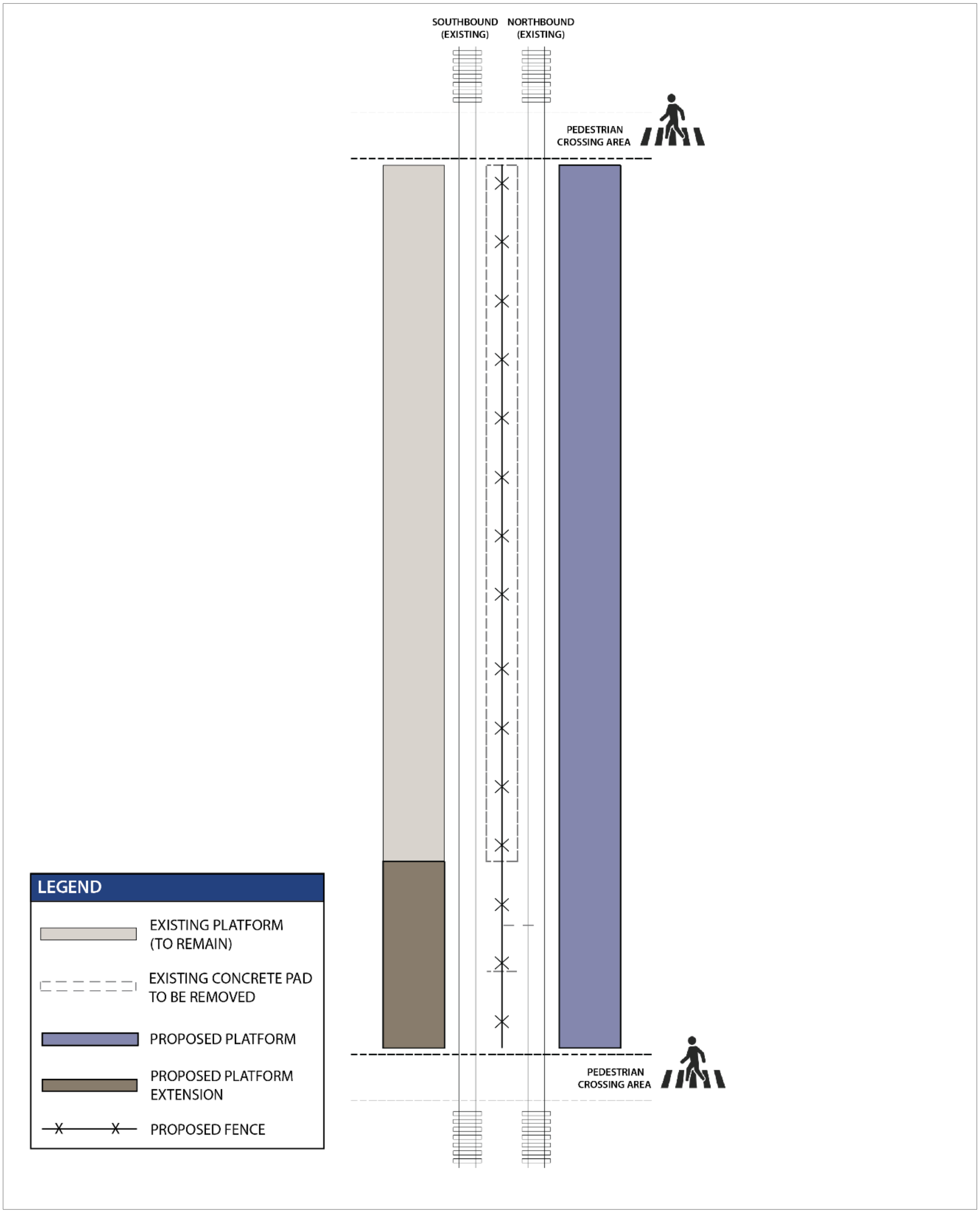
Two existing Caltrain stations—Broadway and Atherton Stations—would be modified as part of the blended system improvements to remove the existing hold-out rule. As illustrated on Figure 2-2, new outboard platforms would be built at these stations to eliminate the need for passengers to cross between the tracks. The Brisbane LMF would require relocation of a station platform and pedestrian overpass at the Bayshore Station in Brisbane.

2.1.2 Safety and Security Modifications to the Right-of-Way

Consistent with FRA safety guidelines for HSR systems with operating speeds of up to 110 mph, the blended system would implement safety improvements at the at-grade crossings to create a “sealed corridor” that would reduce conflicts with automobiles and pedestrians. Safety improvements would include installing four-quadrant gates extending across all lanes of travel and median separators to channelize and regulate paths of travel. These gates would prevent drivers from traveling in opposing lanes to avoid the lowered gate arms. Pedestrian crossing gates also would be built parallel to the tracks and aligned with the vehicular gates on either side of the roadway.

Depending on the configuration of the existing at-grade crossing, one of six different four-quadrant gate applications (illustrated on Figures 2-3 through 2-5) would be installed at each of the 38 at-grade crossings currently without four-quadrant gates along the Project Section. Table 2-1 identifies the number and locations of four-quadrant gate applications. These applications would specify the improvements at each at-grade crossing, including the number of vehicle and pedestrian gates, and the need for channelization or raised medians.

[5] *Superelevation* is the vertical distance between the height of the inner and outer rails at a curve. Superelevation is used to partially or fully counteract the centrifugal force acting radially outward on a train when it is traveling along the curve.

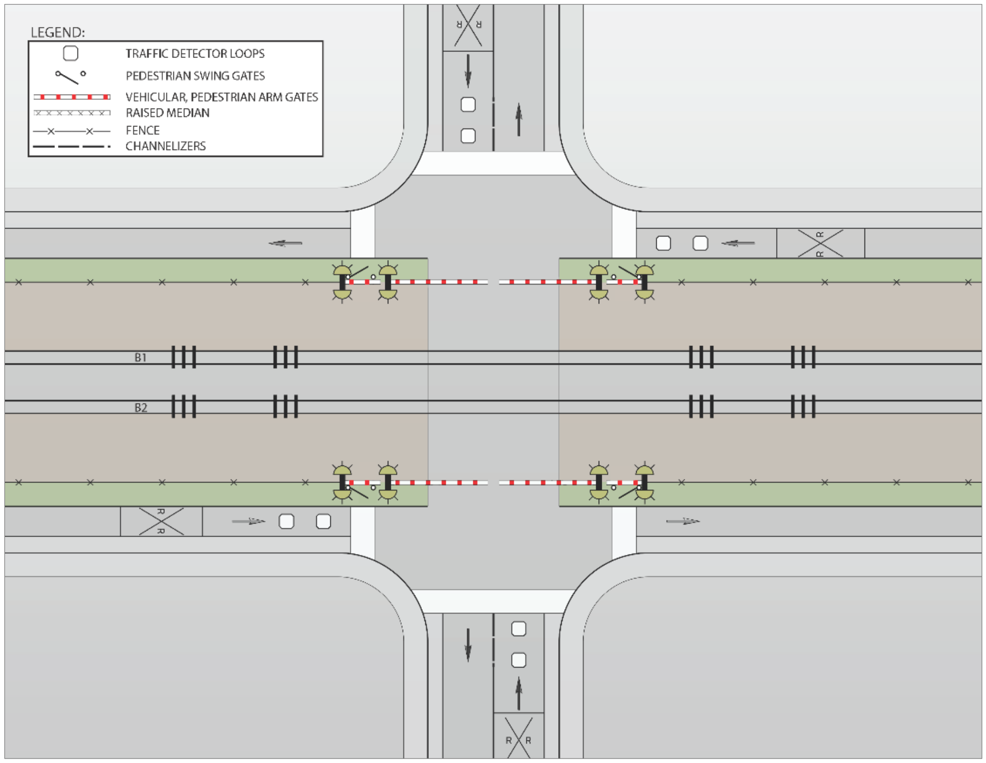


Source: Authority 2019

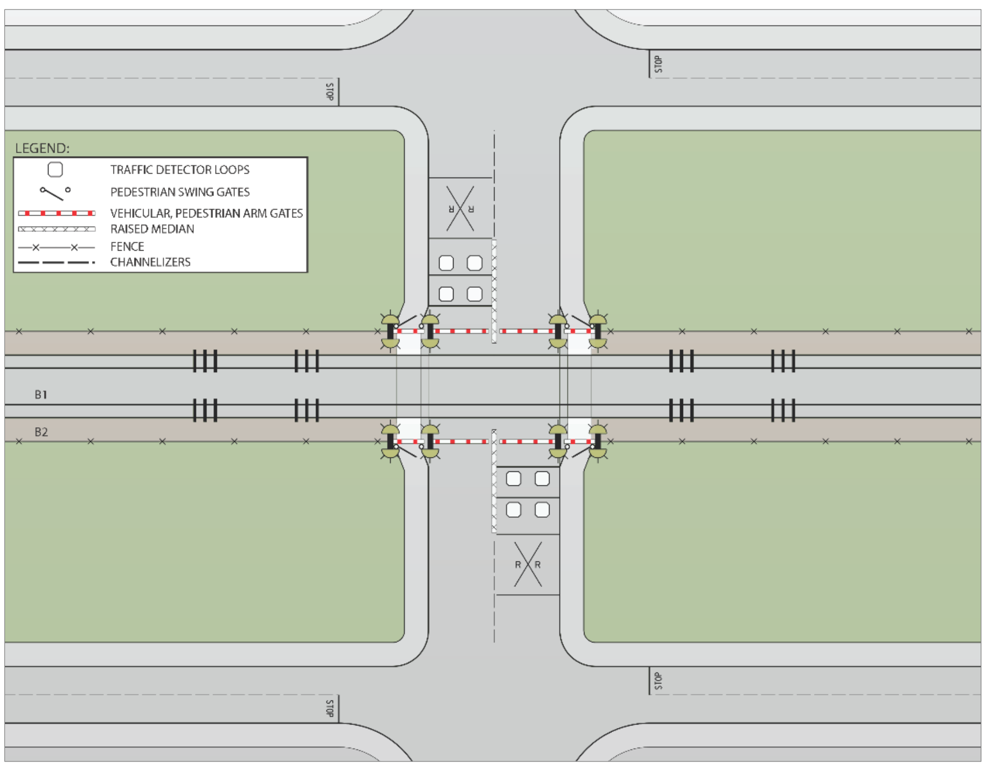
MAY 2019

Figure 2-2 Illustration of Hold-Out Rule Stations

Option A



Option B



Source: Authority 2019

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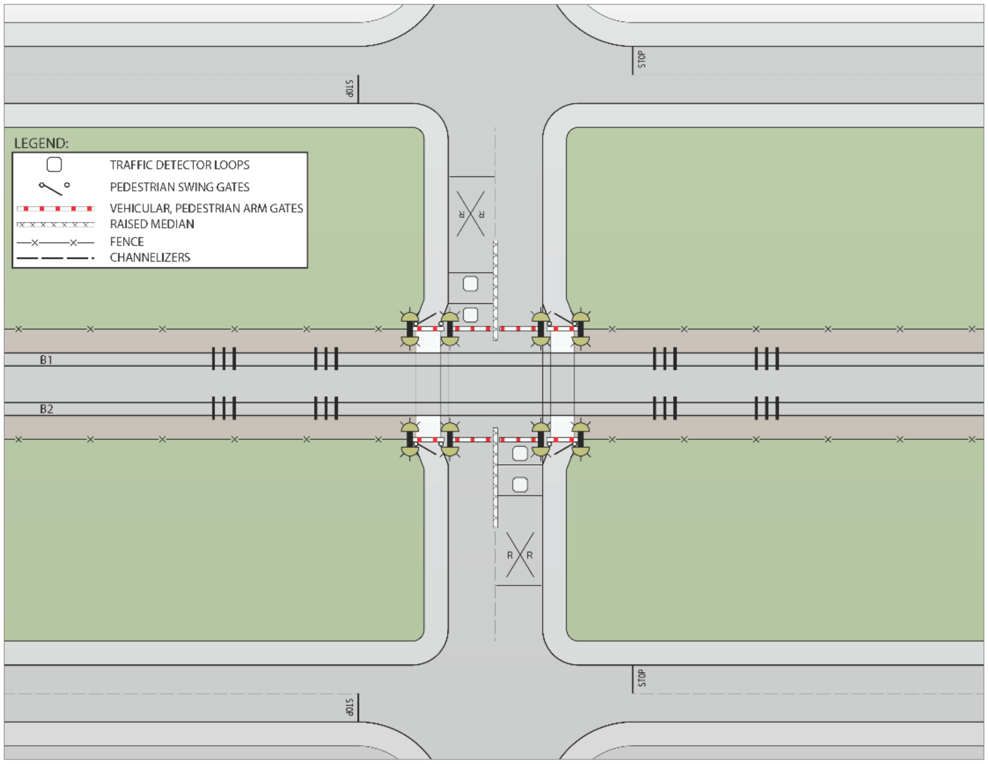
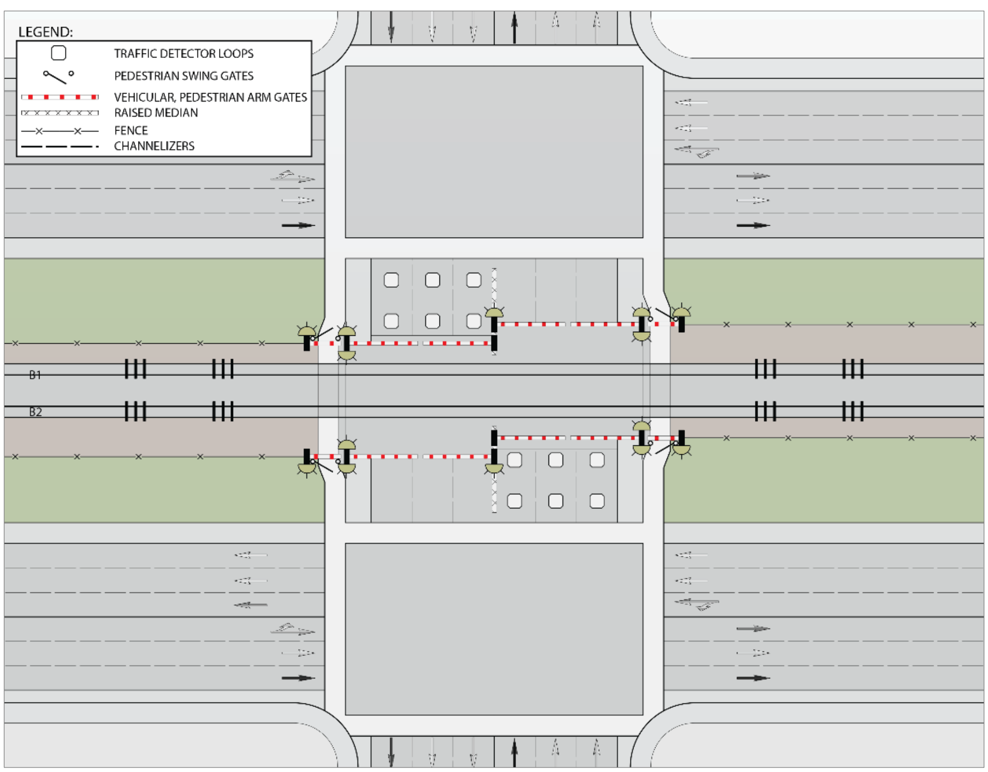
Figure 2-3 Applications of Four-Quadrant Gates (Options A and B)

Option B1



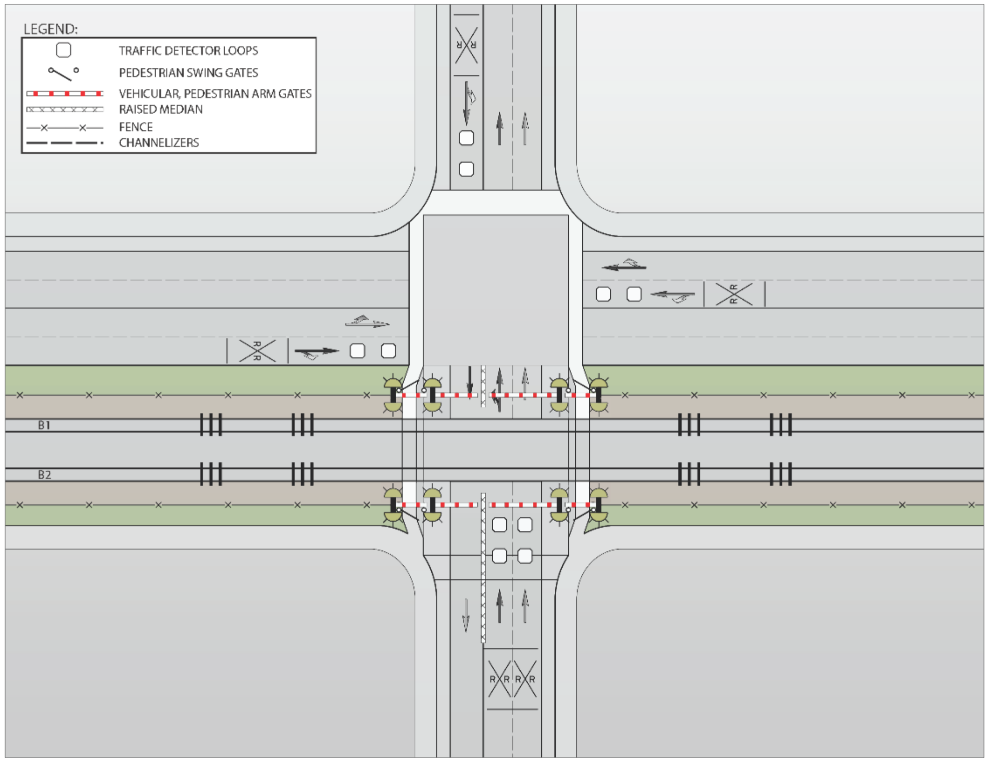
Option C



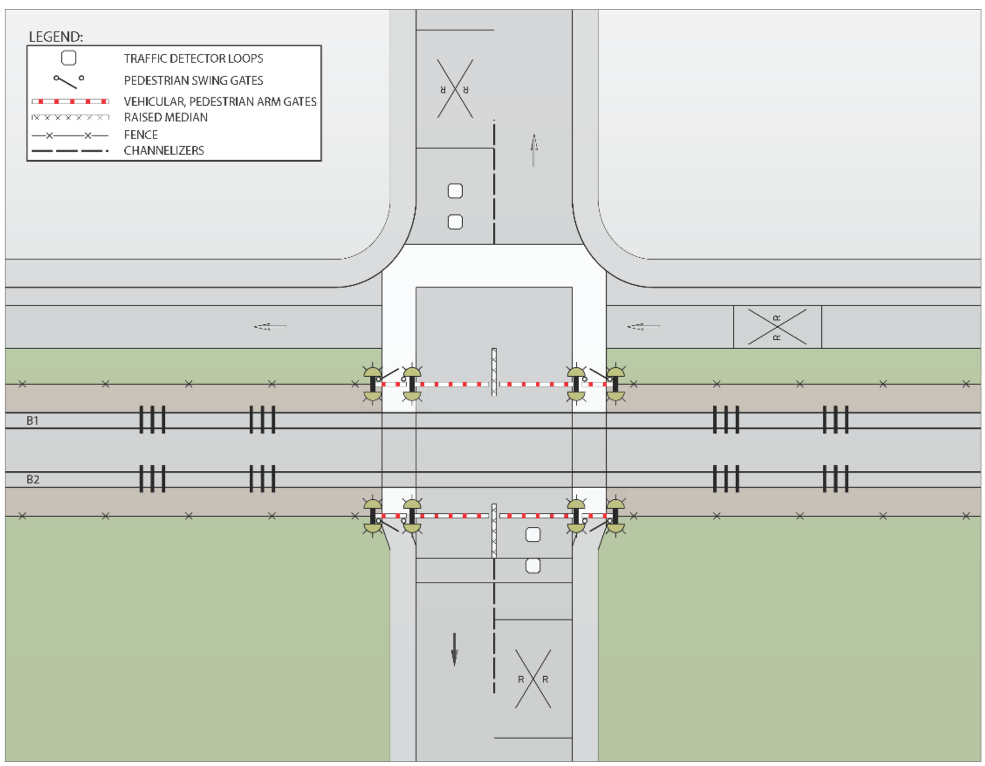
Source: Authority 2019 MAY 2019

Figure 2-4 Applications of Four-Quadrant Gates (Options B1 and C)

Option D



Option E



Source: Authority 2019 MAY 2019

Figure 2-5 Applications of Four-Quadrant Gates (Options D and E)

Table 2-1 Number and Locations of Four-Quadrant Gate Applications within the Project Section

Application	Number of At-Grade Crossings	Location of At-Grade Crossings
A	7	Mission Bay Drive and 16th Street (San Francisco); 4th Avenue and 5th Avenue (San Mateo); Oak Grove Avenue and Ravenswood Avenue (Menlo Park); and Mary Avenue (Sunnyvale)
B	11	Center Street (Millbrae); Oak Grove Avenue, North Lane, Howard Avenue, Bayswater Avenue, and Peninsula Avenue (Burlingame); Villa Terrace and Bellevue Avenue (San Mateo); Chestnut Street (Redwood City); Encinal Avenue (Menlo Park); Alma Street (Palo Alto)
B1	2	Scott Street (San Bruno); Watkins Avenue (Atherton)
C	4	Broadway (Burlingame); Whipple Avenue (Redwood City); Rengstorff and Castro Street (Mountain View)
D	7	Linden Avenue (South San Francisco); Brewster Avenue and Broadway (Redwood City); Churchill Avenue, Meadow Drive and Charleston Road (Palo Alto); Sunnyvale Avenue (Sunnyvale)
E	7	1st Avenue, 2nd Avenue, 3rd Avenue, and 9th Avenue (San Mateo); Maple Street, Main Street (Redwood City); and Glenwood Avenue (Menlo Park)
Total	**38**	N/A

Source: Authority 2019
N/A = not applicable

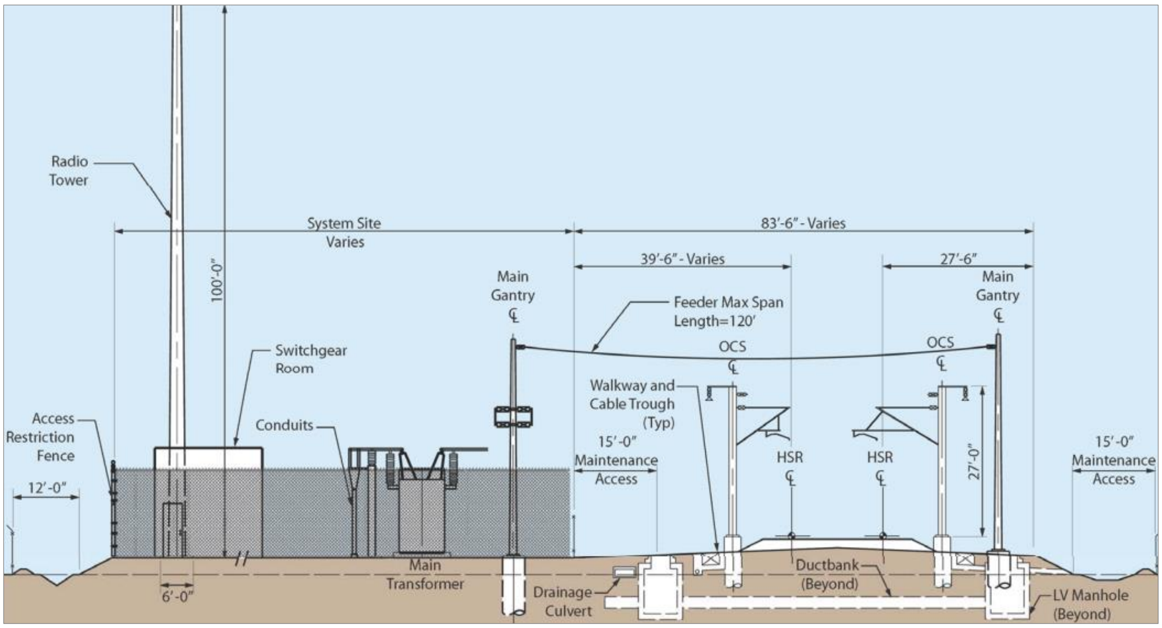
In addition to four-quadrant gates, the Authority would install fencing at the at-grade crossings and along the perimeter of the Caltrain corridor. Consistent with Caltrain's design standards, existing fencing would be extended to adjacent structures to close any gaps. Figure 2-6 depicts photographs of existing perimeter fencing of railroad rights-of-way.

SEPTEMBER 2018

Figure 2-6 Photographs of Perimeter Fencing of Right-of-Way

2.1.3 Train Control and Communication Facilities

HSR would install a radio-based communications network to maintain communications and share data between the HSR trains and the operations control center. Each communications radio towers would consist of an 8-foot by 10-foot communications equipment shelter and a 6- to 8-foot-diameter communications tower extending 100 feet above top-of-rail at approximately 2.5-mile intervals. Where possible, these facilities would be co-located at an existing Caltrain traction power substation (TPSS), switching station, paralleling station, or Caltrain station as illustrated on Figure 2-7. Where communications towers cannot be co-located with other Caltrain facilities, the communications facilities would be sited in an approximately 20-foot by 15-foot fenced area near the Caltrain corridor. For the purposes of environmental clearance, some of the standalone locations have two identified site options but only one would ultimately be implemented.



SEPTEMBER 2018

Figure 2-7 Typical Cross Section of At-Grade Profile with an Adjacent Communications Radio Tower Co-Located with a Traction Power Substation

2.1.4 Traction Power Distribution

The blended system would use the traction power distribution system installed by Caltrain as part of the PCEP, which would install 130 to 140 single-track-miles of OCS between San Francisco and San Jose for the distribution of electric power to the trains. The OCS would consist of a series of mast poles approximately 23.5 feet higher than the top of the rail, with contact wires suspended from the mast poles. The train would have an arm, called a pantograph, to maintain contact with this wire, providing power to the train. The OCS would be powered from a 25-kilovolt, 60-Hertz (Hz), single-phase, alternating current supply system consisting of TPSSs, one switching station, and paralleling stations.[6]

[6] Traction power substations are typically 150 feet by 200 feet in size and include transformers that step down the voltage of power provided by the utility to that needed for the OCS. Switching stations are typically 80 feet by 160 feet in size and would be installed at the midpoint between traction power substations as a phase break to ensure power supplies from each traction power substation are isolated from each other. Paralleling stations are typically 40 feet by 80 feet and would be installed between traction power substations and switching stations to maintain the autotransformer system and system operating voltages. Traction power substations, switching stations, and paralleling stations would be equipped with circuit breakers, switching equipment, and oil-filled transformers.

Relocation of the OCS poles and wires installed by Caltrain as part of the PCEP would be required as part of the HSR project where track modifications would shift tracks more than 1 foot horizontally. Additionally, the project would build new OCS poles and wires for dedicated HSR infrastructure associated with the Brisbane LMF.

Beyond the infrastructure installed as part of the PCEP, HSR trains may require additional equipment (e.g., transformers) to handle HSR electrical loads at the PCEP traction power distribution facilities. Any additional equipment installed at these facilities would be similar in terms of size and capacity to the Caltrain equipment.

2.1.5 Light Maintenance Facility

The Project Section would include an approximately 100- to 110-acre LMF in the city of Brisbane, which would support the San Francisco terminal station operations by dispatching freshly inspected and serviced trains and crews to begin revenue service throughout the day. The LMF would also be the location for daily, monthly, and quarterly maintenance of HSR trainsets. Maintenance activities would include train washing, interior cleaning, wheel truing, testing, and inspections. These activities may occur between runs or as a pre-departure service at the start of the revenue day. Additionally, the LMF would be used as a service point for any trains in need of emergency services. Two LMF site options for the Brisbane LMF, located east and west of the mainline Caltrain tracks, are evaluated in this document as part of the two project alternatives and described in more detail in Section 2.2 and Section 2.3.

The LMF would be designed, constructed, and operated with LEED® Gold Certification—it would be energy efficient and environmentally sensitive. With three overlapping work shifts, activities would occur 24 hours a day. Most maintenance activities would take place overnight, between 10:00 p.m. and 6:00 a.m. Fixed lighting sources at HSR facilities would be designed to direct light downward, minimizing light spillover, but the 24-hour operation of the LMF would require a minimum level of lighting for worker safety and security.

2.2 Alternative A

Alternative A would modify approximately 14.5 miles of existing Caltrain track, predominantly within the existing Caltrain right-of-way, build the East Brisbane LMF, modify seven existing stations or platforms to accommodate HSR, and install safety improvements and communication radio towers. Caltrain has several locations of four-track segments where trains can pass; no additional passing tracks would be built under Alternative A. Table 2-2 presents a summary of the alternative's design features, followed by a more detailed description by subsection.

Table 2-2 Summary of Design Features for Alternative A

Feature	Alternative A
Length of existing Caltrain track (miles)[1]	42.9
Length of modified track (miles)[1]	14.5
Length of track modification <1 ft (miles)[1]	5.1
Length of track modification >1 ft and <3 ft (miles)[1]	2.2
Length of track modification > 3 ft (miles)[1]	7.2
Length of OCS pole relocation (miles)[1, 2]	9.4
LMF	East Brisbane
Modified stations	
Modifications to HSR stations	4th and King Street; Millbrae
Modifications to Caltrain stations due to the LMF	Bayshore (relocated)
Modifications to Caltrain stations due to track shifts	San Bruno; Hayward Park
Modifications to Caltrain stations to remove hold-out rule	Broadway; Atherton
Number of modified or new structures[3]	14

Feature	Alternative A
New structures	2
Modified structures	7
Replaced structures	2
Affected retaining walls	3
Number of at-grade crossings with safety modifications (e.g., four-quadrant gates, median barriers)	38
Length of new perimeter fencing (miles)[1]	7.3
Communication radio towers	20

Source: Authority 2019
LMF = light maintenance facility
OCS = overhead contact system
[1] Lengths shown are guideway mileages, rather than the length of the northbound and southbound track.
[2] OCS pole relocations are assumed for areas with track shifts greater than 1 foot.
[3] Structures include bridges, grade separations such as pedestrian underpasses and overpasses, tunnels, retaining walls, and culverts.

2.2.1 San Francisco to South San Francisco Subsection

The San Francisco to South San Francisco Subsection would extend approximately 10 miles from the 4th and King Street Station in downtown San Francisco to Linden Avenue in South San Francisco, through the cities of San Francisco, Brisbane, and South San Francisco. The existing Caltrain track in this subsection is predominantly two-track at grade, with four two-track tunnel segments in San Francisco, and a four-track at-grade section through Brisbane. As illustrated on Figure 2-8, this alternative would modify the existing 4th and King Street and Bayshore Stations, build the East Brisbane LMF and associated track modifications, reconfigure Tunnel Avenue, relocate the Tunnel Avenue overpass, install four-quadrant gates at three existing at-grade crossings, and install six communication radio towers. Additional right-of-way would be required in San Francisco and Brisbane to accommodate track modification, the East Brisbane LMF, Tunnel Avenue and Tunnel Avenue overpass, four-quadrant gates, and communication radio towers.

Source: Authority 2019

MAY 2019

Figure 2-8 San Francisco to South San Francisco Subsection—Alternative A

2.2.1.1 4th and King Street Station

The existing 4th and King Street Station would serve as the interim terminal station for the Project Section until the Downtown Extension (DTX) provides HSR access to the Salesforce Transit Center (SFTC). Figure 2-9 depicts the site plan for the interim station. Station improvements would include installing a booth for HSR ticketing and support services, adding HSR fare gates, and modifying existing tracks and platforms. Until the DTX can provide service to the SFTC, passengers would be required to use alternative methods of transportation to get there (e.g., San Francisco Municipal Railway [MUNI], ride-share program, or walk). Figures 2-10 and 2-11 present a cross-section view of the HSR tracks and platforms at 4th and King Street Station looking northeast.

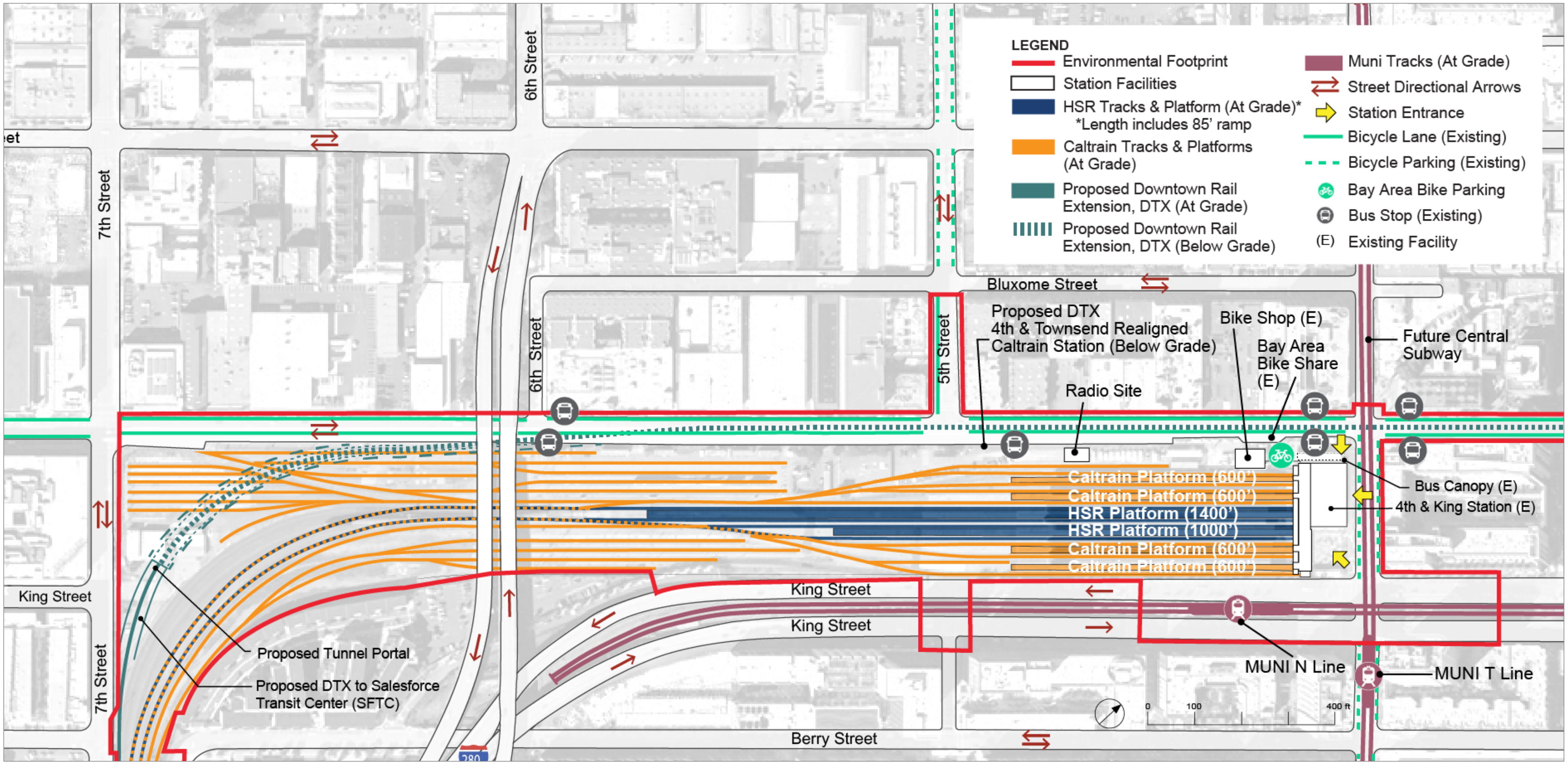
To support HSR operations, two existing Caltrain platforms in the center of the station yard would be raised and lengthened to serve four northbound and southbound HSR tracks. The HSR platforms would be approximately 4.25 feet high, with lengths of 1,000 feet for the platform on the east and 1,400 feet for the platform on the west. Ramps would be installed to provide pedestrian access from the station building to the raised platforms. Four existing Caltrain platforms, 600 feet long, would remain on either side of the HSR platforms to serve eight Caltrain tracks.

2.2.1.2 East Brisbane Light Maintenance Facility

The East Brisbane LMF would be built south of the San Francisco tunnels on approximately 100 acres east of the Caltrain corridor. Direct HSR mainline track access would be provided along double-ended yard leads that would cross over the mainline track on an aerial flyover at the north end, with an at-grade track entering the LMF from the south. Transition tracks (approximately 1,400 feet long) would allow trains to reduce or increase speed when entering or exiting the East Brisbane LMF.

The East Brisbane LMF (Figure 2-12) would include a maintenance yard with 17 yard tracks adjacent and parallel to a maintenance building containing eight shop tracks with interior access and inspection pits for underside and truck inspections. The maintenance building would provide storage areas for reserve equipment, workshops, and office space. A power generator, sewage system, cistern, collection point, and electrical substation would be north of the maintenance building with a 400-space surface parking lot for automobiles and trucks east of the maintenance building. An access road would connect the facility to the realigned Tunnel Avenue.

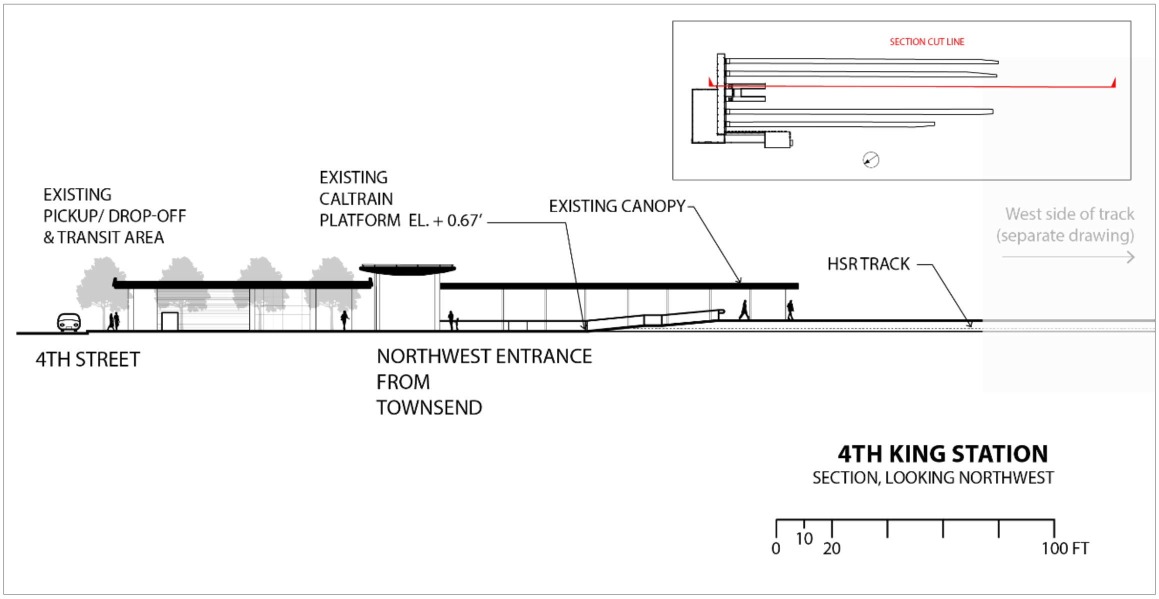
The track modifications associated with the East Brisbane LMF would require relocating the Bayshore Caltrain Station (described in Section 2.2.1.3, Track and Station Modifications), demolishing and relocating the Tunnel Avenue overpass, widening the bridge crossing of Guadalupe Valley Creek in Brisbane, and relocating control point (CP) Geneva. The reconstructed Tunnel Avenue overpass would connect to Bayshore Boulevard at its intersection with Valley Drive (north of its existing connection). The widened Guadalupe Valley Creek Bridge would support the East Brisbane LMF lead tracks where they cross the creek. Track modification near CP Geneva could require relocating the overhead signal pole.



Source: Authority 2019

MAY 2019

Figure 2-9 4th and King Street Station Site Plan—Alternatives A and B



Source: Authority 2019

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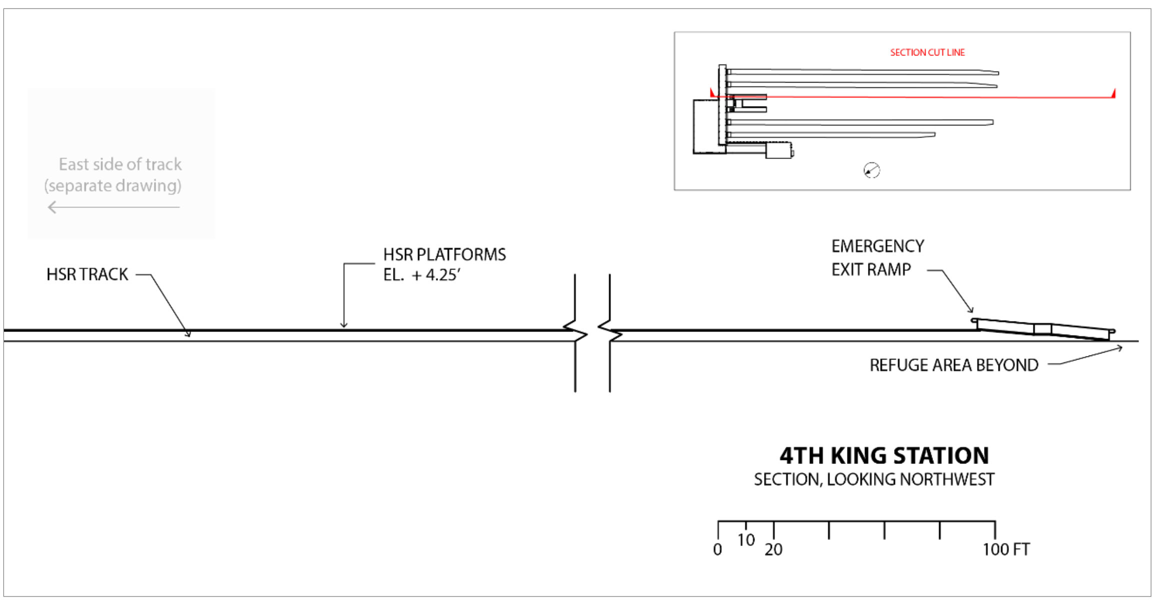
Figure 2-10 4th and King Street Station Cross Section (Northern Portion)—Alternatives A and B



Source: Authority 2019

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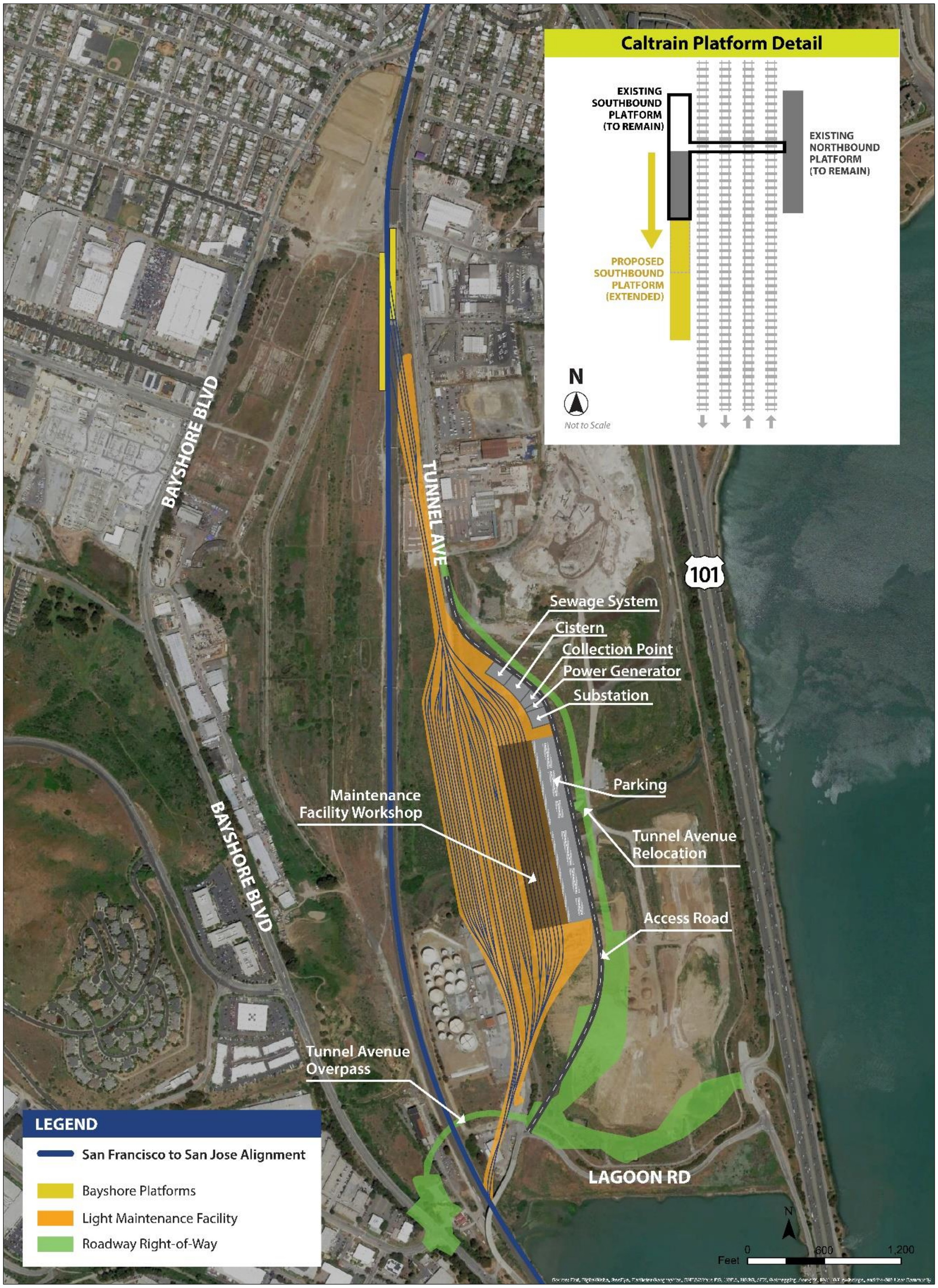
Figure 2-11 4th and King Street Station Cross Section (Southern Portion)—Alternatives A and B



JUNE 2021

Figure 2-12 East Brisbane Light Maintenance Facility Layout—Alternative A

2.2.1.3 Track and Station Modifications

Track and station modifications in the San Francisco to South San Francisco Subsection (Figure 2-8) are predominantly associated with the 4th and King Street Station modifications and the East Brisbane LMF. To accommodate the realignment of the mainline tracks for the East Brisbane LMF, the existing southbound platform at the Bayshore Caltrain Station would be extended further south; the northern portion of the extended platform would serve as a walkway to access trains stopped on the southern portion of the platform (inset on Figure 2-12). The extended southbound platform at the Bayshore Caltrain Station would be closer to the planned Geneva Avenue extension, which would extend from Bayshore Boulevard to U.S. Highway (US) 101.

Track modifications not associated with the 4th and King Street Station, the approach to the 4th and King Street Station, and East Brisbane LMF would be limited to minor track shifts of less than 1 foot within the existing right-of-way in San Francisco and South San Francisco, and track modifications in South San Francisco to accommodate the planned South San Francisco Caltrain Station Improvement Project being implemented by Caltrain in coordination with the City of South San Francisco. The South San Francisco Caltrain Station Improvement Project, which is anticipated to be completed in summer 2021, would replace the existing South San Francisco Station platforms (which are subject to the hold-out rule) with a standard center boarding platform connected to a pedestrian underpass, to improve safety and eliminate the hold-out rule. The project would shift tracks up to 27 feet, install crash barriers at the Grand Avenue overpass, and replace columns that support the US 101 overpass with a pair of solid pier walls.

2.2.1.4 Safety and Security Modifications to the Right-of-Way

To improve safety, four-quadrant gates would be installed at three at-grade crossings in the subsection—Mission Bay Drive, 16th Street, and Linden Avenue (Figure 2-8). Table 2-1 specifies the four-quadrant gate application for each at-grade crossing, and Figures 2-3, 2-4, and 2-5 illustrate the configurations of these applications. Perimeter fencing (Figure 2-6) would be installed along the right-of-way where it does not already exist.

2.2.1.5 Train Control and Communication Facilities

There would be six communication radio towers in this subsection (Figure 2-8). Two site options are evaluated for each standalone communications radio tower, with the exception of a single site option at 4th and King Street Station and at Blanken Avenue; however, only one site would be selected for construction at each site:

- Standalone radio tower at the 4th and King Street Station in San Francisco (one site option)
- Co-located radio tower at Caltrain's Paralleling Station 1 in the Potrero Hill neighborhood of San Francisco
- Standalone radio tower in the Bayview neighborhood of San Francisco (either at Jerrold Avenue or Newcomb Avenue)
- Standalone radio tower at Blanken Avenue in Brisbane (one site option)
- Standalone radio tower in Brisbane adjacent to Bayshore Boulevard (two site options)
- Co-located radio tower at Caltrain's TPSS 1 in South San Francisco

2.2.2 San Bruno to San Mateo Subsection

The San Bruno to San Mateo Subsection would extend approximately 8 miles from Linden Avenue in South San Francisco to Ninth Avenue in San Mateo through South San Francisco, San Bruno, Millbrae, Burlingame, and San Mateo. The existing Caltrain track in this subsection is predominantly two-track at grade on retained fill with a three-track at-grade section south of the Millbrae Caltrain Station. As illustrated on Figure 2-13, this alternative would modify the existing San Bruno, Millbrae, and Broadway Caltrain Stations; modify track; install four-quadrant gates at 16 existing at-grade crossings; and install three communication radio towers. Additional right-of-way would be required in Millbrae, Burlingame, and San Mateo associated with communication radio towers, the Millbrae Station modifications to accommodate HSR service, track modifications, roadway relocations, and four-quadrant gates.

2.2.2.1 Millbrae Station

New HSR infrastructure would be constructed at the existing Millbrae Bay Area Rapid Transit (BART)/Caltrain Intermodal Station. As illustrated on Figure 2-14, new HSR station facilities on the west side of the existing Caltrain corridor would include a new station entrance with ticketing and support services along El Camino Real. The station area design would provide intermodal connectivity with Caltrain and BART via an overhead pedestrian crossing that would extend from the new station entrance over the extension of California Drive, connecting to the existing station concourse with vertical circulation elements (stairs, escalators and elevators) providing access to HSR, Caltrain, and BART platforms.

The primary access to the Millbrae HSR Station is intended to be by transit (Caltrain, BART, San Mateo County Transit District [SamTrans]), bicycles, walking and vehicle pick-up and drop-off. Pick-up and drop-off facilities for vehicles would accommodate shuttles, taxis, car sharing, network transportation services and private vehicles.

Enhanced automobile access would be provided on the west side of the station through the extension of California Drive to Victoria Avenue. Curbside passenger pick-up and drop-off facilities west of the station would be located along the new extension of California Drive and El Camino Real; facilities east of the station would be located on the first level of the BART parking structure. Replacement parking for displaced Caltrain and BART parking would be provided at four surface parking lots on the west side of the alignment, with a fifth parking area at Murchison Drive with 37 parking spots for HSR passengers. HSR passengers desiring to drive and park would be able to use available long-term commercial parking located off-site or at the San Francisco International Airport (SFO) and arrive at the station by shuttle.

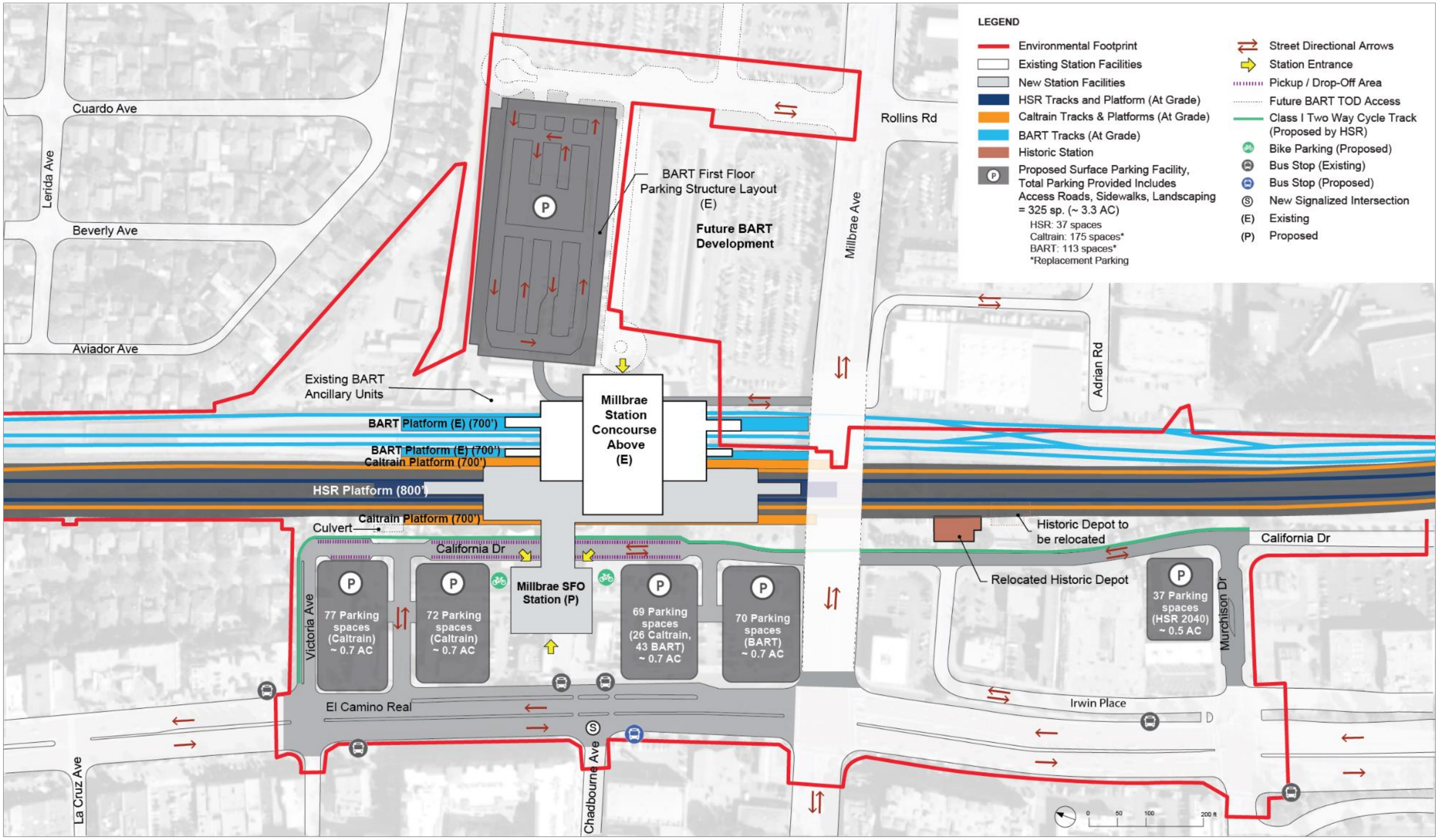
The SamTrans bus stops would be located along El Camino Real at the new signalized intersection and pedestrian crossings at Chadbourne Avenue, with direct access to the station. A new dedicated bike path would provide west side bicycle access to the station. Figures 2-15 and 2-16 illustrate cross-section views of the Millbrae Station looking south.

Track modifications extending approximately 1 mile north and south of the station would require additional right-of-way along the west side of the Caltrain corridor and modification of existing Caltrain tracks, station platforms, and structures. Constructing two new tracks would require widening the Hillcrest Boulevard underpass north of the Millbrae Station. At the station, the existing BART tracks and platforms and the easternmost Caltrain track (mainline track [MT]1) and platform would remain unchanged. The westernmost Caltrain track (MT2) would be shifted west by up to 40 feet for construction of two new tracks serving an 800-foot-long center HSR platform and a new Caltrain MT2 outboard platform. The historic Southern Pacific Depot/Millbrae Station (previously relocated to accommodate station improvements) and associated surface parking along California Drive would be relocated to accommodate these track modifications.

Source: Authority 2019

MAY 2019

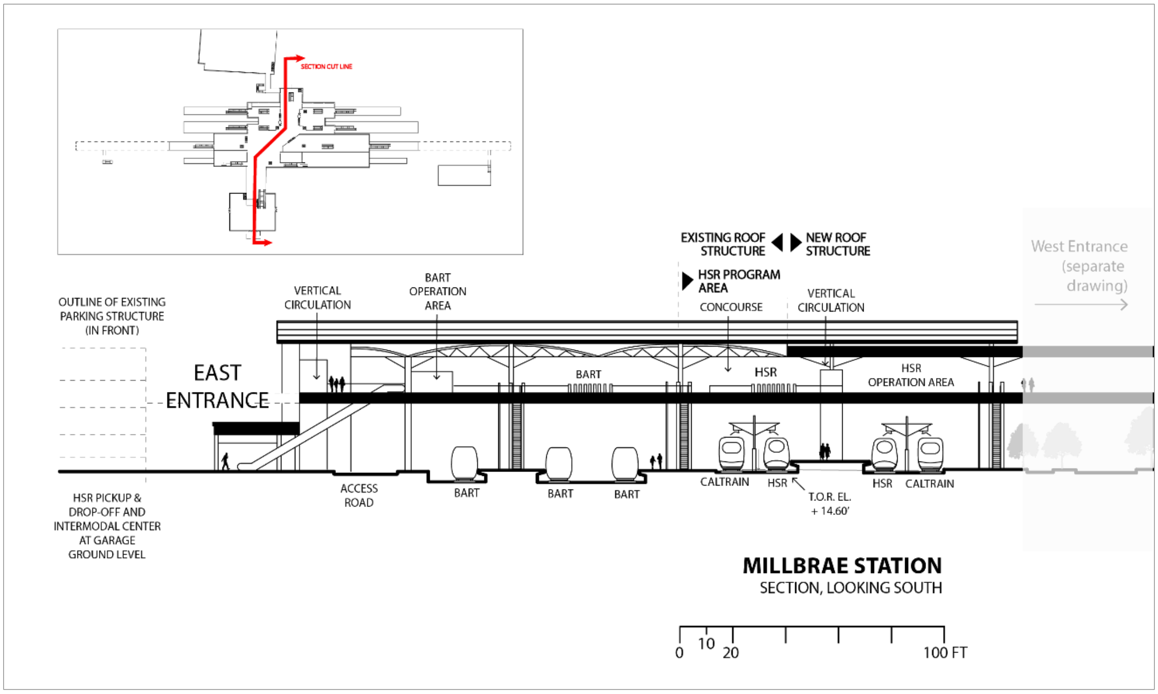
Figure 2-13 San Bruno to San Mateo Subsection—Alternatives A and B



Source: Authority 2019

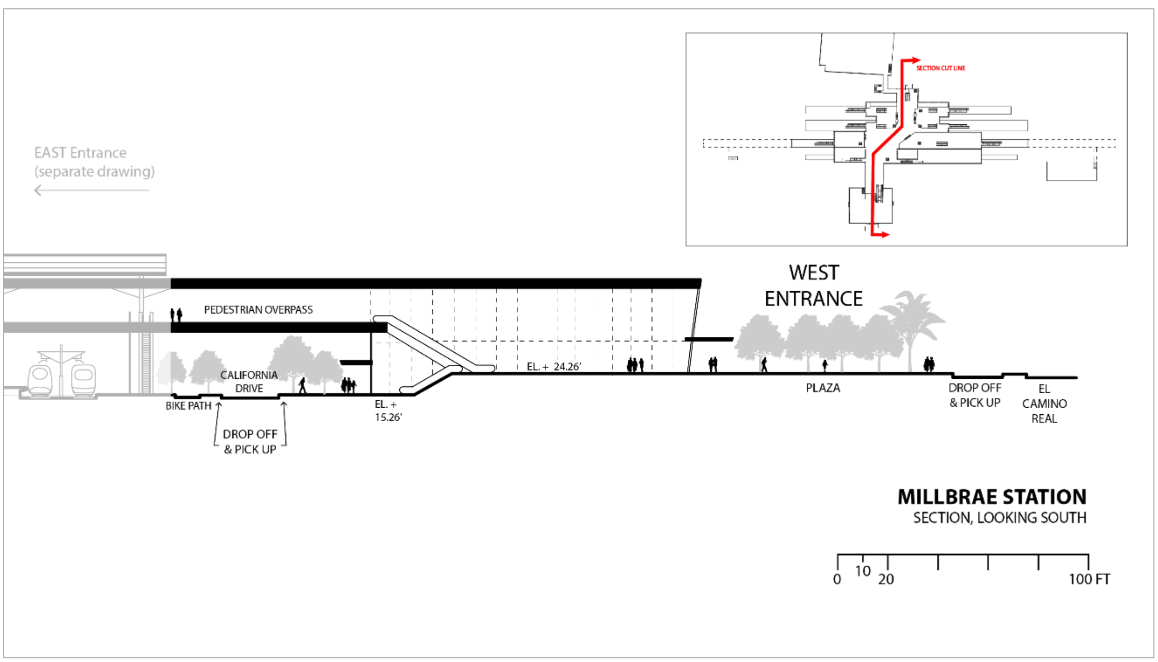
MAY 2019

Figure 2-14 Millbrae Station Site Plan—Alternatives A and B



Source: *Authority 2019* MAY 2019

Figure 2-15 Millbrae Station Cross Section (East Entrance)—Alternatives A and B



Source: *Authority 2019* MAY 2019

Figure 2-16 Millbrae Station Cross Section (West Entrance)—Alternatives A and B

2.2.2.2 Track and Station Modifications

Track and station modifications in this subsection include curve straightening near the San Bruno Station, platform modifications at the Broadway Station to eliminate the hold-out rule, and several minor track shifts in San Bruno and San Mateo. The curve straightening at the San Bruno Station would require an extension of the existing platforms approximately 145 feet south, and relocation of the existing stairs/ramps from the northern to southern side of the northbound platform. The Euclid Avenue pedestrian underpass, just north of the San Bruno Station, would be widened to support the realigned tracks, and the concrete retaining wall along the east side would be modified to accommodate the realigned tracks. Safety-related modifications would be made to the Broadway Station, including platform upgrades that would eliminate the hold-out rule by adding a second outboard platform to serve the northbound track and extending the southbound platform (Figure 2-2). The southbound platform extension would affect the station's surface parking along California Drive, and minor track shifts south of the Broadway Station would require widening of the Sanchez Creek and Mills Creek Culverts.

2.2.2.3 Safety and Security Modifications to the Right-of-Way

To improve safety four-quadrant gates and channelizers would be installed at 16 at-grade crossings: Scott Street, Center Street, Broadway, Oak Grove Avenue, North Lane, Howard Avenue, Bayswater Avenue, Peninsula Avenue, Villa Terrace, Bellevue Avenue, First Avenue, Second Avenue, Third Avenue, Fourth Avenue, Fifth Avenue, and Ninth Avenue. As illustrated on Figure 2-13, most of these crossings are in Burlingame and San Mateo. Table 2-1 specifies the four-quadrant gate application for each at-grade crossing, and Figures 2-3, 2-4, and 2-5 illustrate the configurations of these applications. Perimeter fencing (Figure 2-6) would be installed along the right-of-way where it does not already exist.

2.2.2.4 Train Control and Communication Facilities

Three communication radio towers would be built in the subsection. Locations of these facilities—a new standalone radio tower near SFO (at either San Marco Avenue or Santa Lucia Avenue), a co-located radio tower at Paralleling Station 3 in Burlingame, and a new standalone radio tower in San Mateo near Cypress or 2nd Avenue—are illustrated on Figure 2-13. Two site options are evaluated for each standalone communications radio tower; however, only one site would be selected for construction.

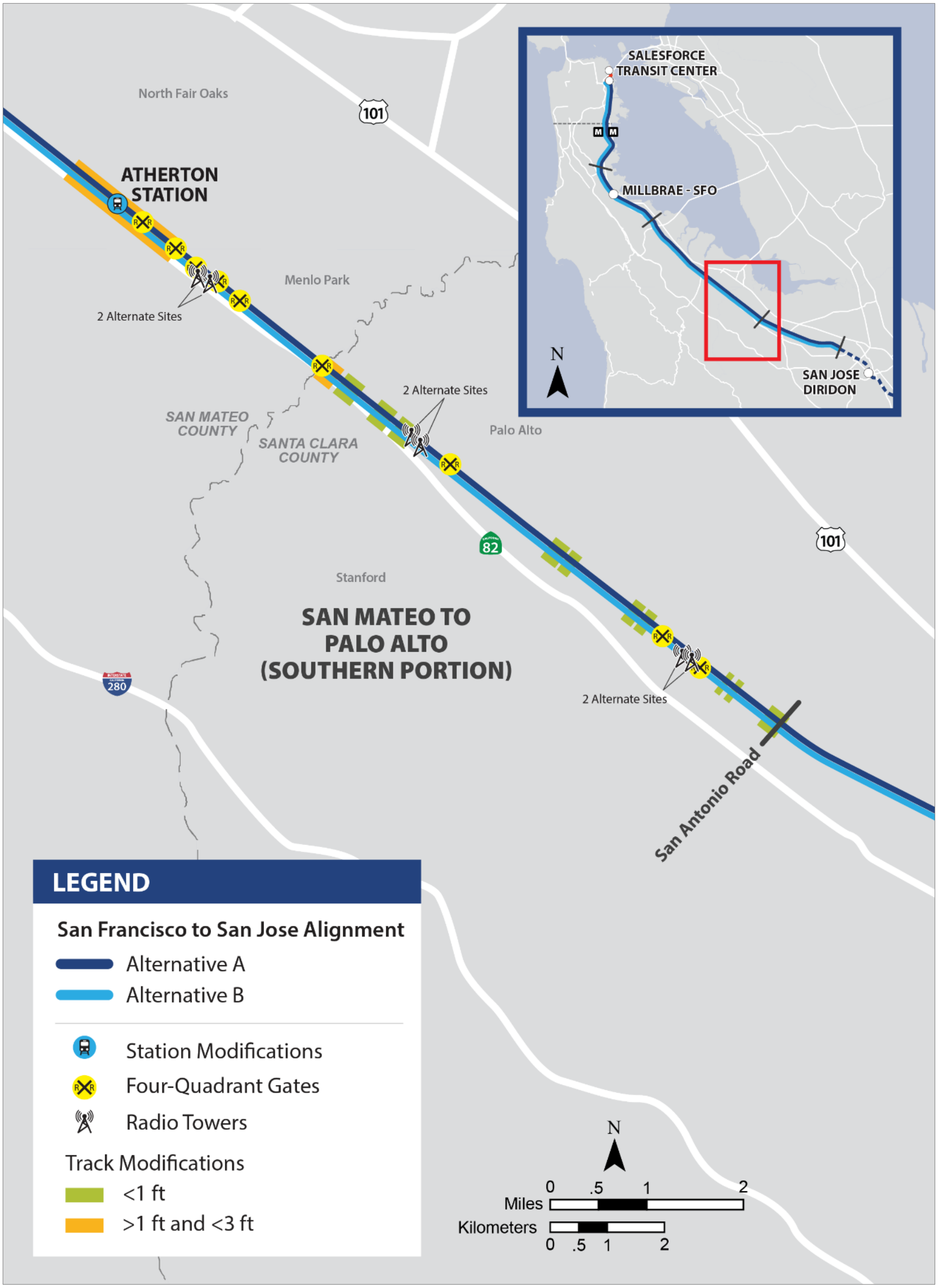
2.2.3 San Mateo to Palo Alto Subsection

The San Mateo to Palo Alto Subsection would extend approximately 16 miles from Ninth Avenue in San Mateo to San Antonio Road in Palo Alto through San Mateo, Belmont, San Carlos, Redwood City, Atherton, Menlo Park, and the northern portion of Palo Alto. The existing Caltrain track in this subsection is predominantly two-track at grade on retained fill. As illustrated on Figures 2-17 and 2-18, this alternative would modify platforms at the existing Hayward Park and Atherton Stations, modify tracks, install four-quadrant gates at 15 existing at-grade crossings, and install 7 communication radio towers. Minor amounts of additional right-of-way would be required in San Mateo, Belmont, San Carlos, Redwood City, Menlo Park, and Palo Alto for the siting of four-quadrant gates and communication radio towers.

Source: Authority 2019

MAY 2019

Figure 2-17 San Mateo to Palo Alto Subsection (Northern Portion)—Alternative A



Source: Authority 2019

MAY 2019

Figure 2-18 San Mateo to Palo Alto Subsection (Southern Portion)—Alternatives A and B

2.2.3.1 Track and Station Modifications

Track and station modifications in this subsection (Figures 2-17 and 2-18) consist of curve straightening predominantly in San Mateo, Belmont, San Carlos, and Palo Alto, platform modifications at the Hayward Park Station to accommodate curve straightening, and platform modifications at the Atherton Station to remove the hold-out rule by extending the southbound platform and adding a second outboard platform to serve the northbound track. In several locations, these track modifications would result in modifications to existing Caltrain structures; track shifts south of Ralston Street in Belmont and north of Holly Street in San Carlos would require the modifying the existing retaining walls along the west side of the Caltrain corridor to accommodate the shifted track. The HSR project would be compatible with Caltrain and the City of San Mateo's planned 25th Avenue Grade-Separation Project. This grade-separation project, expected to be built by 2020, would elevate the existing at-grade track between State Route (SR) 92 and Hillsdale Boulevard to provide a grade-separated undercrossing of 25th Avenue, build new east-west crossings under the track corridor at 28th and 31st Avenues, and relocate Hillsdale Station. No design changes to the 25th Avenue Grade-Separation Project are expected to result from the blended system.

2.2.3.2 Safety and Security Modifications to the Right-of-Way

To improve safety four-quadrant gates and median barriers would be installed at 15 at-grade crossings: Whipple Avenue, Brewster Avenue, Broadway, Maple Street, Main Street, Chestnut Street, Watkins Avenue, Encinal Avenue, Glenwood Avenue, Oak Grove Avenue, Ravenswood Avenue, Alma Street, Churchill Avenue, Meadow Drive, and West Charleston Road. As illustrated on Figures 2-17 and 2-18, most of these crossings are in Redwood City, Menlo Park, and Palo Alto. Table 2-1 specifies the four-quadrant gate application that would be applicable to each at-grade crossing, and Figures 2-3, 2-4, and 2-5 illustrate the configurations for these applications. Perimeter fencing would be installed along the right-of-way where it does not already exist (Figure 2-6).

2.2.3.3 Train Control and Communication Facilities

Seven communication radio towers would be built (Figures 2-17 and 2-18). Two site options are evaluated for each standalone communications radio tower; however, only one site would be selected for construction at each location:

- Co-located radio tower at Caltrain's Paralleling Station 4 south in San Mateo
- Standalone radio tower near the Belmont Station (either Middle Road or Ralston Avenue)
- Standalone radio tower in San Carlos (either near El Camino Real/Central Avenue or Center Street)
- Co-located radio tower at Caltrain's Switching Station 1, Option 2 in Redwood City
- Standalone radio tower in Menlo Park (either at Derby Lane or Ravenswood Avenue)
- Standalone radio tower in Palo Alto north of Embarcadero Road
- Standalone radio tower in Palo Alto north of West Charleston Road

2.2.4 Mountain View to Santa Clara Subsection

The Mountain View to Santa Clara Subsection would extend approximately 9 miles from San Antonio Road in Palo Alto to Scott Boulevard in Santa Clara through Palo Alto (southern portion), Mountain View, Sunnyvale, and Santa Clara. The existing Caltrain track in this subsection is predominantly two-track at grade (except for the four-track section from North Fair Oaks to north of Bowers Avenue) and there are no major project features in this subsection. As illustrated on Figure 2-19, this alternative would make minor track modifications, install four-quadrant gates at four at-grade crossings, and install four communication radio towers. Minor amounts of additional right-of-way would be required in Palo Alto, Mountain View, and Sunnyvale for communication radio towers.

2.2.4.1 Track and Station Modifications

Minor track shifts of less than 1 foot would be required in several locations in Mountain View, Sunnyvale, and Santa Clara. The largest track shift in this subsection would be a shift of 2.5 feet near Bowers Avenue in Santa Clara. None of these track shifts would require modifying existing Caltrain structures or stations.

2.2.4.2 Safety and Security Modifications to the Right-of-Way

To improve safety, four-quadrant gates and median barriers would be installed at four at-grade crossings in Mountain View and Sunnyvale: Rengstorff Avenue, Castro Street, Mary Avenue, and Sunnyvale Avenue (Figure 2-19). Table 2-1 specifies the four-quadrant gate application for each at-grade crossing, and Figures 2-3, 2-4, and 2-5 illustrate the configurations of these applications. Perimeter fencing would be installed along the right-of-way where it does not already exist.

2.2.4.3 Train Control and Communication Facilities

Four communication radio towers would be installed (Figure 2-19). Two site options are evaluated for each standalone communications radio tower; however, only one site would be selected for construction at each location:

- Standalone radio tower in Mountain View
- Standalone radio tower in Sunnyvale east of SR 237
- Co-located radio tower at Caltrain’s Paralleling Station 6 near the Sunnyvale Station
- Standalone radio tower in Sunnyvale east of County Road G2

Source: Authority 2019

MAY 2019

Figure 2-19 Mountain View to Santa Clara Subsection—Alternatives A and B

2.3 Alternative B

Alternative B would modify approximately 17.4 miles of existing Caltrain track, predominantly within the existing Caltrain right-of-way, build the West Brisbane LMF and a four-track passing track, modify 10 existing stations or platforms to accommodate HSR, and install safety improvements and communication radio towers. Table 2-3 summarizes the alternative's design features, followed by a more detailed description by subsection.

Table 2-3 Summary of Design Features for Alternative B

Feature	Alternative B
Length of existing Caltrain track (miles)[1]	42.9
Length of modified track (miles)[1]	17.4
Length of track modification <1 ft (miles)[1]	4.3
Length of track modification >1 ft and <3 ft (miles)[1]	1.9
Length of track modification > 3 ft (miles)[1]	11.2
Length of OCS pole relocation (miles)[1, 2]	13.1
LMF	West Brisbane
Modified stations	
Modifications to HSR stations	4th and King Street; Millbrae
Modifications to Caltrain stations due to the LMF	Bayshore (relocated)
Modifications to Caltrain stations due to the passing tracks	Hayward Park; Hillsdale; Belmont; San Carlos (relocated)
Modifications to Caltrain stations due to track shifts	San Bruno
Modifications to Caltrain stations to remove hold-out rule	Broadway; Atherton
Number of modified or new structures[3]	35
New structures	3
Modified structures	18
Replaced structures	7
Affected retaining walls	7
Number of at-grade crossings with safety modifications (e.g., four-quadrant gates, median barriers)	38
Length of new perimeter fencing	8.7
Communication radio towers	20

Source: Authority 2019
LMF = light maintenance facility
OCS = overhead contact system
[1] Lengths shown are guideway mileages.
[2] OCS pole relocations are assumed for areas with track shifts greater than 1 foot.
[3] Structures include bridges, grade separations such as pedestrian underpasses and overpasses, tunnels, retaining walls, and culverts.

2.3.1 San Francisco to South San Francisco Subsection

The Alternative B characteristics in this subsection would be predominantly the same as those described for Alternative A in Section 2.2.1, San Francisco to South San Francisco Subsection. Siting the LMF on the west side of the Caltrain corridor (West Brisbane LMF) would, however, require different track, roadway, and Bayshore Station modifications than described for Alternative A. Locations of track modifications, safety and security improvements, and communication radio towers in this subsection are illustrated on Figure 2-20.

Source: Authority 2019

MAY 2019

Figure 2-20 San Francisco to South San Francisco Subsection—Alternative B

2.3.1.1 West Brisbane Light Maintenance Facility

The West Brisbane LMF would be built south of the San Francisco Caltrain tunnels on approximately 110 acres west of the Caltrain corridor. Direct mainline track access would be along double-ended yard leads that would cross over the mainline track on aerial flyover and would enable north and south movements. The four existing mainline tracks would be shifted west by up to 16.5 feet, and new yard leads connecting to the West Brisbane LMF would be constructed east and west of the existing tracks. The yard leads east of the existing tracks would cross over the realigned four-track alignment on an aerial flyover to avoid train operations on the mainline track, converging with the yard leads on the west side of the track alignment. Transition tracks (approximately 1,400 feet long) would allow trains to reduce or increase speed when entering or exiting the LMF.

The West Brisbane LMF (Figure 2-21) would include a maintenance yard with 17 yard tracks parallel to a runaround track and a maintenance building with shop tracks. A power generator, sewage system, cistern, collection point, and an electrical substation would be located north of the maintenance building. A 400-space surface parking lot would be provided west of the maintenance building with truck and vehicle access to Industrial Way, which parallels and connects to Bayshore Boulevard.

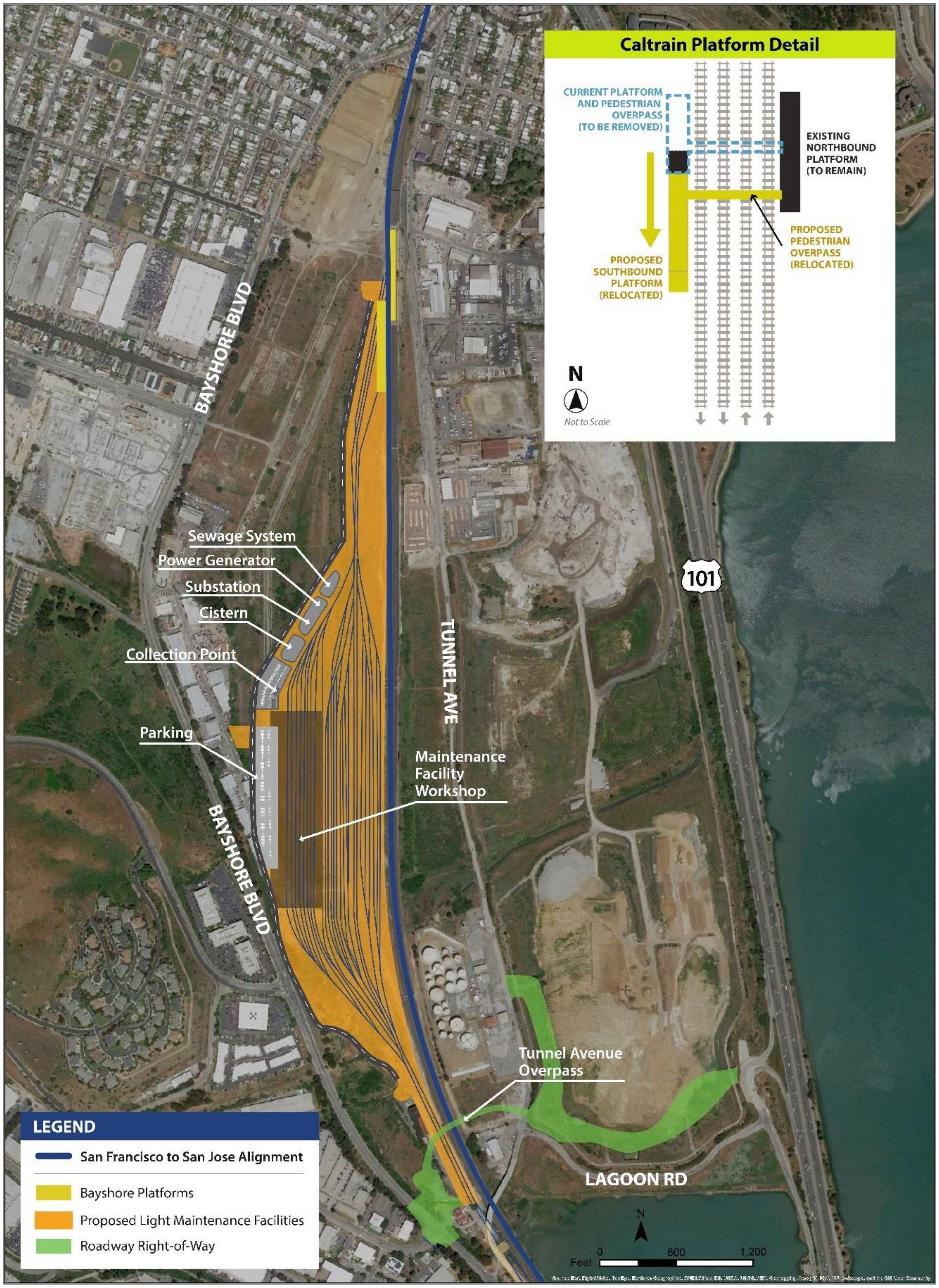
Track modifications associated with the West Brisbane LMF would require relocating the Tunnel Avenue overpass, widening the bridge crossing Guadalupe Valley Creek in Brisbane, and relocating CP Geneva at its intersection with Valley Drive. The widened Guadalupe Valley Creek Bridge would support the West Brisbane LMF lead tracks where they cross the creek. Track modification near CP Geneva could require relocating the overhead signal pole.

2.3.1.2 Track and Station Modifications

Track and station modifications in the San Francisco to South San Francisco Subsection for Alternative B (Figure 2-20) would predominantly be associated with the West Brisbane LMF. The realignment of the mainline tracks for the West Brisbane LMF would require relocation of the Bayshore Caltrain Station and pedestrian overpass. The Bayshore Caltrain Station and associated surface parking lot, southbound platform, and a new pedestrian overpass would be reconstructed approximately 0.2 mile south of the existing station (inset on Figure 2-21). The new pedestrian overpass would provide access to the reconstructed station by connecting to Tunnel Avenue on the east and the planned local roadway network envisioned in the *Draft Brisbane Baylands Specific Plan* on the west (City of Brisbane 2011). The Bayshore Caltrain Station would be closer to the planned future Geneva Avenue extension, which would extend from Bayshore Boulevard to US 101.

2.3.2 San Bruno to San Mateo Subsection

The characteristics of the San Bruno to San Mateo Subsection of Alternative B would be the same as those described for Alternative A in Section 2.2.2, San Bruno to San Mateo Subsection. The track and station modifications, safety and security improvements, Millbrae Station, and communication radio towers in this subsection are illustrated on Figure 2-13.



JUNE 2020

Figure 2-21 West Brisbane Light Maintenance Facility Layout

2.3.3 San Mateo to Palo Alto Subsection

In the San Mateo to Palo Alto Subsection, Alternative B would build a passing track through San Mateo and San Carlos and modify the Hayward Park, Hillsdale, Belmont and San Carlos Stations to accommodate the additional passing tracks. As illustrated on Figures 2-18 and 2-22, this alternative would modify existing track, install four-quadrant gates at 15 existing at-grade crossings, and install 7 communication radio towers. The platforms at the existing Atherton Station would be modified to eliminate the hold-out rule. While the northern portion of this subsection (Figure 2-22) differs from Alternative A because of the passing tracks and associated track and station modifications, the characteristics of the southern portion of the San Mateo to Palo Alto Subsection would be the same as those described for Alternative A in Section 2.2.3, San Mateo to Palo Alto Subsection (Figure 2-18). Additional right-of-way would be required in San Mateo, Belmont, San Carlos, Redwood City, Menlo Park, and Palo Alto associated with four-quadrant gates, communication radio towers, passing tracks, and the reconfiguration or relocation of existing Caltrain stations.

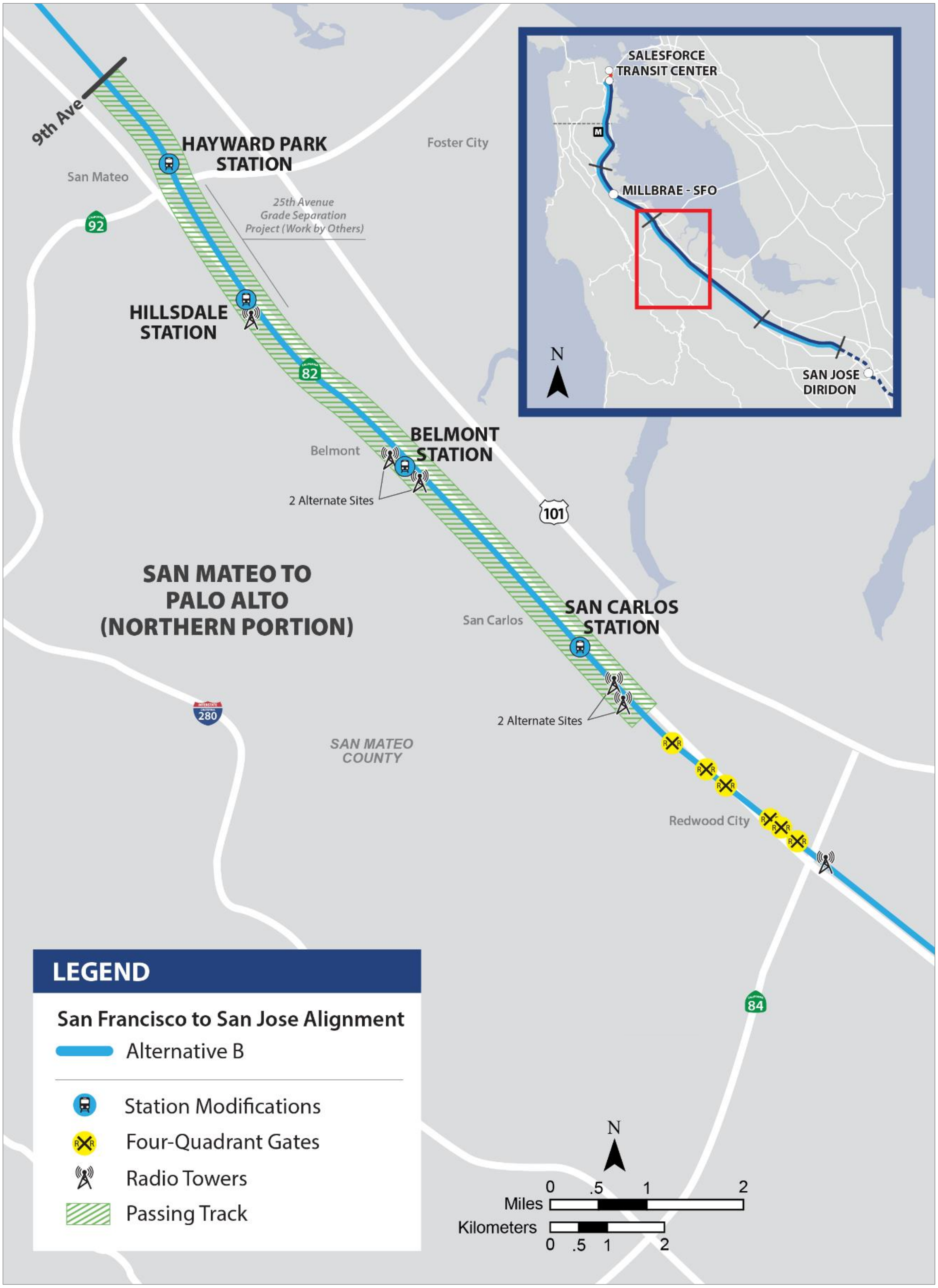
2.3.3.1 Passing Tracks

The approximately 6-mile-long passing track would extend through San Mateo, Belmont, San Carlos, and into the northern portion of Redwood City. South of Ninth Avenue in San Mateo, the two-track alignment would diverge to four tracks continuing at grade and on retained fill. The existing tracks would be realigned predominantly within the existing right-of-way to accommodate the new four-track configuration. Additional right-of-way would be required in some areas with particularly narrow existing rights-of-way or where curve straightening would be necessary to achieve higher speeds.

25th Avenue Grade Separation Project

This grade-separation project, which is being undertaken by Caltrain in coordination with the City of San Mateo, would elevate the existing at-grade track between State Route 92 and Hillsdale Boulevard to provide a grade-separated undercrossing of 25th Avenue, build new east-west crossings under the track corridor at 28th and 31st Avenues, and relocate the Hillsdale Station. Construction is expected to be completed in 2020.

Beginning in Hayward Park north of the SR 92 crossing, the tracks on retained fill would be shifted up to 46 feet, requiring acquisition of additional right-of-way. New outboard platforms, a pedestrian underpass at the Hayward Park Caltrain Station, and a new structure south of the SR 92 overpass would be built to carry the reconfigured four-tracks over the Borel Creek Culvert. South of the Hayward Park Station, the passing tracks would use the infrastructure installed by the planned 25th Avenue Grade Separation Project (see text box). A new retaining wall would be installed between SR 92 and Hillsdale Boulevard to match the elevation of the 25th Avenue Grade Separation Project, along with new bridge structures for the two new tracks at Borel Creek and 25th, 28th, and 31st Avenues. Additionally, a northbound Hillsdale Station platform would be built, eliminating some existing parking at the Hillsdale Station. At Hillsdale Boulevard, the existing underpass structure would be widened to accommodate the realigned tracks, along with widening of the existing Laurel Creek underpass to the south.



Source: Authority 2019

MAY 2019

Figure 2-22 San Mateo to Palo Alto Subsection (Northern Portion)—Alternative B

South of Hillsdale Boulevard, the passing tracks would ascend to a four-track aerial viaduct. Between Hillsdale Boulevard and Whipple Avenue, the following structures or facilities would be replaced or rebuilt: CP Ralston tie-in points, Belmont Station platforms, and San Carlos Station and platforms. The Belmont Station and platforms would be reconstructed to accommodate the new four-track configuration. The San Carlos Station and platforms would be relocated approximately 2,260 feet south of their currently location to Arroyo Avenue and a pedestrian underpass would be constructed. The following structures would be removed and replaced or modified: 42nd Avenue underpass, Belmont Caltrain Station pedestrian underpass, Ralston Avenue underpass, Harbor Boulevard underpass, F Street pedestrian underpass, Holly Street and San Carlos Station pedestrian underpass, Arroyo Avenue pedestrian underpass, Brittan Avenue, and Howard Avenue. South of Howard Avenue, Alternative B would descend to grade and converge back to a two-track configuration.

2.3.3.2 Track and Station Modifications

The track and station modifications under Alternative B would vary from those described for Alternative A in Section 2.2.3 in the northern portion of the subsection between Ninth Avenue in San Mateo and Whipple Avenue in Redwood City. In this portion of the subsection, the addition of two passing tracks would result in modifications to the existing Hayward Park, Hillsdale, Belmont, and San Carlos Caltrain Stations. Alternative B would modify and realign station platforms at the Hayward Park Caltrain Station, build new platforms at the Hillsdale and Belmont Caltrain Stations, and relocate the San Carlos Caltrain Station approximately 2,260 feet south of its existing location (Figure 2-23).

South of Whipple Avenue, the track and station modifications in the southern portion of this subsection would be the same as those described for Alternative A. Safety-related modifications would be made to the Atherton Station, including platform upgrades that would eliminate the hold-out rule by extending the southbound platform and adding a second outboard platform to serve the northbound track (Figure 2-2).

2.3.4 Mountain View to Santa Clara Subsection

The characteristics of the Mountain View to Santa Clara Subsection under Alternative B would be the same as those described for Alternative A. The locations for track modifications, safety and security improvements, and communication radio towers within this subsection are illustrated on Figure 2-19.

Source: Authority 2019

MAY 2019

Figure 2-23 San Carlos Station Relocation—Alternative B

2.4 Impact Avoidance and Minimization Features

The Authority has developed IAMFs as standard practices, actions, and design features that are incorporated into the project. The description of each IAMF details the means and effectiveness of the feature in addressing affected resources, as well as the environmental benefits of implementing the feature. Table 2-4 shows complete descriptions of the IAMF related to noise and vibration.

Table 2-4 Noise and Vibration Impact Avoidance and Minimization Features

IAMF	Description
NV-IAMF#1: Noise and Vibration	Prior to construction, the contractor would prepare and submit to the Authority 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 being conducted within 1,000 feet of sensitive receptors. Typical construction practices contained in the FTA and FRA guidelines for minimizing construction noise and vibration impacts include the following: ▪ Construct 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, when possible. ▪ Construct walled enclosures around especially noisy activities or around clusters or noise 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 time period. ▪ Avoid impact pile driving where possible in vibration-sensitive areas.

Authority = California High-Speed Rail Authority
FRA = Federal Railroad Administration
FTA = Federal Transportation Administration

3 LAWS, REGULATIONS, AND ORDERS

This chapter provides a summary of federal, state, and local laws, regulations, orders, or plans that pertain to noise and vibration in the geographic area that would be affected by the project.

3.1 Federal

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

The Noise Control Act of 1972 (42 United States Code [U.S.C.] § 4901) was the first comprehensive statement of national noise policy. It declared, “it is the policy of the U.S. 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 technical report were largely created in response to passage of the act.

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

The Occupational Safety and Health Administration has regulated worker noise exposure to a time-weighted average of 90 A-weighted decibels (dBA) over an 8-hour work shift. Areas where time-weighted average 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 construction activities in the RSA. Noise from construction activities might also elevate noise levels at nearby construction sites within approximately 140 feet to levels that exceed time-weighted average levels of 85 dBA and thus trigger the need for administrative or engineering controls and hearing conservation programs for worker safety, as detailed by the Occupational Safety and Health Administration.

3.1.3 Federal Railroad Administration

3.1.3.1 Noise and Vibration Impact Assessment Guidelines

The FRA provides guidance regarding the evaluation of noise and vibration impacts of HSR trains in the *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. Consistent with this guidance, the noise and vibration impact criteria are discussed in this technical report in Section 4.1.3, Impact Criteria, and Section 4.2.3, Impact Criteria, respectively.

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

The FRA’s Railroad Noise Emission Compliance Regulation (49 Code of Federal Regulations [C.F.R.] Part 210) prescribes 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, 93 dBA at 100 feet while moving at speeds greater than 45 mph.

Whether or not the USEPA standard applies to high-speed trainsets, the analysis in this technical report does not assume that HSR 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 HSR 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 technical report 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 would meet the USEPA standard.

3.1.3.3 Locomotive Horn Rule (49 C.F.R. Parts 222, 229)

FRA regulations require engineers to 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 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 Caltrain, 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 long 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, 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.

3.1.4 Federal Transit Administration

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 their *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 includes an impact assessment method that is applicable to HSR station activities, LMF activities, and conventional-speed rail operations. The FTA construction noise and vibration assessment method is consistent with the method described in the FRA guidance manual. Consistent with the FRA guidance, the noise and vibration impact criteria are discussed in this technical report in Section 4.1.3 and Section 4.2.3, respectively.

3.1.5 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 spaces/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-decibel (dB) increase in peak-noise-hour traffic noise is a significant increase as defined by the FHWA procedures.

3.2 State

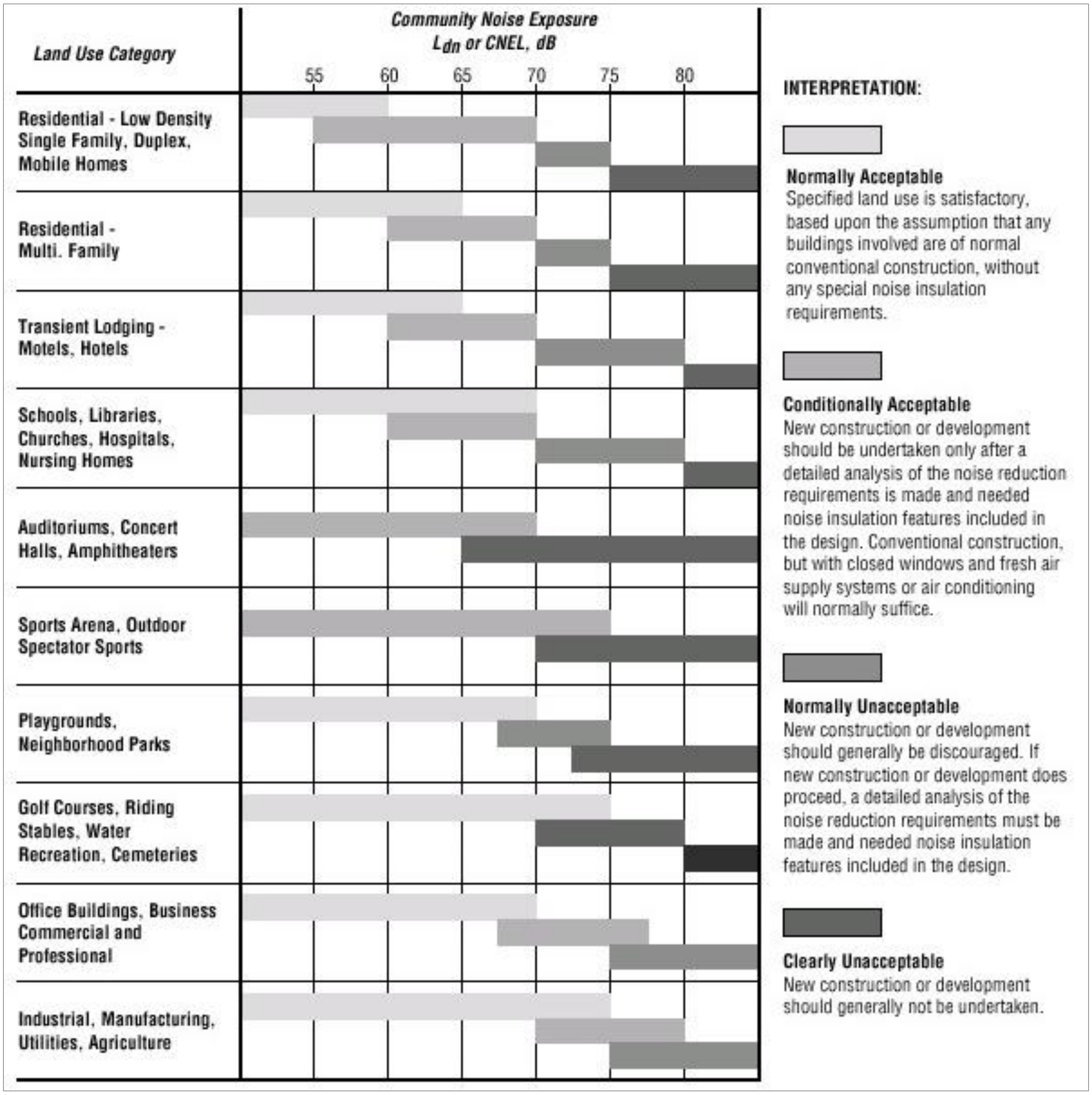
3.2.1 California Noise Control Act of 1973 (Cal. Health and Safety Code, Division 28, Noise Control Act, § 46000 et seq.)

The relevant legacy of the California Noise Control Act of 1973 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).

3.2.2 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 *State of California 2017 General Plan Guidelines* (California Governor’s Office of Planning and Research [OPR] 2017) outlines the development of the noise element for local agencies.

Figure 3-1 from the noise-compatible land use planning guidance 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.



Source: OPR 2017

Figure 3-1 State of California Land Use Compatibility Guidelines

3.2.3 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 takes place and for determining reasonable and feasible noise abatement measures. These criteria are relevant to the extent that the project would result in reconstruction or reconfiguration of an existing highway or traffic lanes, or would affect traffic patterns. Under FHWA (23 C.F.R. Part 772) and Caltrans policies, noise barriers should be considered for transportation improvement projects when various traffic NAC are exceeded.

3.3 Regional and Local

Counties and cities in California prepare general plans with noise policies and ordinances (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 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 (these would include the project alignments). Noise-level contours must be mapped for these sources using the community noise equivalent level (CNEL) or the day-night sound level (L_{dn}), and are to be used as a guide in land use decisions to minimize the exposure of community residents to excessive noise.

These noise elements often incorporate specific allowable noise levels to achieve a quality environment. Where airports exist, the general plans often include a section on airport land use compatibility with respect to noise so that new, noise-sensitive uses are not located near or do not encroach on areas surrounding airports. In some instances, general plans include the existing L_{dn} near airports. General plans may, but usually do not address ground-borne vibration. 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.

Table 3-1 shows a summary of noise and vibration elements in the plans and policies adopted by the cities and counties in the RSA that were identified and considered in the preparation of this analysis.

Table 3-1 Applicable Local Plans and Policies

Plan/Policy Document	Summary
City and County of San Francisco	
San Francisco General Plan, Environmental Protection Element (2004)	The Environmental Protection Element of the San Francisco General Plan was amended in December 2004. It establishes the overall policy framework for countywide land use and urban development, including noise and vibration. The plan includes the following objectives policies relevant to noise and vibration: Objective 9: Reduce transportation-related noise. ▪ Policy 9.1: Enforce noise emission standards for vehicles. ▪ Policy 9.2: Impose traffic restrictions to reduce transportation noise. ▪ Policy 9.3: Limit city purchases of vehicles to models with the lowest noise emissions and adequately maintain city-owned vehicles and travel surfaces. ▪ Policy 9.4: Regulate use of emergency sirens. ▪ Policy 9.5: Retain and expand the electric trolley network. ▪ Policy 9.6: Discourage changes in streets which will result in greater traffic noise in noise-sensitive areas. Objective 10: Minimize the impact of noise on affected areas. ▪ Policy 10.1: Promote site planning, building orientation and design, and interior layout that will lessen noise intrusion. ▪ Policy 10.2: Promote the incorporation of noise insulation materials in new construction ▪ Policy 10.3: Construct physical barriers to reduce noise transmission from heavy traffic carriers. Objective 11: Promote land uses that are compatible with various transportation noise levels. ▪ Policy 11.2: Consider the relocation to more appropriate areas of those land uses which need more quiet and cannot be effectively insulated from noise in their present location, as well as those land uses which are noisy and are presently in noise-sensitive areas. ▪ Policy 11.3: Locate new noise-generating development so that the noise impact is reduced.

<table>
<tr><th>Plan/Policy Document</th><th>Summary</th></tr>
<tr><td>San Francisco Police Code Article 29</td><td>The San Francisco Police Code Article 29: Regulation of Noise Guidelines for Noise Control Ordinance Monitoring and Enforcement establishes noise guidelines for San Francisco. The following sections from the code are relevant to the project:

SEC. 2907. Construction Equipment. [. . .] it shall be unlawful for any person to operate any powered construction equipment if the operation of such equipment emits noise at a level in excess of 80 dBA when measured at a distance of 100 feet from such equipment, or an equivalent sound level at some other convenient distance.

SEC. 2908. Construction Work at Night. It shall be unlawful for any person, between the hours of 8:00 p.m. and 7:00 a.m. to erect, construct, demolish, excavate for, alter or repair any building or structure if the noise level created thereby is in excess of the ambient noise level by 5 dBA at the nearest property plane [. . .]

Section 2909. Noise Limits. This section summarizes the noise limits for various property types:
▪ Residential Property Noise Limits: No person or machine will be allowed to produce a noise level more than five dBA above the ambient on residential property or more than five dBA above the local ambient three feet from any wall, floor, or ceiling inside any dwelling unit on a multi-unit residential property.
▪ Commercial and Industrial Noise Limits: No person or machine will be allowed to produce a noise level more than eight dBA above the local ambient on commercial or industrial property.
▪ Public Property Noise Limits: No person or machine will be allowed to produce a noise level more than ten dBA above the local ambient at a distance of twenty-five feet or more from a public property unless the machine or device is being operated to serve or maintain the property.
▪ Fixed Residential Interior Noise Limits: No fixed noise source may cause the noise level measured inside any sleeping or living room in any dwelling unit located on residential property to exceed 45 dBA between the hours of 10:00 p.m. to 7:00 a.m. or 55 dBA between the hours of 7:00 a.m. to 10:00p.m. with windows open except where building ventilation is achieved through mechanical systems that allow windows to remain closed.</td></tr>
<tr><td colspan="2">San Mateo County</td></tr>
<tr><td>San Mateo County General Plan (2013)</td><td>The San Mateo County General Plan was adopted in 1986, and the policies were updated in 2013. The plan includes the following objectives policies relevant to noise and vibration:

Goals and Objectives
▪ Policy 16.1: Strive Toward a Livable Noise Environment. Strive toward an environment for all residents of San Mateo County which is free from unnecessary, annoying, and injurious noise.
▪ Policy 16.2: Reduce Noise Impacts Through Noise/Land Use Compatibility and Noise Mitigation. Reduce noise impacts within San Mateo County through measures which promote noise/land use compatibility and noise mitigation.
▪ Policy 16.3: Promote Protection of Noise Sensitive Land Uses and Noise Reduction in Quiet Areas and Noise Impact Areas. Promote measures which: (1) protect noise sensitive land uses, (2) preserve and protect existing quiet areas, especially those which contain noise sensitive land uses, and (3) promote noise compatibility in Noise Impact Areas.
▪ Policy 16.4: Noise Reduction Priority. Give priority to reducing noise at the source rather than at the receiver, recognizing that it is less expensive and more equitable to build noise mitigation into the source than providing for it along the path and at the receiver.</td></tr>
</table>

Plan/Policy Document	Summary
	▪ Policy 16.5: Noise Reduction Along the Path and at the Receiver. Promote noise reduction along the path and at the receiver through techniques which can be incorporated into the design and construction of new and existing development including, but not limited to, site planning, noise barriers, architectural design, and construction techniques. Transportation Noise Reduction ▪ Policy 6.17: Promote Transportation Related Noise Reduction. Promote measures which reduce transportation related noise, particularly aircraft and vehicle noise, to enhance the quality of life within San Mateo County. ▪ Policy 16.18: Encourage Public Transportation Noise Control. Encourage public transportation carriers to make every feasible effort to reduce noise emissions including, but not limited to, consideration of noise when purchasing equipment, and routing and scheduling operations.
San Mateo County Zoning Regulations	The San Mateo County zoning regulations permit construction weekdays from 7:00 a.m. to 6:00 p.m.; Saturdays from 9:00 a.m. to 5:00 p.m.; prohibited on Sundays and holidays. The maximum exterior noise levels permitted would be: ▪ Not more than 55 dBA daytime (defined as 7:00 a.m. to 10:00 p.m.) and 50 dBA nighttime (defined as 10:00 p.m. to 7:00 a.m.) for 30 minutes per hour. ▪ Not more than 60 dBA daytime and 55 dBA nighttime for 15 minutes per hour. ▪ Not more than 65 dBA daytime and 60 dBA nighttime for 5 minutes per hour. ▪ Not more than 75 dBA daytime and 70 dBA nighttime for any length of time. The maximum exterior noise levels permitted would be: ▪ Not more than 45 dBA daytime and 40 dBA nighttime for 5 minutes per hour. ▪ Not more than 55 dBA daytime and 50 dBA nighttime for any length of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient.
North Fair Oaks Community Plan (2011)	The *North Fair Oaks Community Plan* was adopted in 2011 and defines goals and objectives for the unincorporated neighborhood of North Oaks, which is located in San Mateo County and bounded by the cities of Redwood City, Atherton, and Menlo Park. This partial list of the plan goals and objectives includes those most relevant to HSR: ▪ Goal 5.23: Maintain acceptable noise levels in North Fair Oaks ▪ Policy 23A: Reduce or eliminate existing objectionable noise sources and require new noise sources to comply with noise standards. ▪ Policy 23B: Consider both indoor and outdoor noise levels to protect health and safety. ▪ Policy 23C: Mitigate new noise impacts from traffic along Middlefield Road, El Camino Real, 5th Avenue, the rail corridor, and industrial uses within the neighborhood by buffering development sites or using other strategies to reduce or absorb sound. Where there are existing impacts, coordinate with nearby jurisdictions and agencies to advocate for design improvements that will reduce noise impacts.

Plan/Policy Document	Summary
City of Brisbane	
City of Brisbane General Plan (2019)	The *City of Brisbane General Plan* was adopted in 1994, and the Community Health and Safety Element was amended in 2019, which contains the following noise-related goals and objectives relevant to the project: ▪ Policy 176: Minimize the intrusion of unwarranted and intrusive noise on community life. ▪ Program 176a: Discourage new sources that generate excessive noise. ▪ Policy 177: Maintain ongoing communication with County, State, and Federal agencies in an effort to reduce noise impacts from regional uses. ▪ Policy 180: Establish and enforce truck routes and times of operation for haul routes to minimize impacts on residential areas. ▪ Policy 183: Coordinate land uses and construction conditions to minimize noise impacts of the Caltrain corridor and major highway arterials on adjacent land uses.
City of Brisbane Code of Ordinances	**8.28.020. Definitions.** Defines the minimum local ambient noise as 35 dBA for interior noise and 45 dBA in all other locations. **8.28.030. Noise Levels for Residential Zoning Districts.** Prohibits noise levels in single-family residential zoning districts that exceed 10 dBA above the local ambient for more than 10 minutes in any hour, more than 20 dBA above the local ambient for more than 3 minutes in any hour, or more than 30 dBA above the local ambient at any receiver. **8.28.060. Construction Activities.** Construction shall be allowed between the hours of 7:00 a.m. and 7:00 p.m. on weekdays and 9:00 a.m. to 7:00 p.m. on weekends and holidays. No individual piece of equipment shall produce a noise level exceeding 83 dBA at a distance of 25 feet from the source, and the noise level outside the property plane of the project shall not exceed 86 dBA.
City of Daly City	
Daly City 2030 General Plan (2013)	The Daly City 2030 General Plan Noise Element was adopted in 2013. It is the city's goal to "Promote a noise environment that reflects a balance of the various City objectives while providing an environment that maintains a healthy living environment; fosters relaxation and recreation; is conducive to the work environment; and provides pleasant living conditions." The updated policies that relevant to the project include: ▪ Policy NE-3: Maintain a CNEL level of not more than 70 dBA L_{eq} in residential areas. ▪ Policy NE-4: Maintain a noise level not in excess of 75 dBA CNEL in open space, parks, and tot lots, including outdoor activity areas such as outdoor entertainment or green space of multi-family projects. ▪ Policy NE-5: Maintain the City's current standard of 75 dBA CNEL for office, commercial and professional areas.
Daly City Code of Ordinances	Daly City has outlined the code 9.22.030 for Noise which states the following: **9.22.030 -** Between the hours of 10 p.m. and 6 a.m. of the following day, no person shall cause, create or permit any noise, music, sound or other disturbance upon his property which may be heard by, or which noise disturbs or harasses, any other person beyond the confines of the property, quarters or apartment from which the noise, music, sound or disturbance emanates.

Plan/Policy Document	Summary
City of South San Francisco	
South San Francisco General Plan (1999)	The *South San Francisco General Plan*, adopted in 1999, establishes the following noise and vibration policies relevant to the project: ▪ Policy 9-G-1: Protect public health and welfare by eliminating or minimizing the effects of existing noise problems, and by preventing increased noise levels in the future. ▪ Policy 9-G-2: Continue efforts to incorporate noise considerations into land use planning decisions and guide the location and design of transportation facilities to minimize the effects of noise on adjacent land uses. ▪ Policy 9-I-8: Require the control of noise at source through site design, building design, landscaping, hours of operation, and other techniques, for new developments deemed to be noise generators. ▪ Policy 9-I-9: Work with BART to ensure that its extension of the transit line to SFO through the city results in minimal impact from noise and ground-borne vibration.
South San Francisco Municipal Code	**8.32.030 Maximum permissible sound levels.** Noise level standards for single-family residential land use zones are: 50 dBA from 10:00 p.m.to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m. Noise level standards for multi-family residential land use zones: 55 dBA from 10:00 p.m. to 7:00 a.m.; 60 dBA from 7:00 a.m. to 10:00 p.m. Noise level standards for commercial uses are: 60 dBA from 10:00 p.m.to 7:00 a.m.; 65 dBA from 7:00 a.m. to 10:00 p.m. The maximum exterior noise levels permitted would be: ▪ The noise level standard for that land use for a cumulative period of more than 30 minutes in any hour; ▪ The noise level standard plus 5 dB for a cumulative period of more than 15 minutes in any hour; ▪ The noise level standard plus 10 dB for a cumulative period of more than 5 minutes in any hour; ▪ The noise level standard plus 15 dB for a cumulative period of more than 1 minute in any hour; or ▪ The noise level standard or the maximum measured ambient level, plus 20 dB for any period of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the permitted noise levels increase in 5 dBA increments above the ambient. **8.32.040 Interior noise limits.** It is unlawful for any person to operate or cause to be operated any source of sound, on multifamily residential property or multitenant commercial or industrial property, a noise level more than 10 dB above the level allowed by [the established noise standard levels for each land use] 3 feet from any wall, floor or ceiling inside any unit on the same property when the windows and doors of the unit are closed, except within the unit in which the noise source or sources is located. **8.32.050 Special provisions.** [. . .] Construction, alteration, repair or landscape maintenance activities which are authorized by a valid city permit shall be allowed on weekdays between the hours of 8 a.m. and 8 p.m., on Saturdays between the hours of 9 a.m. and 8 p.m., and on Sundays and holidays between the hours of 10 a.m. and 6 p.m., if they meet at least one of the following noise limitations: (1) No individual piece of equipment shall produce a noise level exceeding 90 dB at a distance of 25 feet. [. . .] (2) The noise level at any point outside of the property plane of the project shall not exceed 90 dB.

Plan/Policy Document	Summary
City of San Bruno	
San Bruno General Plan (2009)	The *San Bruno General Plan*, adopted in 2009, establishes the following noise and vibration policies relevant to the project: ▪ Policy HS-32: Encourage developers to mitigate ambient noise levels adjacent to major noise sources by incorporating acoustical site planning into their projects. Utilize the City's Building Code to implement mitigation measures, such as: – Incorporating buffers and/or landscaped berms along high-noise roadways or railways; – Incorporating traffic calming measures and alternative intersection design within and/or adjacent to the project; – Using reduced-noise pavement (rubberized asphalt); and – Incorporating state-of-the-art structural sound attenuation measures. ▪ Policy HS-34: Discourage noise sensitive uses such as hospitals, schools, and rest homes from locating in areas with high noise levels. Conversely, discourage new uses likely to produce high levels of noise from locating in areas where noise sensitive uses would be impacted. ▪ Policy HS-38: Require developers to mitigate noise exposure to sensitive receptors from construction activities. Mitigation may include a combination of techniques that reduce noise generated at the source, increase the noise insulation at the receptor, or increase the noise attenuation rate as noise travels from the source to the receptor. ▪ Policy HS-43: Allow reasonable latitude for noise generated by uses that are essential to community health, safety, and welfare, such as emergency vehicle operations and sirens. ▪ Policy HS-46: Encourage transit agencies to develop and apply noise reduction technologies for their vehicles to reduce the noise and vibration impacts of Caltrain, BART and bus traffic. ▪ Policy T-84: The City shall work closely with the High Speed Rail Authority to ensure all impacts associated with the High Speed Rail Project are mitigated to the fullest extent possible. The City shall work to ensure that the design for the High Speed Rail project is consistent with the train station and grade separation design approved by the Citizens Advisory Committee and City Council.
San Bruno Municipal Code	Minimum ambient noise level limits are defined as 45 dBA from 10:00 p.m. and 7:00 a.m.; 60 dBA from 7:00 a.m. and 10:00 p.m. **6.16.050 Noise levels exceeding ambient base level.** [Noise levels shall not exceed] the zone ambient base level at the property plane of any property, or the zone ambient base level on any adjacent residential area zone [. . .] by more than 10 dB. However, during the period of 7 a.m. to 10 p.m. the ambient base level may be exceeded by 20 dB for a period not to exceed 30 minutes during any 24-hour period. **6.16.070 Construction of buildings and projects.** No person shall, within any residential zone, or within a radius of 500 feet there from, operate equipment [. . .] between the hours of 7 a.m. and 10 p.m., a noise level of 85 dB as measured at 100 feet, or exceed between the hours of 10 p.m. and 7 a.m. a noise level of 60 dB as measured at 100 feet [. . .]. **6.16.080 Public areas.** A. No source of sound [. . .] shall exceed 70 dB at a distance of 50 feet from the source of the sound between the hours of 11 a.m. and 4 p.m. [. . .] B. No source of sound [. . .] shall exceed 60 dB at a distance of 50 feet from the source of the sound between the hours of 4 p.m. and 11 a.m.

<table>
<tr><th>Plan/Policy Document</th><th>Summary</th></tr>
<tr><td colspan="2">City of Millbrae</td></tr>
<tr><td>City of Millbrae General Plan (1998)</td><td>
The City of Millbrae General Plan was adopted in 1998 and provides guidance for code enforcement and other regulations. The following plans and policies are relevant to the project:

Goal NS1: Preserve and Improve the “Quiet Ambiance” in Existing Neighborhoods. Protect Millbrae’s neighborhoods by providing an acceptable noise level throughout the community, identifying and alleviating or minimizing existing noise problems where possible.
Policy NS1.2: Protection of Residential Areas. Protect the noise environment in existing residential areas, requiring the evaluation of mitigation measures for projects under the following circumstances:

The project would cause the L_{dn} to increase 3 dB(A) or more.
Any increase would result in an L_{dn} greater than 60 dB(A).
The L_{dn} already exceeds 60 dB(A).
The project has the potential to generate significant adverse community response.

Policy NS1.4: Construction Noise. Regulate construction activity to reduce noise between 7:00 p.m. and 7:00 a.m.
Policy NS2.4.1a Commercial or Industrial Source Noise. Noise created by commercial or industrial sources associated with new projects or developments shall be controlled so as not to exceed the noise level standards set forth in the table below [. . .] as measured at any affected residential land use.

Maximum Allowable Noise Exposure for Stationary Noise Sources (1)
<table>
<tr><th></th><th>Daytime (5)
(7 AM to 10 PM)</th><th>Nighttime (2,5)
(10 PM to 7 AM)</th></tr>
<tr><td>Hourly Leq, DB (3)</td><td>55</td><td>45</td></tr>
<tr><td>Maximum Level, dB (3)</td><td>70</td><td>65</td></tr>
<tr><td>Maximum Level, dB - Impulsive Noise (4)</td><td>65</td><td>60</td></tr>
</table>

Policy NS2.6: Noise Reduction Techniques. As appropriate, based on design, use, site layout and other considerations, require mitigation measures to reduce noise impacts on adjacent properties through the following and other means, as a condition of development approval:

Screen and control noise sources such as parking, outdoor activities and mechanical equipment.
Increase setbacks for noise sources from adjacent dwellings.
Wherever possible do not remove fences, walls or landscaping that serve as noise buffers, although design, safety, and other impacts must be addressed.
Require sound walls, earth berms, and/or other landscape features to provide an adequate noise buffer.
Use soundproofing materials and double-glazed windows.
Control hours of operation, including deliveries and trash pickup to minimize noise impacts.

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<table>
<tr><th>Plan/Policy Document</th><th>Summary</th></tr>
<tr><td></td><td>Policy NS3.2: Work with the county Airport Land Use Commission, State Office of Noise Control, Caltrans, SFO, Joint Powers Board and other agencies to reduce noise generated from sources outside the City's jurisdiction.</td></tr>
<tr><td colspan="2">City of Burlingame</td></tr>
<tr><td>Envision Burlingame General Plan (2019)</td><td>The Envision Burlingame General Plan was adopted in January 2019 and implemented the following goals and policies:
Goal CS-4: Protect residents and visitors to Burlingame from excessive noise and disruptive ground vibration.
CS-4.2: Residential Noise Standards. Require the design of new residential development to comply with the following noise standards:
The maximum acceptable interior noise level for all new residential units [. . .] shall be an Ldn of 45 dBA with windows closed.
For project locations that are primarily exposed to noise from aircraft, Caltrain, BART, Highway 101, and Interstate 280 operations, the maximum instantaneous noise level in bedrooms shall not exceed 50 dBA at night (10:00 pm to 7:00 am), and the maximum instantaneous noise level in all interior rooms shall not exceed 55 dBA during the day (7:00 am to 10:00 pm) with windows closed.
CS-4.10: Construction Noise Study. Require development projects subject to discretionary approval to assess potential construction noise impacts on nearby sensitive uses and to minimize impacts on those uses consistent with Municipal Code provisions.
CS-4.11: Train Noise. Require that all new development within 1,000 feet of the rail line provide deed notices disclosing noise impacts upon transfer of title to residents and property owners.
CS-4.12: Quiet Zones for Trains. Coordinate with applicable railroad authorities to study options for reducing railroad noise impacts, including feasibility of Quiet Zone technology where appropriate.
CS-4.13: Vibration Impact Assessment. Require a vibration impact assessment for proposed projects in which heavy-duty construction equipment would be used (e.g., pile driving, bulldozing) within 200 feet of an existing structure or sensitive receptor. If applicable, require all feasible mitigation measures to be implemented to ensure that no damage or disturbance to structures or sensitive receptors would occur.</td></tr>
<tr><td>Burlingame Downtown Specific Plan (2018)</td><td>The Burlingame Downtown Specific Plan was adopted in October 2010 and last amended in 2018. The following section is relevant to the project:
Section 7.2.4: California High Speed Rail. [. . .] Given that the [HSR] alignment is proposed to pass through Burlingame and its downtown, there is concern over the potential for the rail line to create a physical barrier through the city if it involves bridging, elevated tracks, or the use of retaining walls. Like other peninsula cities, Burlingame has indicated a preference for having the rail line in an underground tunnel rather than at surface or above grade. Having the line underground would be more compatible with the continued economic vitality and quality of life of Burlingame and its downtown. It would also be more compatible with the preservation of valuable historic resources such as the eucalyptus grove and the Burlingame Avenue and Broadway train stations. If all rail lines are accommodated underground along the length of the peninsula alignment, it will enable dozens of surface crossings to be relieved of train conflicts, thereby easing access at many scales and reducing congestion throughout the peninsula. [. . .]</td></tr>
</table>

Plan/Policy Document	Summary
Burlingame Municipal Code	**10.40.035 General noise regulations.** [. . .] it is unlawful for any person willfully to make or continue, or cause to be made or continued, any loud, unnecessary or unusual noise which disturbs the peace and quiet of any neighborhood or which causes discomfort or annoyance to any reasonable person of normal sensitiveness residing in the area. [. . .] **10.40.037 Powered equipment.** No person shall operate any lawnmower, lawn edger, riding tractor or any other mechanical or electrical machinery, equipment or device which creates a loud, raucous or impulsive sound, within any residential district except between the hours of 8:00 a.m. and 7:00 p.m. on Monday through Saturday, or 10:00 a.m. and 6:00 p.m. on Sunday and holidays.
City of San Mateo	
A Vision of San Mateo in 2030 (2010)	The Noise Element of *A Vision of San Mateo in 2030,* adopted in 2010, establishes the following noise-related policies and goals related to the project: ▪ Goal 1: Protect "noise sensitive" land uses from excessive noise levels. ▪ Policy N 1.1: Interior Noise Level Standard. Require submittal of an acoustical analysis and interior noise insulation for all "noise sensitive" land uses listed in Table N-1 that have an exterior noise level of 60 dB (L_{dn}) or above. The maximum interior noise level shall not exceed 45 dB (L_{dn}) in any habitable rooms. ▪ Policy N 1.2: Exterior Noise Level Standard. Require an acoustical analysis for new parks, play areas, and multi-family common open space that have an exterior noise level of 60 dB (L_{dn}) or above, as shown on Figure N-1. Require an acoustical analysis that uses peak hour L_{eq} for new parks and play areas. Require a feasibility analysis of noise reduction measures for public parks and play areas. Incorporate necessary mitigation measures into residential project design to minimize common open space noise levels. Maximum exterior noise should not exceed 67 dB (L_{dn}) for residential uses and should not exceed 65 dB (L_{eq}) during the noisiest hour for public park uses. Goal 2: Minimize unnecessary, annoying, or unhealthful noise. ▪ Policy N 2.1: Noise Ordinance. Continue implementation and enforcement of the City's existing noise control ordinance: a) which prohibits noise that is annoying or injurious to neighbors of normal sensitivity, making such activity a public nuisance, and b) restricts the hours of construction to minimize noise impact. ▪ Policy N 2.2: Minimize Noise Impact. Protect all "noise-sensitive" land uses listed in Tables N-1 and N-2 from adverse impacts caused by the noise generated on-site by new developments. Incorporate necessary mitigation measures into development design to minimize noise impacts. Prohibit long-term exposure increases of 3 dB (Ldn) or greater at the common property line, or new uses which generate noise levels of 60 dB (Ldn) or greater at the property line, excluding existing ambient noise levels. ▪ Policy N 2.5: Railroad Noise. Promote the installation of noise barriers along the railroad corridor where "noise-sensitive" land uses are adversely impacted by unacceptable noise levels (60 dB or greater). Promote adequate noise mitigation to be incorporated into any rail service expansion or track realignment. Study the need of depressing the rail line to eliminate at-grade crossings or other mitigation measures to decrease noise levels prior to substantial expansion of the rail service.
City of San Mateo Municipal Code	**NOISE LEVEL STANDARDS (per Table 7.30.040)** Noise level standards for single-family residential land use zones are 50 dBA from 10:00 p.m. to 7:00 a.m. and 60 dBA from 7:00 a.m. to 10:00 p.m. Noise level standards for commercial/mixed residential and multi-family residential land use zones are 55 dBA from 10:00 p.m. to 7:00 a.m. and 60 dBA from 7:00 a.m. to 10:00 p.m. **7.30.040 MAXIMUM PERMISSIBLE SOUND LEVELS.**

Plan/Policy Document	Summary
	(a) It is unlawful for any person to operate or cause to be operated any source of sound at any location [. . .] which causes the noise level when measured on any other property to exceed: (1) The noise level standard for that property as specified in Table 7.30.040 for a cumulative period of more than thirty minutes in any hour; (2) The noise level standard plus five dB for a cumulative period of more than fifteen minutes in any hour; (3) The noise level standard plus ten dB for a cumulative period of more than five minutes in any hour; (4) The noise level standard plus fifteen dB for a cumulative period of more than one minute in any hour; or (5) The noise level standard or the maximum measured ambient level, plus twenty dB for any period of time. (b) If the measured ambient level for any area is higher than the standard set in Table 7.30.040, then the ambient shall be the base noise level standard for purposes of subsection (a)(1) of this section. In such cases, the noise levels for purposes of subsections (a)(2) through (a)(5) of this section shall be increased in five dB increments above the ambient. **7.30.050 INTERIOR NOISE LIMITS**. It is unlawful for any person to operate or cause to be operated any source of sound, on multifamily residential property or multi-tenant commercial or industrial property at a noise level more than ten dB above the level allowed by Section 7.30.040 three feet from any wall, floor or ceiling inside any unit on the same property when the windows and doors of the unit are closed, except within the unit in which the noise source or sources is located. **7.30.060 SPECIAL PROVISIONS.** (b) Vehicle Horns. Vehicle horns, back-up warning devices, or other devices primarily intended to create a loud noise for warning purposes, shall be used only when the vehicle is in a situation where life, health or property are endangered or as required by law. (e) Construction. Construction shall be allowed on weekdays between the hours of 7 a.m. and 7 p.m., on Saturdays between the hours of 8 a.m. and 5 p.m., and on Sundays and holidays between the hours of 12 and 4 p.m., if they meet at least one of the following noise limitations: (1) No individual piece of equipment shall produce a noise level exceeding 90 dB at a distance of 25 feet. (2) The noise level at any point outside of the property plane of the project shall not exceed 90 dB.
City of Belmont	
2035 General Plan (2017)	The City of Belmont *2035 General Plan* (adopted in 2017) establishes the following noise-related goals and policies for the City's growth through 2035: ▪ Goal 7.1: Strive to achieve an acceptable noise environment for the environmental, health, and safety needs of present and future residents of Belmont. ▪ Policy 7.1-2: Use the Community Noise Level Exposure Standards, shown in Table 7-1, as review criteria for new land uses. Require all new development that would be exposed to noise greater than the "normally acceptable" noise level range to reduce interior noise through design, sound insulation, or other measures. ▪ Policy 7.1-3: Require noise-reducing mitigation to meet allowable outdoor and indoor noise exposure standards in Table 7-2. Noise mitigation measures that may be approved to achieve these noise level targets include but are not limited to the following: construct façades with substantial weight and insulation; use sound-rated windows for primary sleeping and activity areas; use sound-rated doors for all exterior entries at primary sleeping and activity areas; use minimum setbacks and exterior barriers; Use acoustic baffling of vents for chimneys, attic and gable ends; and install a mechanical ventilation system that provides fresh air under closed window conditions. ▪ Policy 7.1-4: Exclude residential and noise-sensitive uses located in the Belmont Village PDA from outdoor noise standards in Table 7-2, where it is determined application of

Plan/Policy Document	Summary
	noise mitigation measures will be detrimental to the realization of the General Plan's goals and policies to realize a vibrant activity center in the Village. ▪ Policy 7.1-7: For transportation projects subject to City approval, require that the project sponsor mitigate noise created by new transportation and transportation-related stationary noise sources, including roadway improvement projects, so that resulting noise levels do not exceed the City's adopted standards for noise-sensitive land uses. ▪ Policy 7.1-10: Require developers of new development anticipated to generate a substantial amount of vibration during construction to implement mitigation practices to reduce vibration, which can include: operating heavy equipment as far as practical from residential uses; using smaller bulldozers (operating weight less than 20,000 pounds) when grading must occur within approximately 50 feet of residential uses or other vibration sensitive uses; and using quiet pile driving technology when feasible. ▪ Policy 7.1-11: Require development projects to include mitigation measures to protect the development from ground borne vibration from the railway if located within 120 feet of the centerline of Caltrain rail tracks. ▪ Goal 7.2: Protect noise-sensitive land uses, such as schools, hospitals, and senior care facilities, from encroachment of and exposure to excessive levels of noise. Policy 7.3-1: Work with Caltrans, Caltrain, SamTrans, and other agencies to mitigate transportation-related noise impacts on residential areas and sensitive uses. This may include encouraging installation of sound barriers or bus stop relocation in selected locations.
City of Belmont Noise Ordinance	**15-102 Noise limitations** Sound Level Limits. Sound levels shall not exceed the following limits: – Residential and non-residential property: 55 dBA between sunset and 8:00 a.m. on weekdays and between sunset and 10:00 a.m. on weekends and holidays; 65 dBA between 8:00 a.m. and sunset on weekdays and between 10:00 a.m. and sunset on weekends and holidays. Construction activities are subject to the following regulations: All construction and related activities, which require a city permit, including the use of powered equipment in connection with such activities, shall be allowed only during the hours of 8:00 a.m. to 5:00 p.m. Monday through Friday, and 10:00 a.m. to 5:00 p.m. Saturdays. All gasoline-powered construction equipment shall be equipped with an operating muffler or baffling system as originally provided by the manufacturer.
City of San Carlos	
San Carlos 2030 General Plan (2009)	The noise element within the San Carlos General Plan identifies some local sources of noise and establishes the following policies and guidelines relevant to the project: ▪ Goal NOI-1: Encourage compatible noise environments for new development and control sources of excessive noise citywide. ▪ Policy NOI-1.1: Use the Noise and Land Compatibility Standards shown in Figure 9-1, the noise level performance standards in Table 9-1 and the projected future noise contours for the General Plan shown in Figure 9-3 and detailed in Table 9-2, as a guide for future planning and development decisions. ▪ Policy NOI-1.2: Minimize noise impacts on noise sensitive land uses. Noise-sensitive land uses include residential uses, retirement homes, hotel/motels, schools, libraries, community centers, places of public assembly, daycare facilities, churches and hospitals. ▪ Policy NOI-1.3: Limit noise impacts on noise-sensitive uses to noise level standards as indicated in Table 9-1.

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	▪ Policy NOI-1.4: Require a detailed acoustic report in all cases where noise-sensitive land uses are proposed in areas exposed to exterior noise levels of 60 CNEL L_{dn} or greater. If recommended in the report, mitigation measures shall be required as conditions of project approval. ▪ Policy NOI-1.5: New development of noise-sensitive land uses proposed in noise-impacted areas shall incorporate effective mitigation measures into the project design to reduce exterior and interior noise levels to the following acceptable levels: – For new single-family residential development, maintain a standard of 60 L_{dn} (day/night average noise level) for exterior noise in private use areas. – For new multi-family residential development maintain a standard of 65 L_{dn} in community outdoor recreation areas. Noise standards are not applied to private decks and balconies and shall be considered on a case-by-case basis in the downtown core. – Interior noise levels shall not exceed 45 L_{dn} in all new residential units (single- and multi-family). [. . .] – Where new residential units (single and multi-family) would be exposed to intermittent noise levels generated during train operations, maximum railroad noise levels in side homes shall not exceed 50 dBA in bedrooms or 55 dBA in other occupied spaces. These single event limits are only applicable where there are normally four or more train operations per day. ▪ Policy NOI-1.6: Where noise mitigation measures are required to achieve the noise level standards, the emphasis of such measures shall be placed upon site planning and project design. The use of noise barriers shall be considered after practical design-related noise mitigation measures have been integrated into the project. ▪ Policy NOI-1.7: The City shall seek to reduce impacts from ground-borne vibration associated with rail operations by requiring that vibration-sensitive buildings (e.g., residences) are sited at least 100 feet from the centerline of the railroad tracks whenever feasible. The development of vibration-sensitive buildings within 100 feet from the centerline of the rail-road tracks would require a study demonstrating that ground borne vibration issues associated with rail operations have been adequately addressed (i.e., through building siting, foundation design and construction techniques). ▪ Policy NOI-1.8: During all phases of construction activity, reasonable noise reduction measures shall be utilized to minimize the exposure of neighboring properties to excessive noise levels. a. Construction activities shall comply with the City's noise ordinance. ▪ Policy NOI-1.9: Minimize potential transportation related noise through the use of setbacks, street circulation design, coordination of routing and other traffic control measures and the construction of noise barriers and consider use of "quiet" pavement surfaces when resurfacing roadways. ▪ Policy NOI-1.12: Ensure consistency with the noise compatibility policies and criteria contained in the San Carlos Airport Land Use Plan. ▪ Policy NOI-1.14: The Federal Transit Administration vibration impact criteria and assessment methods shall be used to evaluate the compatibility of train vibration with proposed land uses adjoining the UPRR (Caltrain) corridor. Site specific vibration studies shall be completed for vibration-sensitive uses proposed within 100 feet of active railroad tracks.

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San Carlos Noise Ordinance

18.21.050. Noise. Establishes maximum allowable noise limits, as shown in Table 18.21.050-A.

TABLE 18.21.050-A: NOISE LIMITS

Land Use Receiving the Noise	Noise-Level Descriptor	Exterior Noise Level Standard in Any Hour (dBA)		Interior Noise-Level Standard in Any Hour (dBA)	
		Daytime (7 a.m. – 10 p.m.)	Nighttime (10 p.m. – 7 a.m.)	Daytime (7 a.m. – 10 p.m.)	Nighttime (10 p.m. – 7 a.m.)
Residential	L_{50}	55	45	40	30
	L_{max}	70	60	55	45
Medical, convalescent	L_{50}	55	45	45	35
	L_{max}	70	60	55	45
Theater, auditorium	L_{50}	-	-	35	35
	L_{max}	-	-	50	50
Church, meeting hall	L_{50}	55	-	40	40
	L_{max}	-	-	55	55
School, library, museum	L_{50}	55	-	40	-
	L_{max}	-	-	55	-

9.30.070 Exempt activities.

The following noise-generating activities are exempt from the provisions of this chapter:

A. Transportation facilities, such as freeways, airports, buses and railroads;

B. Construction activities; such activities, however, shall be limited to the hours of eight a.m. to six p.m. Monday through Friday, and nine a.m. to five p.m. on Saturdays and Sundays. No construction noise-related activities on holidays. All gasoline-powered construction equipment shall be equipped with an operating muffler or baffling system as originally provided by the manufacturer, and no modification to these systems is permitted.

Redwood City

***Redwood City General Plan* (2010)**

The Redwood City General plan was adopted in October 2010 and outlines the goals, policies, and programs for the city. The following goals and policies are relevant to the project:

- Goal PS-13: Minimize the impact of point source noise and ambient noise levels throughout the community.
- Policy PS-13.3: Consider noise impacts as part of the development review process, particularly the location of parking, ingress/egress/loading, and refuse collection areas relative to surrounding residential development and other noise sensitive land uses.
- Policy PS-13.4: In accordance with the Municipal Code and noise standards contained in the General Plan, strive to provide a noise environment that is at an acceptable noise level near schools, hospitals, and other noise sensitive areas.
- Policy PS-13.5: Limit the hours of operation at all noise generation sources that are adjacent to noise sensitive areas, wherever practical.
- Policy PS-13.6: Require all exterior noise sources (construction operations, air compressors, pumps, fans, and leaf blowers) to use available noise suppressions devices and techniques to bring exterior noise down to acceptable levels that are compatible with adjacent land uses.
- Policy PS-13.8: Implement appropriate standard construction noise controls for all construction projects.

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	▪ Policy PS-13.9: Require noise created by new non-transportation noise sources to be mitigated so as not to exceed acceptable interior and exterior noise level standards. ▪ Goal PS-14.1 Minimize the impacts of transportation-related noise. *[Refer to Figure PS-10, Redwood City Noise Guidelines for Land Use Planning.]* ▪ Policy PS-14.1: Consult with responsible federal and State agencies to minimize the impact of transportation-related noise, including noise associated with freeways, major arterials, rail lines, and airports. ▪ Policy PS-14.4: Require development that is, or will be, affected by railroad noise and/or vibration to include appropriate measures to minimize adverse noise effects on residents and business persons. ▪ Goal BE-28: Provide maximum opportunities for upgrading passenger rail service for faster and more frequent trains, while making this improved service a positive asset to Redwood City that is attractive, accessible, and safe. ▪ Policy BE-28.2: Support attractive and pedestrian-friendly railroad track grade-separated crossings and other appropriate measures to mitigate potential noise, air pollution, safety, and traffic impacts of increased Caltrain service and new high-speed rail service.
Redwood City Noise Ordinance	**CHAPTER 24, NOISE REGULATIONS.** The local ambient sound level is a minimum of 30 dBA for interior noise and 40 dBA in all other locations. **Sec. 24.21. PROHIBITED NOISE LEVELS IN RESIDENTIAL DISTRICTS.** Noise levels of more than 6 dB above the local ambient within a residential district or more than 6 dB above the local ambient measured 3 feet from any wall, floor or ceiling inside any dwelling unit on the same property within a residential district, when the windows and doors of the dwelling unit are closed, except within the dwelling unit in which the noise source or sources are located, between the hours of 8:00 p.m. and 8:00 a.m. **Sec. 24.31. - PROHIBITED NOISE LEVELS:** It shall be unlawful for any person to suffer or allow noise levels to be generated by: A. Construction activities, including demolition, alteration, repair or remodeling of or to existing structures and construction of new structures on property within the City, at more than 110 dB measured at any point within a residential district of the City and outside of the plane of said property; or B. An individual item of machinery, equipment or device used during construction activities, including demolition, alteration, repair or remodeling of or to existing structures and construction of new structures on property within the City, at more than 110 dB measured within a residential district of the City at a distance of 25 feet from said machinery, equipment or device. If said machinery, equipment or device is housed within a structure on the property, then the measurement shall be made at a distance as near to 25 feet from said machinery, equipment or device as possible. **Sec. 24.32. - TIME LIMITATIONS.** [. . .] it shall be unlawful for any person to engage in construction activities, including demolition, alteration, repair or remodeling of or to existing structures and the construction of new structures on property in a residential district or within 500 feet of a residential district in the City, between the hours of 8:00 p.m. and 7:00 a.m. the following day, Monday through Friday of any week or at any time on Saturdays, Sundays or holidays if the noise level generated by any such activity exceeds the local ambient measured at any point within the residential district and outside of the plane of said property.

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Town of Atherton	
Atherton General Plan (2020)	The *Atherton General Plan* (updated in 2020) identifies goals, objectives, and policies to guide development in the City of Atherton. The following noise-related policies and goals are relevant to the project: ▪ Noise Element Goal N-1: To maintain the serene atmosphere of the Town by minimizing the intrusion of noise-generating activities. ▪ Noise Element Policy N-1.2: Noise contours have been prepared in accordance with Section 65302(f) of the Government Code and accompanies this Element. The noise contours shall be used as a tool for land use decision making. ▪ Noise Element Policy N-1.3: If complaints about noise increase in the future, procedures for dealing with complaints in the community will be established. ▪ Noise Element Policy N-1.6: Consider requiring noise mitigation for a project that results in Ldn increases that are: (a) 5 dBA or greater and the future Ldn is less than 60 dBA, or (b) 3 dBA or greater and the future Ldn is 60 dBA or greater and less than 65 dBA, or (c) 1.5 dBA or greater and the future Ldn is 65 dBA or greater.
Atherton Municipal Code	**8.16.030 Basic Noise Regulation.** Establishes sound level limits of 60 dBA between 7:00 a.m. and 10:00 p.m. and 50 dBA between 10 p.m. and 7:00 a.m. for noises emanating from any property, public or private, beyond the property line. **15.40.120 Time Limits.** Establishes time period during which construction, pickup and delivery are permitted between 8:00 a.m. and 5:00 p.m. on weekdays, and prohibits construction outside of this time period, on weekends, and holidays.
City of Menlo Park	
City of Menlo Park General Plan, Open Space/Conservation, Noise and Safety Elements (2013)	The City of Menlo Park adopted the Open Space/Conservation, Noise and Safety Elements of the Connect Menlo Park General Plan in May 2013. The following noise-related goals and policies are relevant to the project: ▪ Goal N1: Achieve Acceptable Noise Levels. It is the goal of Menlo Park to have acceptable noise levels. ▪ Policy N1.1: Compliance with Noise Standards. Consider the compatibility of proposed land uses with the noise environment when preparing or revising community and/or specific plans. Require new projects to comply with the noise standards of local, regional, and building code regulations [. . .] ▪ Policy N1.4: Noise Sensitive Uses. Protect existing residential neighborhoods and noise sensitive uses from unacceptable noise levels and vibration impacts. Noise sensitive uses include, but are not limited to, hospitals, schools, religious facilities, convalescent homes and businesses with highly sensitive equipment. Discourage the siting of noise-sensitive uses in areas in excess of 65 dBA CNEL without appropriate mitigation and locate noise sensitive uses away from noise sources unless mitigation measures are included in development plans. ▪ Policy N1.6: Noise Reduction Measures. Encourage the use of construction methods, state-of-the-art noise abating materials and technology and creative site design including, but not limited to, open space, earthen berms, parking, accessory buildings, and landscaping to buffer new and existing development from noise and to reduce potential conflicts between ambient noise levels and noise-sensitive land uses. Use sound walls only when other methods are not practical or when recommended by an acoustical expert. ▪ Policy N1.7: Noise and Vibration from New Non-Residential Development. Design non-residential development to minimize noise impacts on nearby uses. Where vibration impacts may occur, reduce impacts on residences and businesses through the use of

<table>
<tr><th>Plan/Policy Document</th><th>Summary</th></tr>
<tr><td></td><td>setbacks and/or structural design features that reduce vibration to levels at or below the guidelines of the Federal Transit Administration near rail lines and industrial uses.

Policy N1.8: Potential Annoying or Harmful Noise. Preclude the generation of annoying or harmful noise on stationary noise sources, such as construction and property maintenance activity and mechanical equipment.
Policy N1.9: Transportation Related Noise Attenuation. Strive to minimize traffic noise through land use policies, traffic-calming methods to reduce traffic speed, law enforcement and street improvements, and encourage other agencies to reduce noise levels generated by roadways, railways, rapid transit, and other facilities.
Policy N1.10: Nuisance Noise. Minimize impacts from noise levels that exceed community sound levels through enforcement of the City’s Noise Ordinance. Control unnecessary, excessive and annoying noises within the City where not preempted by Federal and State control through implementation and updating of the Noise Ordinance.
</td></tr>
<tr><td>City of Menlo Park Municipal Code</td><td>8.06.030 Noise limitations. Establishes noise limits for sound measured from any residential property to be 50 dBA during nighttime hours (10:00 p.m. to 7:00 a.m.) and 60 dBA during daytime hours (7:00 a.m. to 10:00 p.m.). For all sources within a multifamily residential structure transmitting through a common interior partition from one dwelling unit to another the noise limit will be 35 dBA during nighttime hours and 45 dBA during daytime hours.
8.06.040 Exceptions. Construction activities are permitted between the hours of 8 a.m. and 6 p.m. Monday through Friday.</td></tr>
<tr><td colspan="2">Santa Clara County</td></tr>
<tr><td>Santa Clara County General Plan (1994)</td><td>The Santa Clara County General Plan was adopted in 1994. The general plan includes the following strategies, policies, and implementation recommendations relevant to noise and vibration:
Strategy 1: Prevent or Minimize Noise Conflicts

Policy C-HS 24: Environments for all residents of Santa Clara County free from noises that jeopardize their health and well-being should be provided through measures which promote noise and land use compatibility.
Policy C-HS 25: Noise impacts from public and private projects should be mitigated.

Implementation C-HS(i) 23: Project design review should assess noise impacts on surrounding land uses.
Implementation C-HS(i) 24: Where necessary, construct sound walls or other noise mitigations.
Implementation C-HS(i) 25: Prohibit construction in areas which exceed applicable interior and exterior standards, unless suitable mitigation measures can be implemented.
Implementation C-HS(i) 26: Require project-specific noise studies to assess actual and protected dB noise contours for proposed land uses likely to generate significant noise.

Strategy 2: Provide Adequate Sound Buffers

Policy C-HS 26: New development in areas of noise impact (areas subject to sound levels of 55 DNL or greater) should be approved, denied, or conditioned so as to achieve a satisfactory noise level for those who will use or occupy the facility (as defined in “Noise Compatibility Standards for Land Use” and “Maximum Interior Noise Levels For Intermittent Noise”).
</td></tr>
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Santa Clara County Ordinance Code	The Santa Clara Ordinance Code was originally adopted in 1972. The Code establishes the following sections of Division B11, Chapter VIII, Control of Noise and Vibration, relevant to noise and vibration: **Section B11-152. – Exterior noise limits** Maximum permissible sound levels by receiving land use: ▪ The noise standards for the various receiving land use categories as presented in [the following bullets, derived from Table B11-152] will apply to all property within any zoning district: – One and Two-Family Residential – 45 dBA between 10 pm to 7 am, and 55 dBA between 7 am to 10 pm; – Multiple Family Dwelling – 50 dBA between 10 pm and 7 am; – Residential Public Space – 55 dBA between 7 am to 10 pm; – Commercial – 60 dBA between 10 pm and 7 am, and 65 dBA between 7 am to 10 pm; – Light Industrial -- 70 dBA at all times; and – Heavy Industrial – 75 dBA at all times. ▪ No person may operate or cause to be operated any source of sound at any location within the unincorporated territory of the County or allow the creation of any noise on property owned, leased, occupied or otherwise controlled by the person, which causes the noise level when measured on any other property either incorporated or unincorporated, to exceed: – The noise standard for that land use as specified [above] for a cumulative period of more than 30 minutes in any hour; or – The noise standard plus five dB for a cumulative period of more than 15 minutes in any hour; or – The noise standard plus ten dB for a cumulative period of more than five minutes in any hour; or – The noise standard plus 15 dB for a cumulative period of more than one minute in any hour; or – The noise standard plus 20 dB or the maximum measured ambient, for any period of time. ▪ If the measured ambient level exceeds that permissible within any of the first four noise limit categories above, the allowable noise exposure standard will be increased in five dB increments in each category as appropriate to encompass or reflect the ambient noise level. In the event the ambient noise level exceeds the fifth noise limit category, the maximum allowable noise level under the category will be increased to reflect the maximum ambient noise level. **Sec. B11-153. - Interior noise standards** Maximum permissible dwelling interior sound levels: ▪ The interior noise standards for multifamily residential dwellings as presented in [the following bullet, derived from Table B11-153] will apply, unless otherwise specifically indicated, within all dwellings: – Multi-Family Dwelling – 35 dBA allowable interior noise level between 10 pm and 7 pm, and 45 dBA between 7 am and 10 pm. ▪ No person will operate or cause to be operated within a dwelling unit any source of sound or allow creation of any noise which causes the noise level when measured inside a neighboring receiving dwelling unit to exceed:

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	– The noise standard as specified [above] for a cumulative period of more than five minutes in any hour; or – The noise standard plus five dB for a cumulative period of more than one minute in any hour; or – The noise standard plus ten dB or the maximum measured ambient, for any period of time. – If the measured ambient level exceeds that permissible within any of the noise limit categories above, the allowable noise exposure standard will be increased in five-dB increments in each category as appropriate to reflect the ambient noise level. **Section B11-154. – Prohibited acts** The following acts, and the causing or permitting thereof, are declared to be in violation of this chapter: ▪ Construction/demolition a) Operating or causing the operation of any tools or equipment used in construction, drilling, repair, alteration or demolition work between weekdays and Saturday hours of 7 p.m. and 7 a.m., or at any time on Sundays or holidays, that the sound therefrom creates a noise disturbance across a residential or commercial real property line, except for emergency work of public service utilities or by variance. b) Where technically and economically feasible, construction activities will be conducted in a manner that the maximum noise levels at affected properties will not exceed those listed in the following schedule: i. Mobile equipment. Maximum noise levels for nonscheduled, intermittent, short-term operation (less than ten days) of mobile equipment: [See full ordinance for table of maximum noise levels] ii. Stationary equipment. Maximum noise levels for repetitively scheduled and relatively long-term operation (periods of ten days or more) of stationary equipment are as follows: [See full ordinance for table of maximum noise levels] ▪ Vibration: Operating or permitting the operation of any device that creates a vibrating or quivering effect that: i. Endangers or injures the safety or health of human beings or animals; or ii. Annoys or disturbs a person of normal sensitivities; or iii. Endangers or injures personal or real properties.
City of Palo Alto	
Palo Alto Comprehensive Plan (2017)	The Palo Alto Comprehensive Plan (adopted in 2017) identifies goals, policies, and programs that shape growth in Palo Alto. This partial list includes the elements most relevant to HSR: ▪ Policy T-3.18: Improve safety and minimize adverse noise, vibrations and visual impacts of operations in the Caltrain rail corridor on adjoining districts, public facilities, schools and neighborhoods with or without the addition of High Speed Rail. ▪ Policy T-3.19: Coordinate proactively with the California High Speed Rail Authority and Caltrain to minimize negative impacts and maximize benefits to Palo Alto from any future high speed rail service through Palo Alto. ▪ Goal N-1: An environment that minimizes the adverse impacts of noise. ▪ Policy N-6.1: Encourage the location of land uses in areas with compatible noise environments. Use the guidelines in Table N-1 to evaluate the compatibility of proposed

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	land uses within existing noise environments when preparing, revising, or reviewing development proposals. Acceptable exterior, interior and ways to discern noise exposure include: – The guideline for maximum outdoor noise levels in residential areas is an Ldn of 60 dB. [. . .] – Interior noise, per the requirements of the State of California Building Standards Code (Title 24) and Noise Insulation Standards (Title 25), must not exceed an Ldn of 45 dB in all habitable rooms of all new dwelling units. ▪ Policy N-6.3: Protect the overall community and especially sensitive noise receptors, including schools, hospitals, convalescent homes, senior and childcare facilities and public conservation land from unacceptable noise levels from both existing and future noise sources, including construction noise. ▪ Policy N-6.5: Protect residential and residentially zoned properties from excessive and unnecessary noise from any sources on adjacent commercial or industrial properties. ▪ Policy N-6.11: Continue to prioritize construction noise limits around sensitive receptors, including through limiting construction hours and individual and cumulative noise from construction equipment. ▪ Policy N-6.13: Minimize noise spillover from rail related activities into adjacent residential or noise-sensitive areas. ▪ Program N6.13.1: Encourage the Peninsula Corridors Joint Powers Board to pursue technologies and grade separations that would reduce or eliminate the need for train horns/whistles in communities served by rail service. ▪ Program N6.13.2: Evaluate changing at-grade rail crossings so that they qualify as Quiet Zones based on Federal Railroad Administration (FRA) rules and guidelines in order to mitigate the effects of train horn noise without adversely affecting safety at railroad crossings. ▪ Program N6.13.3: Participate in future environmental review of the California High-Speed Rail (HSR) Project, planned to utilize existing Caltrain track through Palo Alto, to ensure that it adheres to noise and vibration mitigation measures. ▪ Policy N-6.14: Reduce impacts from noise and ground borne vibrations associated with rail operations by requiring that future habitable buildings use necessary design elements such as setbacks, landscaped berms and soundwalls to keep interior noise levels below 45 dBA Ldn and ground-borne vibration levels below 72 VdB.
City of Palo Alto Municipal Code	The local ambient sound level is a minimum of 30 dBA for interior noise and 40 dBA in all other locations. **9.10.030 Residential property noise limits.** Establishes limits of no more than 6 dB above the local ambient beyond the residential property plane or within the interior of a dwelling unit on the same property. **9.10.040 Commercial and industrial property noise limits**. Establishes limits of no more than 8 dB above the local ambient for commercial or industrial property outside of the property plane. **9.10.050 Public property noise limits**. Establishes limits of no more than 15 dB above the local ambient at a distance of 25 feet or more [. . .]. **9.10.060 Special provisions**. **(b)** Construction, alteration and repair activities shall be prohibited on Sundays and holidays and shall be prohibited except between the hours of 8 a.m. and 6 p.m. Monday through Friday, 9 a.m. and 6 p.m. on Saturday provided that the construction, demolition or repair activities during those hours meet the following standards:

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	– No individual piece of equipment shall produce a noise level exceeding one hundred ten dBA at a distance of twenty-five feet. If the device is housed within a structure on the property, the measurement shall be made out-side the structure at a distance as close to twenty-five feet from the equipment as possible. – The noise level at any point outside of the property plane of the project shall not exceed one hundred ten dBA.
City of Mountain View	
Mountain View 2030 General Plan (2012)	The *Mountain View 2030 General Plan* (adopted in 2012) addresses noise concerns and how to protect the community from excess amounts of it due to construction activity, amplified sounds, stationary equipment. The noise goals and policies relevant to the project include the following: ▪ Goal NOI-1: Noise levels that support a high quality of life in Mountain View. ▪ Policy NOI 1.1: Land use compatibility. Use the Outdoor Noise Environment Guidelines as a guide for planning and development decisions (Table 7.1). ▪ Policy NOI 1.2: Noise-sensitive land uses. Require new development of noise-sensitive land uses to incorporate measures into the project design to reduce interior and exterior noise levels to the following acceptable levels: – New single-family developments shall maintain a standard of 65 dBA L_{dn} for exterior noise in private outdoor active use areas. – New multi-family residential developments shall maintain a standard of 65 dBA L_{dn} for private and community outdoor recreation use areas. Noise standards do not apply to private decks and balconies in multi-family residential developments. – Interior noise levels shall not exceed 45 dBA L_{dn} in all new single-family and multi-family residential units. – Where new single-family and multi-family residential units would be exposed to intermittent noise from major transportation sources such as train or airport operations, new construction shall achieve an interior noise level of 65 dBA through measures such as site design or special construction materials. This standard shall apply to areas exposed to four or more major transportation noise events such as passing trains or aircraft flyovers per day. ▪ Policy NOI 1.3: Exceeding acceptable noise thresholds. If noise levels in the area of a proposed project would exceed normally acceptable thresholds, the City shall require a detailed analysis of proposed noise reduction measures to determine whether the proposed use is compatible. As needed, noise insulation features shall be included in the design of such projects to reduce exterior noise levels to meet acceptable thresholds, or for uses with no active outdoor use areas, to ensure acceptable interior noise levels. ▪ Policy NOI 1.4: Site planning. Use site planning and project design strategies to achieve the noise level standards in NOI 1.1 (Land use compatibility) and in NOI 1.2 (Noise-sensitive land uses). The use of noise barriers shall be considered after all practical design-related noise measures have been integrated into the project design. ▪ Policy NOI 1.5: Major roadways. Reduce the noise impacts from major arterials and freeways. ▪ Policy NOI 1.6: Sensitive uses. Minimize noise impacts on noise-sensitive land uses, such as residential uses, schools, hospitals and child-care facilities. ▪ Policy NOI 1.7: Stationary sources. Restrict noise levels from stationary sources through enforcement of the Noise Ordinance.

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	▪ Policy NOI 1.9: Rail. Reduce the effects of noise and vibration impacts from rail corridors. ▪ Policy MOB 5.2: California High-Speed Rail. Actively participate with the California HighSpeed Rail Authority in planning any future high-speed rail service to address urban design, traffic, noise and compatibility issues.
City of Mountain View Code of Ordinances	**Sec 21.26. Stationary Equipment Noise.** No person shall own or operate on any property any stationary equipment [. . .] which produces a sound level exceeding 55 dB(A) (50 dB(A) during the night, 10 p.m. to 7 a.m.) when measured at any location on any receiving residentially used property. **Sec. 8.709. Construction Noise.** No construction activity shall commence prior to 7:00 a.m. nor continue later than 6:00 p.m., Monday through Friday, nor shall any work be permitted on Saturday or Sunday or holidays [. . .].
City of Sunnyvale	
Sunnyvale General Plan (2011)	Within this chapter of the *Sunnyvale General Plan*, which was adopted in 2011, the city has outlined the existing noise conditions and policies that are in place to maintain and/or reduce noise caused by local events, transportation, and land use operations. The following goals and policies are relevant to the project: ▪ Goal SN-8: Compatible noise Environment. Maintain or achieve a compatible noise environment for all land uses in the community. ▪ Policy SN-8.3: Attempt to achieve a maximum instantaneous noise level of 50 dBA in other areas of residential units exposed to train or aircraft noise, where the exterior L_{dn} exceeds 55 dBA. ▪ Policy SN-8.4: Prevent significant noise impacts from new development by applying state noise guidelines and Sunnyvale municipal code noise regulations in the evaluation of Land use issues and proposals. ▪ Policy SN-8.5: Comply with "State of California Noise Guidelines for Land Use Planning" (Figure 6-5) for the compatibility of land uses with their noise environments, except where the city determines that there are prevailing circumstances of a unique or special nature. ▪ Policy SN-8.6: Use figure 6-6 "Significant Noise Impacts from New Development on Existing Land Use" to determine if proposed development results in a "Significant Noise impact" on existing development. ▪ Policy SN-8.7: Supplement Figure 6-5 "State of California Noise Guidelines for Land Use Planning" for residential uses by attempting to achieve an outdoor L_{dn} of no greater than 60 DBA for common recreational areas, backyards patios and medium and large-size balconies. These guidelines should not apply where the noise source is railroad or an airport. If the noise source is a railroad, then an L_{dn} of no greater than 70 dba should be achieved in common areas, backyards, patios and medium and large balconies. If the noise source is from aircraft, then preventing new residential uses within areas of high L_{dn} aircraft noise is recommended. ▪ Policy SN-8.8: Avoid construction of new residential uses where the outdoor L_{dn} is greater than 70 dBA as a result from train noise. ▪ Policy SN-8.9: Consider techniques which block the path of noise and insulate people from noise. ▪ Policy SN-8.9a: Use a combination of barriers, setbacks, site planning and building design techniques to reduce noise impacts, keeping in mind their benefits and shortcomings. ▪ Policy SN-8.9c: Proposed sound walls or other noise reduction barriers should be reviewed for design, location and material before installing the barrier. Sound readings

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	should be taken before and after installing the noise reduction barrier in order to determine the efficacy of the noise reduction barrier. Measurement techniques shall be similar to procedures used by Caltrans to measure efficiency of sound walls. Goal SN-9: Acceptable limits for community noise. Maintain or achieve acceptable limits for the levels of noise generated by land use operations and single events. ▪ Policy SN-9.1: Regulate land use operation noise. ▪ Policy SN-9.2: Regulate select single event noises and periodically monitor the effectiveness of the regulations. ▪ Policy SN-9.3: Apply conditions to discretionary land use permits which limit hours of operation, hours of delivery and other factors which affect noise. Goal SN-10: Maintained or reduced transportation noise. Preserve and enhance the quality of neighborhoods by maintaining or reducing the levels of noise generated by transportation facilities. ▪ Policy SN-10.4: Mitigate and avoid the noise impacts from trains and light rail facilities ▪ Policy SN-10.4a: Monitor plans and projects which would increase the number of commuter or freight trains and evaluate their noise impacts and seek mitigation for any change that worsens local conditions. ▪ Policy SN-10.4c: Support legislation to reduce the noise level of trains. ▪ Policy SN-10.4d: Seek the cooperation of train engineers to avoid unnecessary and prolonged use of air horns except for safety purposes.
Sunnyvale Municipal Code	**19.42.030. Noise or sound level.** Operational noise shall not exceed seventy-five dBA at any point on the property line of the premises upon which the noise or sound is generated or produced; provided, however, that the noise or sound level shall not exceed fifty dBA during nighttime or sixty dBA during daytime hours at any point on adjacent residentially zoned property. [. . .] **16.08.030. Hours of construction—Time and noise limitations.** Construction activity shall be permitted between the hours of seven a.m. and six p.m. daily Monday through Friday. Saturday hours of operation shall be between eight a.m. and five p.m. There shall be no construction activity on Sunday or federal holidays when city offices are closed.
City of Santa Clara	
City of Santa Clara 2010-2035 General Plan (2010)	The City of Santa Clara adopted the *2010-2035 General Plan* on November 16, 2010. The general plan includes the following environmental quality goals and policies which are applicable to noise and vibration: Goals ▪ 5.10.6-G1: Noise sources restricted to minimize impacts in the community. ▪ 5.10.6-G2: Sensitive uses protected from noise intrusion. ▪ 5.10.6-G3: Land use, development and design approvals that take noise levels into consideration. **Policies** ▪ 5.10.6-P2: Incorporate noise attenuation measures for all projects that have noise exposure levels greater than General Plan “normally acceptable” levels. ▪ 5.10.6-P3: New development should include noise control techniques to reduce noise to acceptable levels, including site layout, building treatments and structural measures. ▪ 5.10.6-P4: Encourage the control of noise at the source through site design, building design, landscaping, hours of operation and other techniques.

Plan/Policy Document	Summary
	▪ 5.10.6-P5: Require noise-generating uses near residential neighborhoods to include solid walls and heavy landscaping along common property lines, and to place compressors and mechanical equipment in sound-proof enclosures. ▪ 5.10.6-P6: Discourage noise sensitive uses, such as residences, hospitals, schools, libraries and rest homes, from areas with high noise levels, and discourage high noise generating uses from areas adjacent to sensitive uses. ▪ 5.10.6-P10: Encourage transit agencies to develop and apply noise reduction technologies for their vehicles to reduce the noise and vibration impacts of Caltrain, Bay Area Rapid Transit, future High-Speed Rail, light rail and bus traffic.
Santa Clara City Code	The Santa Clara City Code is current through Ordinance 1969, passed in 2017. Chapter 9.10, Regulation of Noise and Vibration, is relevant to noise and vibration: **9.10.040 Noise or sound regulation:** It shall be unlawful for any person to operate or cause to allow to be operated, any fixed source of disturbing, excessive or offensive sound or noise on property owned, leased, occupied or otherwise controlled by such person, such that the sound or noise originating from that source causes the sound or noise level on any other property to exceed the maximum noise or sound levels which are set forth, as follows: ▪ Category 1: Single Family and Duplex Residential – 55 dBA between 7 am to 10 pm, and 50 dBA between 10 pm to 7 am; ▪ Category 2: Multiple Family Residential – 55 dBA between 7 am to 10 pm; 50 dBA between 10 pm and 7 am; ▪ Category 3: Commercial, Office – 65 dBA between 7 am and 10 pm, and 60 dBA between 10 pm and 7 am; ▪ Light Industrial -- 70 dBA at all times; and ▪ Heavy Industrial – 75 dBA at all times. **9.10.050 Vibration regulation:** It shall be unlawful for any person to operate or cause, permit, or allow the operation of, any fixed source of vibration of disturbing, excessive, or offensive vibration on property owned, leased, occupied, or otherwise controlled by such person, such that the vibration originating from such source is above the vibration perception threshold of an individual at the closest property line point to the vibration source on the real property affected by the vibration.

Sources: City and County of San Francisco 2004; City of Belmont 2017; City of Brisbane 2019; City of Burlingame 2018, 2019; City of Daly City 2013; City of Menlo Park 2013; City of Millbrae 1998; City of Mountain View 2012; City of Palo Alto 2017; City of Redwood City 2010; City of San Bruno 2009; City of San Carlos 2009; City of San Mateo 2010; City of Santa Clara 2010; City of South San Francisco 1999; City of Sunnyvale 2011; County of San Mateo 2011, 2013; Town of Atherton 2020

BART = Bay Area Rapid Transit
Caltrans = California Department of Transportation
CNEL = community noise equivalent level
dB = decibel
dBA = A-weighted decibel
DNL = day/night sound level
FRA = Federal Railroad Administration
HSR = high-speed rail
L_{dn} = day-night sound level
L_{eq} = sound level equivalent
PDA = priority development area
SamTrans = San Mateo County Transit District
SFO = San Francisco International Airport
UPRR = Union Pacific Railroad
VdB = velocity level

4 METHODS FOR EVALUATING EFFECTS

Analysts evaluated the effects of noise and vibration from construction and operations of the project quantitatively using FRA-approved methods. Construction noise and vibration and high-speed ground transportation noise and vibration were evaluated in accordance with methods and criteria from FRA's guidance manual (FRA 2012) and the FHWA's *Roadway Construction Noise Model* (FHWA 2006). Non-high-speed transit noise and vibration and noise levels from passenger stations and maintenance facilities were evaluated in accordance with the FTA guidance manual (FTA 2018). Train horn noise was evaluated using the FRA horn noise model (FRA 2000). Highway noise was evaluated in accordance with the FHWA's *Procedures for Abatement of Highway Traffic Noise and Construction Noise* (23 C.F.R. Part 772) as defined by the *Caltrans Traffic Noise Analysis Protocol* (Caltrans 2011). Analysts used design information on the project alternatives and HSR operations assumptions from the Authority's 2016 and 2018 Business Plans (Authority 2016, 2018) in the noise and vibration models, as well as field noise and vibration measurements, and professional judgment.

This technical report evaluates both direct and indirect noise and vibration effects. Direct effects consist of increases in noise and vibration because of construction activities or HSR operations, while indirect effects for noise include the project's effect on traffic patterns, which indirectly affect noise levels. This chapter provides additional details of the methods for the noise and vibration assessments.

4.1 Noise

4.1.1 Descriptors

Noise is typically described as unwanted sound[7] that is typically disagreeable or annoying. Several factors affect sound as perceived by the human ear, including the amplitude (or loudness), the frequency (or pitch), and the time variation (or duration).

The amplitude of a sound is determined by the magnitude of fluctuation caused by sound waves in the air pressure above and below the atmospheric pressure at equilibrium. The units of sound amplitude are dB, which are logarithmic values of the ratio of the pressure produced by the sound wave to a reference pressure (20 micro-Pascals).[8] Decibels more understandably express the extremely large range of absolute sound pressure values that the human ear is capable of perceiving. For example, a train horn sound of 100 dB has about 5,600 times greater pressure than a very low sound of 35 dB typically found in a quiet rural environment.

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 Hz. The average human ear and brain system can generally perceive the pressure fluctuation 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 with respect to human perception, a frequency filter is used to account for the response of the human ear by de-emphasizing the low and very high frequency components of the sound. This filtered sound is defined as A-weighted. The A-weighted sound level correlates well with human response and is expressed in terms of a single number. Figure 4-1 illustrates typical A-weighted noise levels of high-speed trains (including the German TransRapid TR08 maglev system, the steel wheel/rail French TGV, and the steel wheel/rail American Amtrak Acela train). The figure also illustrates other indoor and outdoor noise sources. Typical A-weighted sound levels range from the 40s to the 90s dBA, where 40 dBA is very quiet and 90 dBA is very loud. On average, each sound level increase of 10 dBA corresponds to an approximate doubling of subjective loudness.

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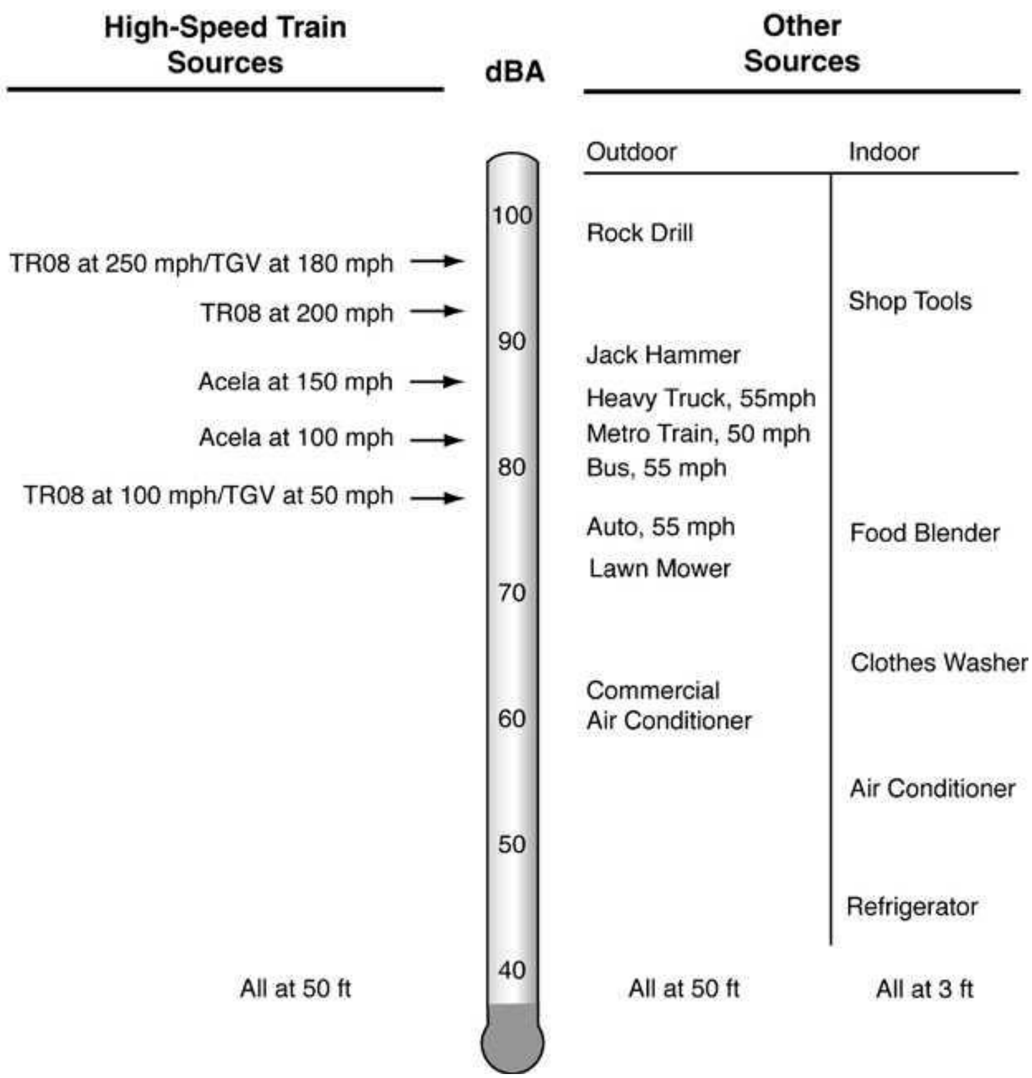
[7] *Sound* is caused by transmission of energy that propagates as waves of alternating pressure through a medium (fluids, solids, or gases such as the air).

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



Source: FRA 2012

Figure 4-1 Typical A-Weighted Maximum Sound Levels

The level of environmental noise commonly varies with time. There are several descriptors (also called *metrics*) used to characterize environmental noise. This analysis uses the following single-number descriptors, all based on the dBA sound pressure level as the fundamental unit for environmental noise measurements, computations, and assessment:

- **Sound Exposure Level (SEL)**—The SEL describes noise exposure from a single noise event. It is represented by the total A-weighted sound energy during the event, normalized to a 1-second interval. The SEL dB value is as if all the sound energy during the event would have occurred in 1 second. This is also the reason that SEL dBs may not be directly compared to normal sound level dBs. The SEL is the primary descriptor of HSR vehicle noise emissions and is an intermediate value in the calculation of both equivalent sound level (L_{eq}) and L_{dn} (defined in the following text).
- **L_{eq}**—The L_{eq} is the logarithmic summation of noise exposure during a period of interest, and it is widely used as a single-number descriptor of environmental noise. L_{eq} is used in this document to report results of short-term noise measurements and to calculate the L_{dn}. The

FRA and FTA have adopted hourly L_{eq} (L_{eq}(h)) as the measure of cumulative noise impact for nonresidential land uses.

- **L_{dn}**—The L_{dn} is the A-weighted L_{eq} for a 24-hour period with a 10 dB penalty applied to noise levels occurring between 10:00 p.m. and 7:00 a.m. As a result, the L_{dn} considers the number of noise events during day and night separately, and the sound energy of each event, which is dependent on the duration of each event, and the train speed. Studies have shown that the L_{dn} is well correlated with human annoyance from community noise. The FRA and FTA (as well as many other federal, state, and local agencies) have adopted L_{dn} as the descriptor of cumulative noise impact for land uses where people sleep, including residential.
- **CNEL**—The CNEL is a 24-hour average A-weighted sound level for a given day, with the addition of a 5 dB penalty to sound levels occurring from 7:00 p.m. to 10:00 p.m., and with the addition of a 10 dB penalty to sound levels occurring from 10:00 p.m. to 7:00 a.m. Although the CNEL was developed and used in California for many years, L_{dn} is now the descriptor of choice.

The use of different descriptors may result in different numerical values for a given sound or acoustic environment even though the actual properties of the sound or environment such as amplitude, frequency, and duration are identical. Because of this, some comparisons of dB may not be appropriate or may be completely invalid, such as comparing the SEL value to the maximum sound level (L_{max}) or to the L_{eq} of a train passby. Comparisons using the same metric, however, may be very useful to evaluate different sounds or noise sources. Additional information about these noise descriptors is included in Section A.1 of the FRA guidance manual.

4.1.2 Resource Study Area

The RSA is the area in which all environmental investigations specific to noise are conducted to determine the resource characteristics and potential effects of the project alternatives (Authority and FRA 2017). The noise RSA extends approximately 2,500 feet from the 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 high-speed trains shown in Table 4-1. The maximum FRA-recommended screening distance for HSR in an existing railroad corridor is 500 feet in quiet suburban areas with train operation speeds up to 170 mph; however, this recommendation assumes there would be 50 train operations per day. Consistent with FRA methods, analysts extended the noise RSA for the project farther than the maximum FRA-recommended screening distances to reflect the frequency of train operations, which would total 144 revenue and non-revenue trains per day based on the Authority's 2018 Business Plan (Authority 2018).

Table 4-1 Federal Railroad Administration–Recommended Screening Distances for Evaluation of HSR Noise Impacts[1]

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

Source: FRA 2012
mph = miles per hour
[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 50 feet.
[3] Rows of buildings 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.

4.1.3 Impact Criteria

4.1.3.1 Construction

The FRA guidance manual includes construction noise assessment criteria as shown in Table 4-2. 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 4-2 Detailed Assessment Criteria for Construction Noise

Land Use	8-Hour L_{eq} (dBA)		L_{dn} (dBA) 30-Day Average
	Day	Night	
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}

4.1.3.2 Operations

The HSR system uses noise impact criteria adopted by the FRA to assess the change resulting from the future contribution of noise from HSR operations and construction compared to the existing noise environment, and by the FTA to assess the future contribution of noise from conventional-speed rail operations and stationary facilities compared to the existing noise environment. These and other agency guidelines identified earlier establish methods for analyzing and assessing noise and vibration impacts. The FRA noise impact criteria are based on maintaining a noise environment considered acceptable for land uses where noise may have an effect. Land use also factors into the determination of 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 impact would occur. Descriptions of the three primary land use categories are shown in Table 4-3. The noise exposure is measured in terms of L_{dn} for residential land uses or in terms of $L_{eq}(h)$ for other land uses. 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. 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). The L_{eq} for land use Categories 1 and 3 are for the noisiest hour of transit-related activity during hours of noise sensitivity.

Table 4-3 Federal Railroad Administration Land Use Categories for Noise Exposure

Land Use Category	Noise Metric (dBA)	Land Use Category
1	Outdoor $L_{eq}(h)$	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 $L_{eq}(h)$	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.

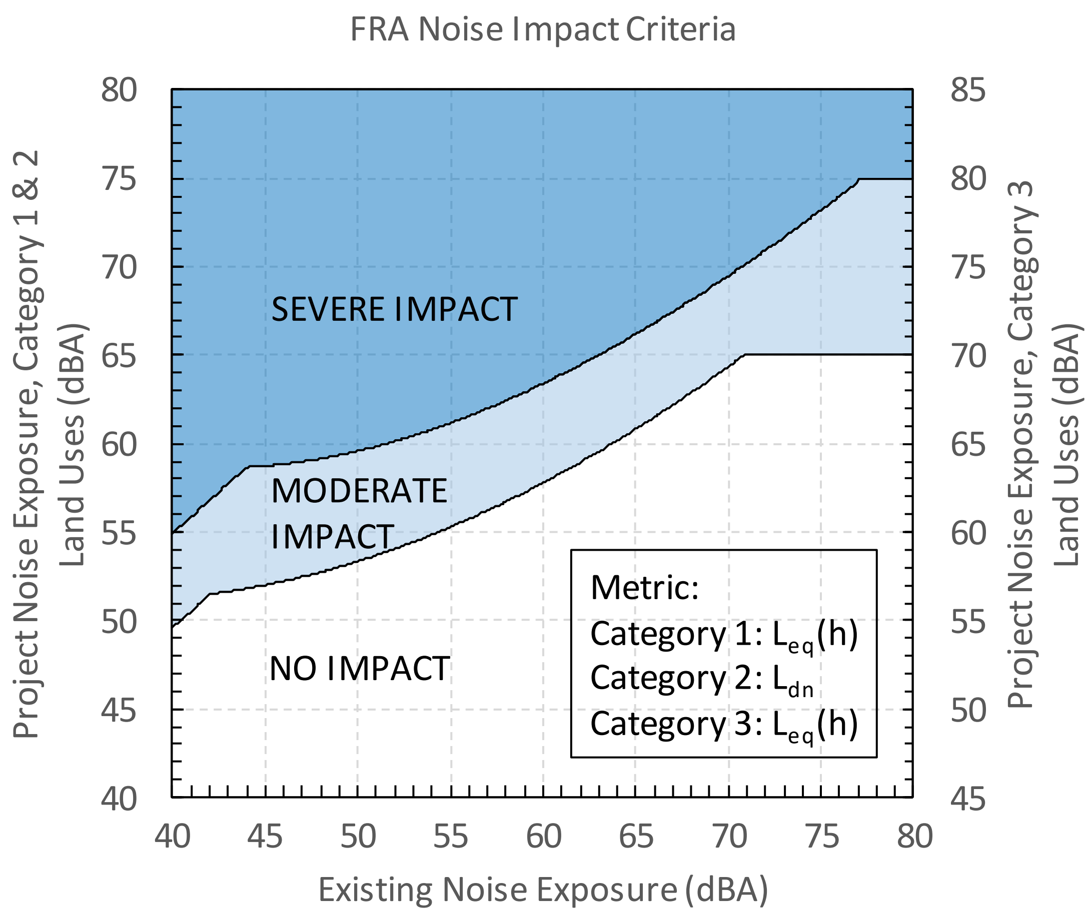
Source: FRA 2012
dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
$L_{eq}(h)$ = hourly equivalent sound level

FRA noise impact criteria for human annoyance are based on comparison of the existing outdoor noise levels and the future outdoor noise levels from a proposed HSR project. The FRA noise impact criteria specify a comparison of future with existing noise levels, not with projections of future build versus no-build noise exposure, because comparison of a projection with an existing condition is more indicative of 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.

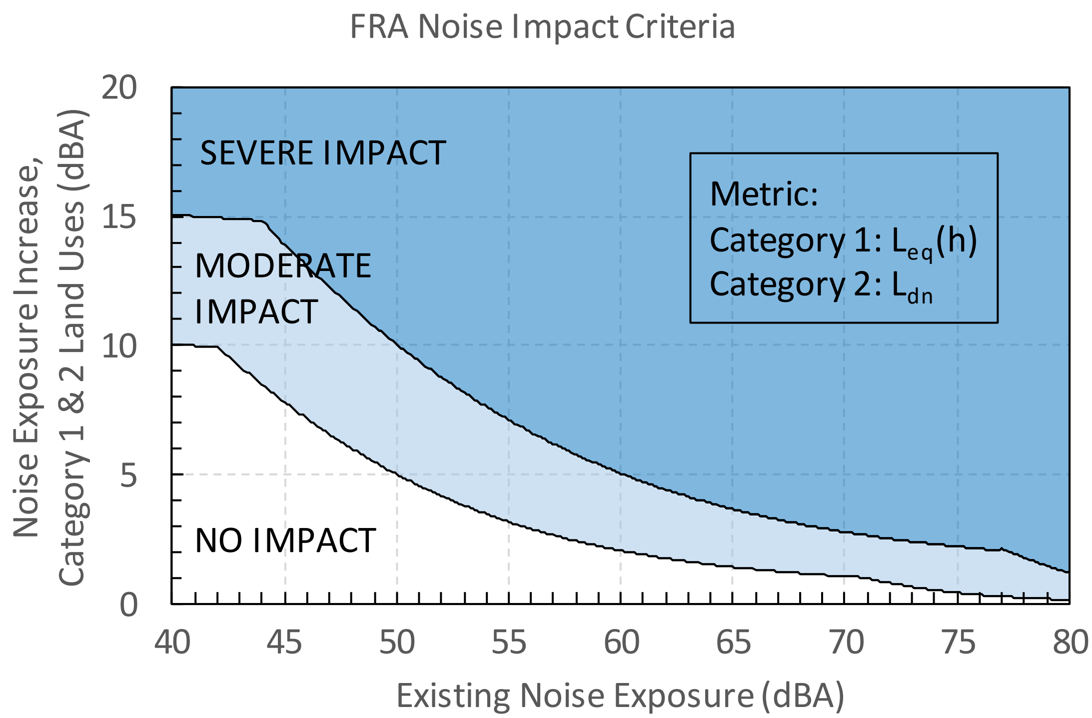
The noise impact criteria are illustrated on Figure 4-2. The figure shows the existing noise exposure and the additional noise exposure from HSR operations that would cause either a moderate impact or severe impact for each land use category. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure from HSR operations. The equations used to calculate the impact curves are found in Section A.3.3 of the FRA guidance manual.



Source: FRA 2012

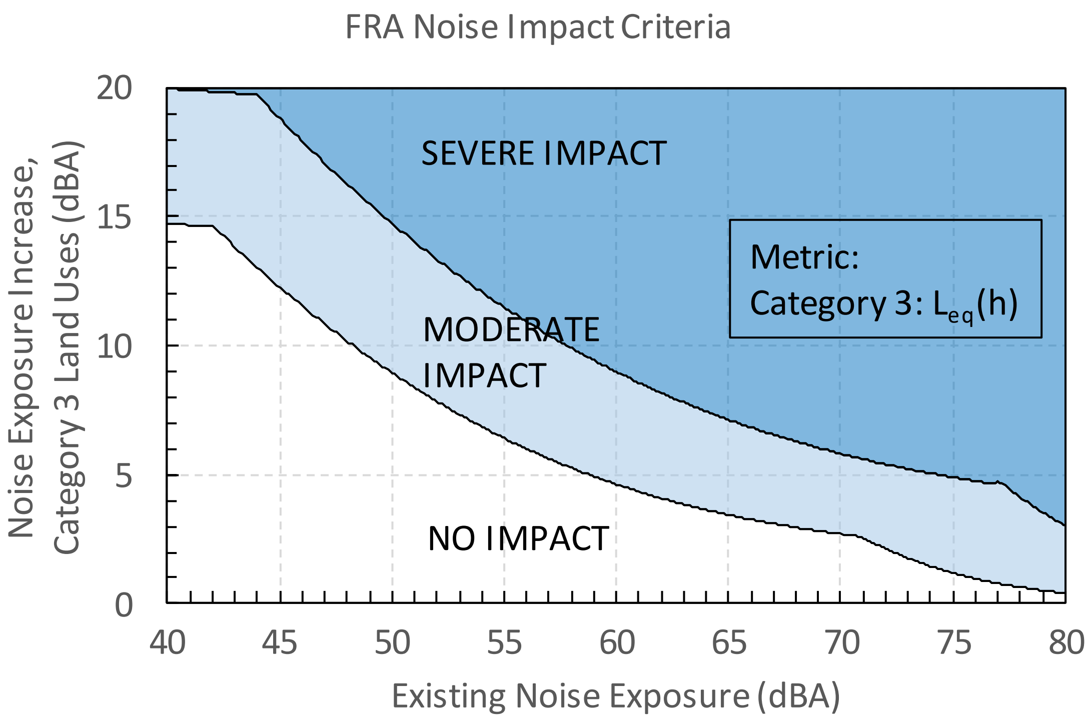
Figure 4-2 Noise Impact Criteria for High-Speed Rail Projects

The absolute criteria illustrated on Figure 4-2 are only applicable to new HSR sources where the existing noise levels generated by existing transit systems, roadways, and other sources would not change because of the project. The FRA criteria can also be presented in terms of relative levels for evaluating the total future noise exposure increases, or increases in cumulative noise exposure, from the project alternatives. If the existing noise is dominated by a source that would change due to the project, it would be incorrect to add the project noise to the existing noise. Therefore, the relative form of the noise criteria must be used for projects involving proposed changes to an existing 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 4-3 illustrates the relative form of the criteria as they apply to Category 1 and 2 land uses and Figure 4-4 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).



Source: FRA 2012

Figure 4-3 Allowable Increase in Cumulative Noise Levels (Land Use Categories 1 & 2)



Source: FRA 2012

Figure 4-4 Allowable Increase in Cumulative Noise Levels (Land Use Category 3)

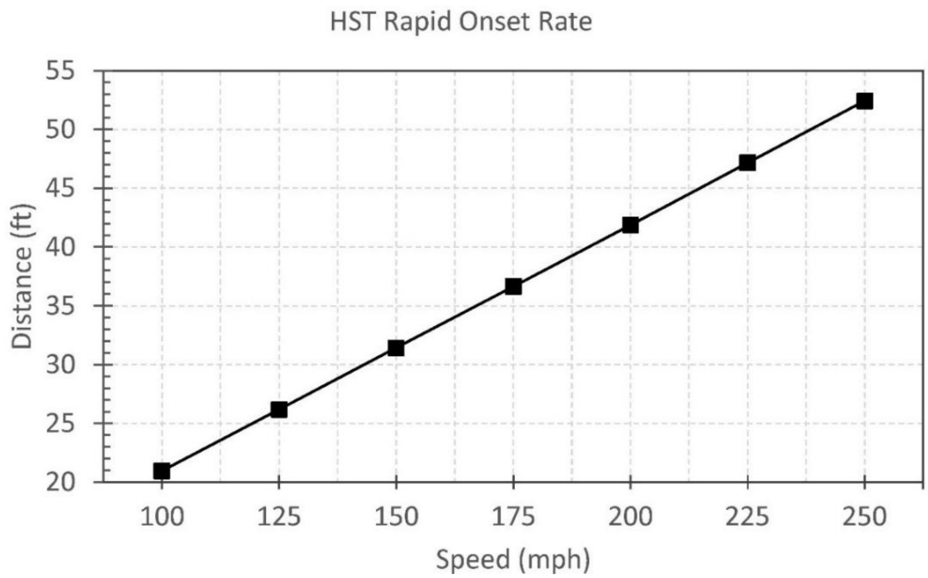
The noise criteria are applied at the outside of building locations at noise-sensitive areas. In some instances, the criteria apply to the building façade near doors and windows. Although noise impact is always determined based on exterior noise levels, interior noise levels may need to be evaluated when considering the need for mitigation at locations where land-use activity is solely indoors.

The process of determining impact severity begins with a determination of land use with reference to the land use categories shown in Table 4-3. Once the land use category has been determined, the appropriate noise metric (L_{dn} or L_{eq}) can be selected and used to determine the noise level and the severity of impact. The next steps are to determine the existing exterior noise exposure for each receptor or group of similar receptors and then to determine project noise exposure or the cumulative noise exposure associated with the project alternatives and other projects. Using the data on Figure 4-2 or Figures 4-3 and 4-4, the severity of impact is determined.

A hypothetical example would be to use a 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[9] would result in a total combined noise exposure of L_{dn} 66 dBA. This represents a potential increase of 6 dBA over the existing noise level. Using Figure 4-3, a line would be drawn vertically at 60 dBA and another line drawn horizontally at 6 dBA from left-hand axis. The intersection of these two lines determines the severity of impact. In this example, the resulting noise increase would be considered a severe impact on the residential receptor.

[9] 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.

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 unexpected increase in sound (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 per second people tend to be startled or surprised by the sudden onset of the sound. Consequently, analysts evaluated startle as an added annoyance factor and identified sensitive receptors that may experience a startle effect. The potential for startle as a function of train speed and distance from the train is illustrated on Figure 4-5.



Source: FRA 2012

Figure 4-5 Distance from Tracks within which Startle Can Occur for HSR

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 threshold for determining when startle would occur on a regular basis.

4.1.4 Methods for Establishing Existing Noise Levels

Analysts established the existing noise levels throughout the noise RSA through extensive field noise measurement programs. Wilson Ihrig conducted noise measurements in 2009, 2010, 2013, 2016, and 2017. A total of 75 measurements of ambient noise were taken in the noise RSA.

Analysts conducted long-term noise measurements (1 to 3 days in duration) to characterize the existing ambient noise in the RSA. The measurements were obtained by means of calibrated, precision, logging, sound level meters installed for a minimum of 24 hours at each location. All noise-measuring instruments used during the noise survey met ANSI S1.4-1993 specifications for Type I sound level meters. The sound level meters monitored the level of noise continuously and provided statistics on the ambient noise level for consecutive 1-hour intervals. During the monitoring period, L_{max}, minimum sound level (L_{min}), and L_{eq} values for each hour were obtained. The L_{eq} values were used to calculate the daily L_{dn} during each measured 24-hour period. For example, at a site where the measurement was conducted over a period of 3 full days, analysts calculated the average of the three hourly L_{eq} values in each hour of the day and subsequently used this to calculate an average L_{dn} at that site.

The L_{dn} describes the total noise exposure over a 24-hour period and is the noise metric FRA uses for residential (Category 2) land uses. The L_{eq} is used as the metric for evaluating noise impacts at institutional (Category 3) land uses with primarily daytime use. The hourly L_{eq} criterion is based on the hour with the loudest sound level. This hour is generally referred to as the peak-noise-hour, which could occur at different times of the day depending on whether the noise source is from train operations or vehicular traffic. The long-term noise measurement data provided the peak hour L_{eq} for Category 3 land uses.

Analysts selected specific locations for conducting the noise measurements throughout the RSA and in a variety of settings. The selection was 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. The measurement locations where ambient noise levels were collected are representative of areas with similar environmental conditions in other areas along the alignment. Areas that have primarily commercial and industrial land uses have fewer noise-sensitive receptors and consequently fewer ambient measurement sites.

Most of the selected measurement sites would have clear line of sight to the alignments and, therefore, are representative of receptors that are directly exposed to existing noise from Caltrain and freight trains. To categorize the dominant existing noise sources in the RSA, analysts located some measurement sites adjacent to roadways along the alignment, some sites near existing rail sources, and some sites near both existing rail and roadway sources.

The existing noise model incorporated the known existing train (passenger and freight) operations, horn noise, and traffic noise from nearby roadways. Analysts used the field noise measurement data to validate a model that uses a spreadsheet to implement the formulae and methods in the FTA guidance to estimate the relative contributions of passenger and freight rail sources. Non-rail sources such as airports were input as fixed values based on information from airport published noise contours (i.e., San Francisco International Airport and Norman Y. Mineta San Jose International Airport contour references) and roadways were input following methods in the FTA guidance. This model of the existing noise was used to calculate existing ambient noise levels at all receptors.

The rail noise model followed the method in Section 4 of the FTA guidance manual (FTA 2018) for a detailed noise analysis. Where noise measurement sites were located close to roadways, noise sources were modeled by adjusting the measured levels with distance following the procedures in Appendix E of the FTA guidance manual. In some instances, for smaller roadways, the noise model incorporated the procedures in Section 4.4 of the FTA guidance manual.

4.1.5 Prediction Methods

4.1.5.1 Construction Noise

Analysts assessed construction noise impacts according to the method described in the FRA guidance manual. Construction noise estimates are always approximate because of the lack of specific information available at the time of the environmental analysis. Decisions about the procedures and equipment to be used would be made by the contractor. 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 included 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 operations 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.

4.1.5.2 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 Operations

High-Speed Rail Traffic

HSR operations would include both revenue service trains and non-revenue service trains with daily trips to and from the planned Brisbane LMF. Table 4-4 shows the number of HSR trains, which would be the same for all project alternatives, from San Francisco to the Brisbane LMF, from the LMF to Millbrae, and from Millbrae to San Jose. The summary combines the number of daily trains in both directions of travel. Analysts conducted noise modeling for 2029 No Project, 2029 Plus Project, 2040 No Project, and 2040 Plus Project conditions. The 2029 and 2040 No Project conditions were modeled to evaluate how these future scenarios would compare to the existing noise environment to provide context for the future Plus Project conditions.

The analysis of HSR project operations in 2029 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 non-revenue 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 just south of Mission Bay Drive to the 4th and King Street Station. Table 4-4 summarizes the number of daily HSR trains for this area.

Table 4-4 Assumed 2029 and 2040 HSR Operations for Noise Impact Assessment

Segment	Total Number of HSR Trains (Both Directions)		
	Daytime[1]	Nighttime[2]	Peak Hour[3] (Approximate)
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

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 non-revenue train movements per hour in addition to standard revenue service operations.

The 2040 analysis assumes that HSR service would be operational for Phase 1, which would connect San Francisco with Los Angeles through the Central Valley. The number of daily trains for both alternatives would be the same. HSR service from the 4th and King Street Station to the SFTC 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 DTX alignment ends, south of Mission Bay Drive in San Francisco to Scott Boulevard in Santa Clara. The 4th and King Street Station (located at grade) 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.

High-Speed Rail System Type

The specific vehicle technology proposed for the HSR system is a very high-speed (VHS) electric multiple unit (EMU) train even though these trains would not be operated above 110 mph in this Project Section. For the purposes of this analysis, the HSR trains are assumed to have a length of 660 feet. The various train technologies under consideration would incorporate 8 to 14 cars, with the length of each car varying to yield a train length of 660 feet.

The project's proposed maximum operation speed is 110 mph. This analysis is based on the maximum design speeds for the track throughout the Project Section. The design speeds used in the analysis were then decreased in some locations based on general operating parameters and track construction.

The noise predictions were based on the noise source reference levels in Table 5-2 of the FRA guidance manual, which are shown in Table 4-5. The source reference level for VHS EMU trains is divided into three categories or speed regimes where one sound source contributes most to the total noise level.

- **Regime I**—Propulsion or machinery noise
- **Regime II**—Mechanical noise resulting from wheel-rail interactions, guideway vibrations, or both
- **Regime III**—Aerodynamic noise resulting from airflow moving past the train, including the pantograph (device mounted to top of train to collect power through the overhead lines)

At train speeds up to approximately 125 mph, the propulsion noise subsource is typically the largest contributor to the total noise. The noise from the wheel-rail interface is typically dominant at speeds of 125–160 mph, but it also contributes to overall train noise at lower speeds. Aerodynamic noise typically becomes equal to wheel-rail noise and thus is an important component at speeds faster than 160 mph. Therefore, at maximum speeds of only 110 mph, aerodynamic noise would be negligible and would not contribute to the overall train noise in this Project Section.

The noise source reference levels shown in Table 4-5 are associated with corresponding reference height, length, and speed reference terms.

The aerodynamic subsource for a VHS EMU train is further divided by noise from the train nose region, the wheel region, and from the pantograph. The following equation from Section 5.2.2 of the FRA guidance manual is used to calculate the SEL for each of the subsources:

$$\mathrm{SEL} = (\mathrm{SEL_{ref}}) + 10 * \mathrm{Log}\left(\frac{\mathrm{len}}{\mathrm{len_{ref}}}\right) + \mathrm{K} * \mathrm{Log}\left(\frac{\mathrm{S}}{\mathrm{S_{ref}}}\right)$$

where:

SEL	=	SEL of component subsource (dBA)
SEL_{ref}	=	Subsource reference SEL (dBA)
len	=	Subsource length (feet)
len_{ref}	=	Subsource reference length (feet)
K	=	Reference speed factor
S	=	Speed (mph)
S_{ref}	=	Speed reference (mph)

- The length term in the equation above, len, for the propulsion subsource is defined as the total length of the power units in the train (len_{power}), which for an EMU is the total length of all cars (660 feet).
- The length term for the wheel-rail noise subsource is the total length of the train (660 feet).
- The length term for the aerodynamic train nose subsource is the length of one car (83 feet) corresponding to an eight-car train.
- Because the total train length is known, and the number of cars is not known, the train nose subsource component is based on an eight-car train (corresponding to longer cars), which yields slightly higher noise levels.

Analysts used assumed HSR operating speeds provided by the design team in the noise and vibration analyses. Table 4-6 shows a summary of the range of operating speeds that apply to both project alternatives within each subsection and by location.

Table 4-5 Federal Railroad Administration Noise Source Reference Levels for High-Speed Trains (SELs at 50 feet)

System Category and Features[1]	Example Systems	Subsource Component		Subsource Parameters: Length Definition, Len	Subsource Parameters: Height Above Rails (feet)	Reference Quantities: SEL_{ref} (dBA)	Reference Quantities: len_{ref} (feet)	Reference Quantities: S_{ref} (mph)	Reference Quantities: K
HS and VHS electric locomotive–hauled trains	Amtrak Acela, TGV, Eurostar, X2000, KTX-I/KTX-II, ETR 500	Propulsion		$Len_{(power)}$	12	86	73	(2)	(2)
		Wheel-rail		$Len_{(train)}$	1	91	634	90	20
		Aero	Train nose	$Len_{(power)}$	10	89	73	180	60
			Wheel region	$Len_{(train)}$	5	89	634	180	60
			Pantograph	(3)	15	86	(3)	180	60
		(Only include aerodynamic subsources for VHS trains above 150 mph)							
HS and VHS EMU trains	IC T, ICE 3, AVE S103, ETR450, KTX-III	Propulsion		$Len_{(power)}$	2	86	634	(2)	(2)
		Wheel-rail		$Len_{(train)}$	1	91	634	90	20
		Aero	Train nose	$Len_{(power)}$	10	89	73	180	60
			Wheel region	$Len_{(train)}$	5	89	634	180	60
			Pantograph	(3)	15	86	(3)	180	60
		(Only include aerodynamic subsources for VHS trains above 150 mph)							
HS gas-turbine locomotive-hauled trains	Rohr RTL-2, Bombardier Jet-Train	Propulsion		$Len_{(power)}$	10	83	73	20	10
		Wheel-rail		$Len_{(train)}$	1	91	634	90	20

Source: FRA 2012
dBA = A-weighted decibel
EMU = electric multiple unit
HS = high speed
K = reference speed factor
len_{ref} = length reference
mph = miles per hour
S_{ref} = speed reference
SEL_{ref} = sound exposure level reference
VHS = very high speed
[1] HS maximum speed 150 mph; VHS maximum speed 250 mph
[2] Source level is not adjusted for train speed
[3] Source level is not adjusted for train length

Table 4-6 Assumed HSR Operating Speeds

Location	Geographic Extent	Range of HSR Operating Speeds (mph)
San Francisco to South San Francisco Subsection		
4th and King Street Station	4th and King Street Station to Mission Bay Drive	25
Design District	Mission Bay Drive to 18th Street	45–110
SF Tunnels No. 1 and 2	18th Street to outlet of Tunnel No. 2	100–110
Islais Creek	Tunnel No. 2 to Tunnel No. 3	100–110
SF Tunnel No. 3	Tunnel No. 3 to Thornton Avenue	110
Portola Place	Thornton Avenue to Key Avenue	110
SF Tunnel No. 4	Key Avenue to Blanken Avenue	65–110
Bayshore	Blanken Avenue to southern boundary of San Francisco City/County	65–110
Brisbane	San Francisco City/County southern boundary to northern boundary of South San Francisco	85–110
South San Francisco	South San Francisco northern boundary to Tanforan Avenue	100–110
San Bruno to San Mateo Subsection		
San Bruno	Tanforan Avenue to San Juan Avenue	100–110
Millbrae	San Juan Avenue to Murchison Drive	100–110
Burlingame	Murchison Drive to Peninsula Avenue	105–110
San Mateo North	Peninsula Avenue to 9th Avenue	79–110
San Mateo to Palo Alto Subsection		
San Mateo South	9th Avenue to North Road	110
Belmont	North Road to F Street	110
San Carlos	F Street to Easton Avenue	110
Redwood City	Easton Avenue to Northumberland Avenue	110
Fair Oaks	Northumberland Avenue to Wilburn Avenue	110
Atherton	Wilburn Avenue to Holbrook-Palmer Park	110
Menlo Park	Holbrook-Palmer Park to Palo Alto Avenue	110
Palo Alto	Palo Alto Avenue to San Antonio Road	110
Mountain View to Santa Clara Subsection		
Mountain View	San Antonio Road to South Bernardo Avenue	90–110
Sunnyvale	South Bernardo Avenue to Lawrence Expressway	110
Santa Clara	Lawrence Expressway to Scott Boulevard	110

Source: Authority 2019
HSR = high-speed rail
mph = miles per hour

The noise level predictions account for the proposed operations schedule, ground propagation attenuation effects, cross-sectional geometry of the guideway and superstructure where it occurs (e.g., elevated guideway), and shielding provided by existing noise barriers and intervening rows of buildings. Analysts assumed all tracks were ballast-and-tie construction. The project would operate on existing tracks with Caltrain and freight operations. The existing track is predominantly two-track at grade, with four short existing tunnels located in San Francisco and several existing four-track areas where trains pass one another.

Figure 4-6 illustrates the projected 24-hour noise levels from HSR operations versus distance at a train speed of 110 mph. The data are representative of a typical at-grade section of track between San Francisco and Santa Clara. The data in the figure do not include any intervening shielding, which would further decrease the noise levels by 5 to 10 dBA. The figure illustrates how the noise levels from HSR operations would attenuate to typical ambient L_{dn} at greater distances from the track.

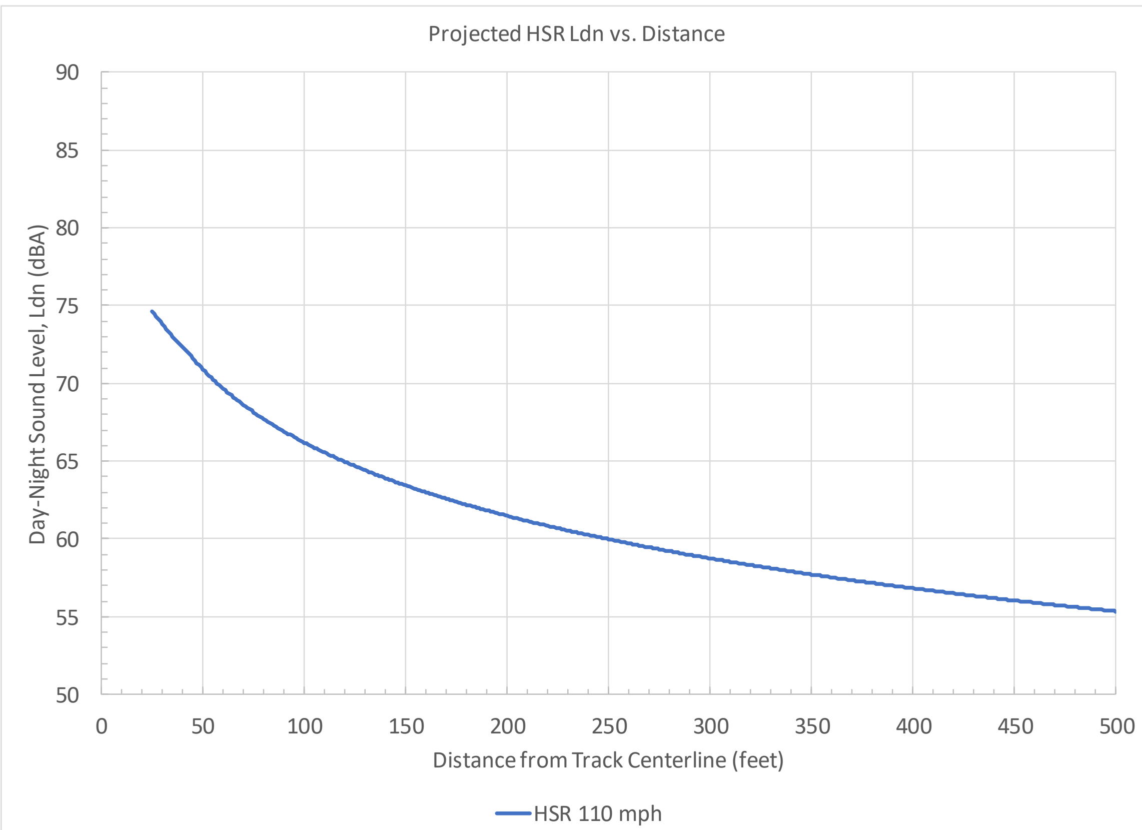


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Figure 4-6 Projected HSR 24-Hour Noise Levels versus Distance for Typical At-Grade Track Section Without Shielding Effects

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 by analysts to be standard frogs. Wheel impacts at turnouts and crossovers with standard frogs were assumed to cause localized increases in noise of up to 6 dBA within 50 feet, decreasing with distance from the track frogs.

Other Rail Traffic

The noise analyses for the 2029 and 2040 conditions include noise-level changes associated with future changes in Caltrain operations between San Francisco and Santa Clara 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 and replace 75 percent of the current train fleet, which consists of diesel locomotive-hauled coaches, with EMU trains. With the commencement of blended service operations, Caltrain service will consist of 100 percent EMUs. The PCEP will also increase service from five to six Caltrain trains per peak hour and from 92 to 114 trains per day. An environmental impact analysis for the PCEP was prepared in 2014. The details of the analysis are contained in the *Caltrain Peninsula Corridor Electrification Project Noise and Vibration Technical Report* (PCJPB 2014). The changes to Caltrain service would increase the existing noise environment in the RSA; therefore, the PCEP is included as part of these analyses.

Similar to the wayside noise projections for HSR, the noise predictions for Caltrain operations were based on the source reference levels and account for the proposed operations schedule, ground effect, cross-sectional geometries, the existing shielding by noise barriers, and intervening rows of buildings where applicable.

Existing freight operations were included in the analysis, and future freight operations were included in the cumulative noise analysis. Freight operations occur mainly during the nighttime. Noise from freight operations was modeled based on FTA methods. Future freight operations in the 2029 and 2040 future conditions were determined based on growth factors and were used in the cumulative noise impact analysis.

Caltrain accounts for the majority of the existing rail traffic along most of the Project Section, followed by freight. Table 4-7 shows the existing daily train operations, Table 4-8 shows the projected daily 2029 train operations, and Table 4-9 shows the projected daily 2040 train operations in the Project Section.

Table 4-7 Existing (2017) Passenger and Freight Train Operations

System	Period	Total Daily Trains (Both Directions) per Segment			
		San Francisco–Quint Street	Quint Street–South San Francisco	South San Francisco–Redwood Junction	Redwood City Junction–Santa Clara
Caltrain	Daytime[1]	77	77	77	77
	Nighttime[2]	15	15	15	15
	Peak hour[3]	10	10	10	10
	Total	**92**	**92**	**92**	**92**
Freight[4]	Daytime[1]	2	2	2	0
	Nighttime[2]	0	0	2	2
	Peak hour[3]	0	1	2	1
	Total	**2**	**2**	**4**	**2**
Total trains	**Total**	**94**	**94**	**96**	**94**

Source: Authority 2019
[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] Approximate
[4] Freight trains do not travel north of the Quint Street lead in San Francisco, which is approximately 2.5 miles south of the 4th and King Street Station.

Table 4-8 Assumed 2029 Passenger and Freight Train Operations

System	Period	Total Daily Trains (Both Directions) per Segment			
		San Francisco–Quint Street	Quint St– South San Francisco	South San Francisco–Redwood Junction	Redwood Junction–Santa Clara
Caltrain	Daytime[1]	100	100	100	100
	Nighttime[2]	14	14	14	14
	Peak hour[3]	12	12	12	12
	Total	**114**	**114**	**114**	**114**
Freight[4]	Daytime[1]	3	3	4	0
	Nighttime[2]	0	0	3	3
	Peak hour[3]	0	2	3	2
	Total	**3**	**3**	**7**	**3**
Total trains	**Total**	**116**	**117**	**121**	**117**

Source: Authority 2019
[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] Approximate
[4] Freight trains do not travel north of the Quint Street lead in San Francisco, which is approximately 2.5 miles south of the 4th and King Street Station.

Table 4-9 Assumed 2040 Passenger and Freight Train Operations

System	Period	Total Daily Trains (Both Directions) per Segment			
		San Francisco–Quint Street	Quint Street–South San Francisco	South San Francisco–Redwood Junction	Redwood Junction–Santa Clara
Caltrain	Daytime[1]	100	100	100	100
	Nighttime[2]	14	14	14	14
	Peak hour[3]	12	12	12	12
	Total	**114**	**114**	**114**	**114**
Freight[4]	Daytime[1]	5	5	5	0
	Nighttime[2]	0	0	5	5
	Peak hour[3]	0	3	4	3
	Total	**5**	**5**	**10**	**5**
Total trains	**Total**	**119**	**119**	**124**	**119**

Source: Authority 2019
[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] Approximate
[4] Freight trains do not travel north of the Quint Street lead in San Francisco, which is approximately 2.5 miles south of the 4th and King Street Station.

Horn Noise

Future HSR would operate on the existing rail tracks between San Francisco and Santa Clara. The existing rail tracks include numerous at-grade crossings where Caltrain and freight trains are currently required by FRA regulations to sound their warning horns. Additionally, trains currently sound horns as they approach Caltrain passenger station platforms. Because HSR trains would be operating on shared track, HSR trains would also sound horns as they approach at-grade crossings and passenger stations. Table 4-10 shows all the locations in the Project Section where trains currently sound warning horns. The table also shows the locations where Caltrain, freight, and HSR trains would sound horns in the future with the project. Caltrain stations are indicated in bold text with an asterisk (*). An “X” in the table indicates that those trains do sound horns in those locations.

To assess noise levels associated with the at-grade crossings and horn-sounding locations for each project alternative, the method for noise prediction included a horn noise model based on the FRA horn noise model (FRA 2000) and field noise measurements of the Caltrain horn. Analysts applied the model to receptors within 0.25 mile of each at-grade crossing and passenger station location where horns must be sounded. Noise measurements in the RSA indicate that the L_{max} from Caltrain train horns is consistently 96 dBA at the wayside, perpendicular to the track, at a distance of 100 feet from the track. These train horns mainly radiate noise within 45 degrees of center (FRA 1993), so that the horn noise measured at a distance of 100 feet at the wayside, perpendicular to the horn, would be very similar to the noise at 100 feet in front of the horn. However, if we assume that the train horn has directional properties, it is the nature of a forward-facing horn that on-axis noise (along the track) will be louder than off-axis (at some angle from the direction of travel). Thus, since the off-axis level is 96 dBA, the on-axis level must be higher. On-axis and off-axis, the Caltrain horn is consistent with the minimum horn sound level allowable by FRA regulations to provide adequate warning of the train approach and is used by existing Caltrain locomotives and future Caltrain EMUs with PCEP.

The noise prediction model for freight train horns was based on a L_{max} of 107 dBA at 100 feet from the track. This assumption is based on FRA field measurement data showing that this is the average horn noise level from freight trains (FRA 2020). The noise prediction model for HSR train horns assumes a L_{max} of 96 dBA at 100 feet from the track, consistent with Caltrain and FRA regulations. Crossing bells near existing at-grade crossings were included in the noise measurement program and were modeled based on the methods in the FTA guidance manual.

The mounting height location of train horns is also an important input to the noise modeling results, because the horn height affects the amount of ground attenuation and shielding provided by noise barriers. The height of the horns on existing Caltrain locomotives is modeled at 16 feet above-top-of-rail (ATOR). Future Caltrain EMUs will incorporate a lower mounted horn height of 3 feet ATOR. Horns on all freight trains are located at a height of 16 feet ATOR. Future HSR trains will have horns mounted at a height of 7 feet ATOR.

Table 4-10 Grade Crossings and Horn-Sounding Locations

Grade Crossing/Station	Existing Horn	Future Caltrain/Freight Horn		Future HSR/Caltrain/ Freight Horn	
		Alternative A	Alternative B	Alternative A	Alternative B
Mission Bay Drive	X	X	X	X	X
16th Street	X	X	X	X	X
22nd Street Station*	X	X	X	X	X
Bayshore Station*	X	X	X	X	X
South San Francisco Station*	X	X	X	X	X

Grade Crossing/Station	Existing Horn	Future Caltrain/Freight Horn		Future HSR/Caltrain/ Freight Horn	
		Alternative A	Alternative B	Alternative A	Alternative B
Linden Avenue	X	X	X	X	X
Scott Street	X	X	X	X	X
San Bruno Station*	X	X	X	X	X
Center Street	X	X	X	X	X
Santa Paula Crossing	X	X	X	X	X
Broadway Avenue	X	X	X	X	X
Broadway Station*	X	X	X	X	X
Morrell Avenue	X	X	X	X	X
Oak Grove Avenue	X	X	X	X	X
North Lane	X	X	X	X	X
Burlingame Station*	X	X	X	X	X
Howard Avenue	X	X	X	X	X
Bayswater Avenue	X	X	X	X	X
Peninsula Avenue	X	X	X	X	X
Villa Terrace	X	X	X	X	X
Bellevue Avenue	X	X	X	X	X
San Mateo Station*	X	X	X	X	X
1st Avenue	X	X	X	X	X
2nd Avenue	X	X	X	X	X
3rd Avenue	X	X	X	X	X
4th Avenue	X	X	X	X	X
5th Avenue	X	X	X	X	X
9th Avenue	X	X	X	X	X
Hayward Park Top Station*	X	X	X	X	X
Hayward Park Bottom Station*	X	X	X	X	X
East 25th Avenue[1]	X				
Hillsdale Station*	X	X	X	X	X
Belmont Station*	X	X	X	X	X
San Carlos Station*	X	X	X	X	X
Whipple Avenue	X	X	X	X	X
Brewster Avenue	X	X	X	X	X
Broadway	X	X	X	X	X

Grade Crossing/Station	Existing Horn	Future Caltrain/Freight Horn		Future HSR/Caltrain/ Freight Horn	
		Alternative A	Alternative B	Alternative A	Alternative B
Redwood City Station*	X	X	X	X	X
Maple Street	X	X	X	X	X
Main Street	X	X	X	X	X
Chestnut Street	X	X	X	X	X
Atherton Station*	X	X	X	X	X
Watkins Avenue	X	X	X	X	X
Encinal Avenue	X	X	X	X	X
Glenwood Avenue	X	X	X	X	X
Oak Grove Avenue	X	X	X	X	X
Menlo Park Station*	X	X	X	X	X
Ravenswood Avenue	X	X	X	X	X
Alma Street	X	X	X	X	X
Palo Alto Station*	X	X	X	X	X
Stanford Station*	X	X	X	X	X
Churchill Avenue	X	X	X	X	X
California Station*	X	X	X	X	X
East Meadow Drive	X	X	X	X	X
Charleston Road	X	X	X	X	X
San Antonio Station*	X	X	X	X	X
Rengstorff Avenue	X	X	X	X	X
Castro Avenue	X	X	X	X	X
Mountain View Station*	X	X	X	X	X
Mary Avenue	X	X	X	X	X
Sunnyvale Station*	X	X	X	X	X
Lawrence Station*	X	X	X	X	X

Source: Authority 2019
HSR = high-speed rail
X = horn noise included at this location
Bold locations denoted with an asterisk (*) identify Caltrain stations.
[1] The 25th Avenue Grade-Separation Project would elevate the existing at-grade track between State Route 92 and Hillsdale Boulevard to provide a grade-separated undercrossing of 25th Avenue, removing the need for train horn sounding at 25th Avenue in the future condition.

Annoyance from Rapid Onset of HSR Passbys

The FRA guidance (FRA 2012) indicates that there is considerable evidence that increased annoyance is likely to occur for train noise events with high travel speeds (rapid onset rates). A rapid rise of sound level can result in a startle effect, particularly for a noise-sensitive receptor near the tracks. Analysts assessed the potential for annoyance from rapid onset based on HSR train speed and distance of the receptor from the track. Figure 4-5 illustrates the relationship of speed and distance to locations where the onset rate for project operations may cause a startle effect. An onset rate of 30 dBA per second 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.

Other Noise Sources

Station Noise

Analysts assessed noise impacts associated with the planned HSR service to stations in San Francisco and Millbrae at each nearby noise-sensitive receptor by following the method for detailed noise analysis for HSR train operations summarized in Section 5.2 of the FRA guidance manual and the method for a general noise assessment for parking facilities summarized in Section 4.4 of the FTA guidance manual.

The dominant noise source associated with project operations at the stations would be HSR train movements, including train horns. The station noise analysis includes noise measurements at representative clusters of receptors near the stations, noise modeling to determine existing ambient noise conditions, and predictions of future noise conditions. The noise predictions at these receptors are based on the HSR operations inputs for mainline conditions that take into account horn noise levels, train schedules, train consists (number of cars), speed profiles (including through trains), and track elevation. The analysis included terrain information and the elevation of all receptors relative to the tracks.

Analysts used the station plan layouts and number of planned parking spaces to predict the noise exposure from the parking facilities at nearby noise-sensitive receptors. The FTA guidance manual Section 4.4 (FTA 2018: page 45 and following) reference SEL of 92 dBA at 50 feet distance corresponding to 1,000 cars in a peak activity hour was used to predict the additional noise from the planned new parking lots at the Millbrae Station. The 4th and King Street Station would not include any new parking facilities, but an analysis of noise from increased vehicular activity near the station was prepared.

Analysts tabulated the predicted noise levels from HSR trains at the stations and from the parking facilities along with the existing ambient noise exposures at the identified receptors or clusters of receptors. Levels of impact (no impact, moderate impact, or severe impact) were determined by comparing the existing and projected noise exposure based on the impact criteria described in Section 4.1.3.

Maintenance Facility Noise

Noise sources at the Brisbane LMF are expected to include daily inspections, pre-departure cleaning and testing, quarterly inspections, and train storage activities. Train maintenance would take place inside the maintenance building with minimal noise spillover into the surrounding area. Analysts used the method in Section 4.4 of the FTA guidance manual (FTA 2018: page 45 and following) to predict noise exposure from the LMF. This method assumes fully loaded yards and shops with noise-generating activity. 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 combined with the HSR operations noise predictions and compared to the impact criteria described in Section 4.1.3.

Vehicle Traffic Noise

In addition to noise from HSR operations, noise from changes in traffic volume due to the project was considered for 2029 and 2040 conditions. Analysts assessed the anticipated increases in noise levels resulting from increased traffic volumes near the HSR stations and LMF. Total daily traffic volumes for roadway segments near the HSR stations and LMF were calculated for each project alternative and compared to existing traffic volumes.

Analysts used the following methods to determine locations with the potential for noise impacts from traffic:

- Where major roads would undergo changes due to the project alternatives, traffic growth factors for road segments were calculated to assess locations where the change in traffic volume would increase noise levels. Increases with and without the project were calculated separately.
- Traffic growth factors for road segments near HSR stations and LMFs were calculated to assess locations where the change in traffic volume would increase noise levels. Increases with and without the project were calculated.
- For each project alternative, roadway segments were identified where the growth factors indicated a potential increase in noise of 3 dB or greater, which represents a noticeable increase in noise level.
- At locations where the growth factors for a project alternative resulted in a 3 dB or greater increase in noise, for instance, a doubling of traffic, an analysis was conducted to determine the increase in traffic volume that would be related to the alternative.

Daily traffic volumes for these roadway segments were used to calculate traffic growth factors to assess the potential change in noise levels for each project alternative. Analysts calculated the potential noise level increase for each roadway segment by comparing the future traffic volume with the project alternatives to the existing volume and the future volume without the alternatives. The comparison to existing traffic volume is consistent with the FRA approach to assessing operations noise impacts. The increases with the alternatives over the projected future volumes without the alternatives are caused by the project. Increases in future traffic volumes without the project alternatives over the existing traffic volumes would be due to other growth factors not related to HSR.

The potential change in noise level for each roadway segment is calculated as follows:

$$\Delta = 10 * \mathrm{Log}\left(\frac{\mathrm{a}}{\mathrm{b}}\right)$$

where:

Δ	=	Change in noise level (dBA) due to the project alternatives
a	=	Future average daily traffic (ADT) traffic volume with or without project alternatives
b	=	Existing ADT traffic volume

Traction Power Facility Noise

In addition to the noise generated by project operations, noise may be generated by the additional equipment that could be installed at the site of Caltrain PCEP TPFs to handle HSR electrical loads. The HSR equipment would be similar in terms of size and capacity to the Caltrain PCEP equipment.

The FRA does not have its own analysis techniques for TPFs because these facilities are not unique to high-speed systems, but instead references the FTA method. Therefore, FTA reference levels were used in the PCEP analysis to calculate the total project noise level at the receivers identified within the screening distance. The FTA reference SEL for substations is 99 dBA at 50 feet, which equates to an L_{dn} of 70 dBA at 50 feet (assuming continuous 24-hour usage).

In the PCEP analysis, potentially affected noise-sensitive receivers from PCEP TPFs were identified using the FTA screening distance of 250 feet from the various facilities (i.e., TPSS, paralleling station, or switching station), within which 15 noise-sensitive receptors were identified. Based on the PCEP analysis, receptors within 100 feet of the TPF were further analyzed with updates from HSR project operations.

Benchmark Tests to Validate HSR Noise Prediction Model

The Authority developed a protocol to validate HSR noise models for accurate HSR noise predictions and consistency among the multiple project sections. The *Benchmark Tests for Calibration of CAHST Noise Models* (May 26, 2010) establishes a series of test cases and input parameters that practitioners use to validate individual noise models (Authority 2010). The purpose is to make sure that the HSR noise models used by practitioners for each of the project sections throughout California agree and achieve consistent prediction results.

The test cases established by the Authority include calculations at two speeds (100 mph and 200 mph) for receptors at multiple distances and elevations for HSR on typical embankment and aerial guideway locations. Input parameters include train vehicle type, length of train, number of trains during daytime and nighttime, as well as specific geometrical track configurations.

The results of the benchmark tests for 100 mph operations are shown in Table 4-11. The results agree with the HSR benchmark noise prediction model results and are consistent with the Authority's established noise model.

Table 4-11 Benchmark Noise Model Results at 100 Miles Per Hour

Results and Model Input Parameters Using VHS Electric (100 mph)							Reference Results			Modeled Results			Difference		
Test Case #	Receptor Height (feet)	Floor of Building	Receptor to Near Track CL Distance (feet)	Source Ground Height (feet)	Barrier Height (feet)	Barrier to Near Track CL Distance (feet)	L_{dn} (dBA)	Peak $L_{eq}(h)$ (dBA)	L_{max} (dBA)	L_{dn} (dBA)	Peak $L_{eq}(h)$ (dBA)	L_{max} (dBA)	L_{dn} (dBA)	Peak $L_{eq}(h)$ (dBA)	L_{max} (dBA)
Case # 1	5	1st	100	4	4	6	69.3	69.4	86.7	69.3	69.4	86.7	0.0	0.0	0.0
	5	1st	200	4	4	6	64.9	65.0	79.2	64.9	65.0	79.2	0.0	0.0	0.0
	5	1st	400	4	4	6	60.4	60.5	71.7	60.4	60.5	71.7	0.0	0.0	0.0
	25	3rd	100	4	4	6	70.2	70.3	87.6	70.2	70.3	87.6	0.0	0.0	0.0
	25	3rd	200	4	4	6	66.3	66.5	80.7	66.3	66.5	80.7	0.0	0.0	0.0
	25	3rd	400	4	4	6	62.4	62.5	73.7	62.4	62.5	73.7	0.0	0.0	0.0
Case # 2	5	1st	100	4	12	21.5	68.2	68.3	87.4	68.2	68.3	87.4	0.0	0.0	0.0
	5	1st	200	4	12	21.5	64.7	64.8	80.4	64.7	64.8	80.4	0.0	0.0	0.0
	25	3rd	100	4	12	21.5	70.3	70.4	88.4	70.3	70.4	88.4	0.0	0.0	0.0
	25	3rd	200	4	12	21.5	66.3	66.4	81.9	66.3	66.4	81.9	0.0	0.0	0.0
Case # 3	5	1st	200	60	63	15.5	66.2	66.4	83.5	66.2	66.4	83.5	0.0	0.0	0.0
	25	3rd	200	60	63	15.5	67.8	67.9	83.5	67.8	67.9	83.5	0.0	0.0	0.0
Case # 4	5	1st	200	60	67	15.5	61.0	61.1	78.7	61.0	61.1	78.7	0.0	0.0	0.0
	25	3rd	200	60	67	15.5	65.3	65.5	83.0	65.3	65.5	83.0	0.0	0.0	0.0

CL = centerline
dBA = A-weighted decibel
$L_{eq}(h)$ = hourly equivalent sound level
L_{max} = maximum sound level
L_{dn} = day-night sound level
mph = miles per hour
VHS = very high speed

4.2 Vibration

4.2.1 Descriptors

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

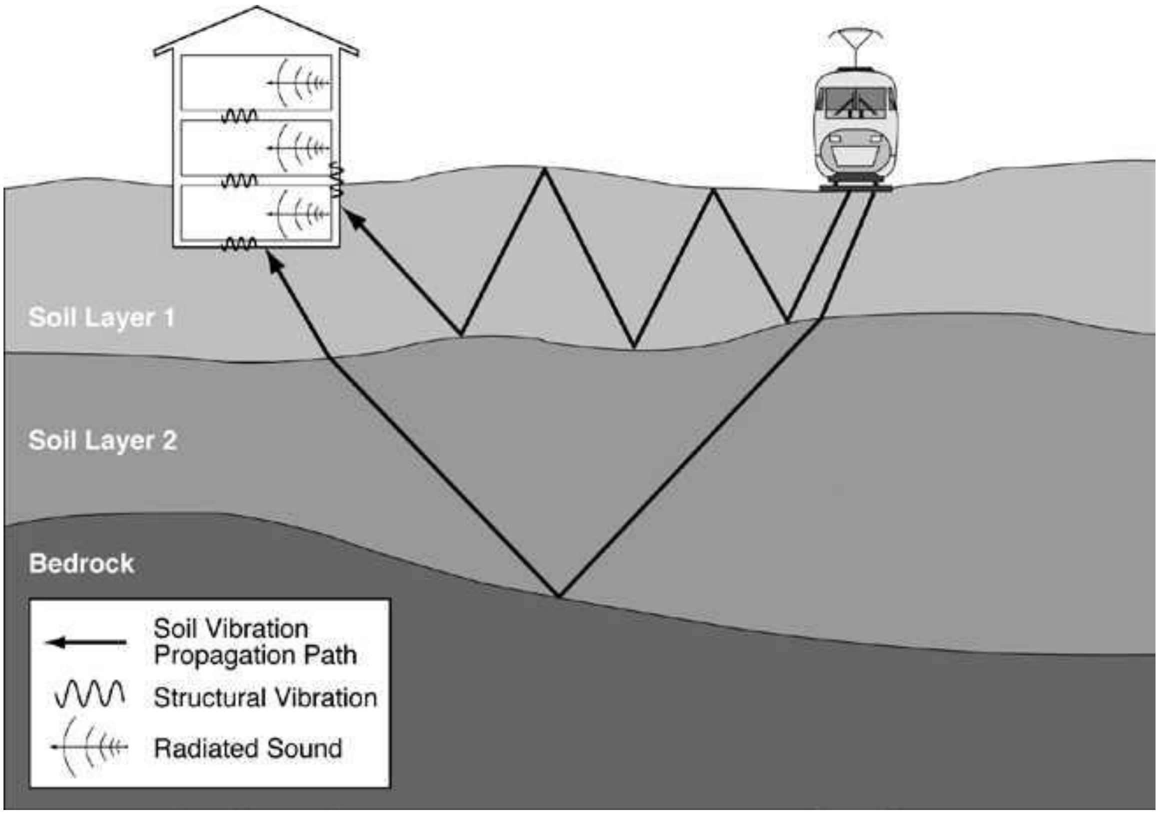
Although vibration velocity can be quantified in units of inches per second, it is common to use the velocity level (L_v) to quantify vibration to cover the wide range of magnitudes that can be encountered. Vibration, expressed in terms of the L_v in dB units, is defined as:

$$Lv = 20 * \mathrm{Log}(\frac{v}{v_{ref}})$$

Where, "v" is the RMS velocity amplitude and "v_{ref}" is the reference velocity amplitude (1 microinch per second [µin/sec]). Thus, the descriptor used to assess ground-borne vibration is L_v in vibration decibels (VdB). Like noise, VdB is related to a reference quantity, in this case 1 µin/sec. Vibration is a function of the frequency of motion measured in Hz. Ground vibration of concern for transportation sources generally spans from 4 to 160 Hz. The overall vibration is the combined energy of ground motion at all frequencies in the range of interest, in this case between 4 and 160 Hz, and this overall vibration level is used in this analysis.

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

Vibration transmitted through the supporting structure, such as at-grade ballast and tie track, radiates energy into the adjacent soil in the form of different types of waves that propagate through the various soil and rock strata to the foundation of nearby buildings. Buildings respond differently to ground vibration depending on the type of foundation, the mass of the building, and the building interaction with the soil. Once inside the building, vibration propagates throughout the building with some attenuation with distance from the foundation, but often with amplification due to floor resonances. The basic concepts for rail system–generated ground vibration are illustrated on Figure 4-7.

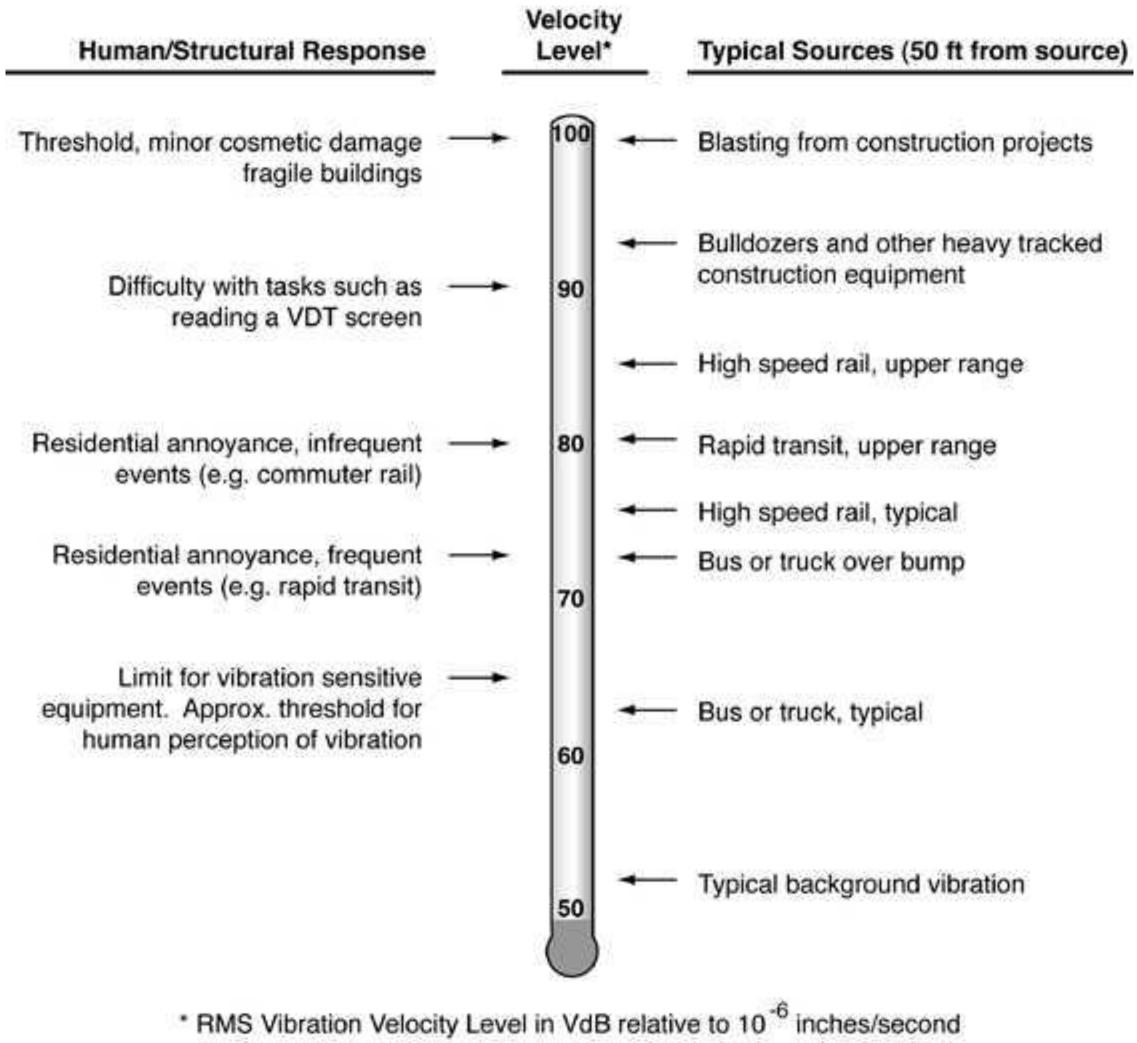


Source: FRA 2012

Figure 4-7 Propagation of Ground-Borne Vibration into Buildings

Figure 4-8 illustrates the typical levels of human response and, at much higher levels, the response of structures to ground-borne vibration. The figure shows 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.

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



Source: FRA 2012

Figure 4-8 Typical Levels of Ground-Borne Vibration and Response to Vibration

4.2.2 Resource Study Area

The vibration RSA extends 220 feet from the project alternatives' centerlines, which is narrower than the noise RSA. This distance is consistent with the FRA screening procedure and was established to identify where vibration impacts from HSR might occur. Table 4-12 shows the FRA-recommended screening distances for vibration assessments of various land uses types. To include all potentially affected areas along the project extent, 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 4-12 Federal Railroad Administration–Recommended Screening Distances for Vibration Assessments

Land Use	Train Frequency[1]	Screening Distance (feet from centerline) Based on Train Speed		
		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

4.2.3 Impact Criteria

4.2.3.1 Construction

The construction vibration assessment is based on the FRA guidance manual (FRA 2012), which covers potential impacts on buildings and potential annoyance to building occupants. Table 4-13 shows FRA guidelines for vibration damage criteria from construction activity. The thresholds are conservative to address the possibility of cosmetic effects that would occur at amplitudes well below that which causes structural damage. The table provides PPV limits for four building categories. Analysts used a crest factor of 4 (representing a PPV–RMS difference of 12 VdB) to calculate the approximate RMS vibration velocity limits in VdB from the PPV limits. These limits were used to identify areas that should be addressed during engineering design of the project alternatives.

Table 4-13 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 = microinch 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

To analyze temporary annoyance to building occupants during the nighttime period or interference with vibration-sensitive equipment inside special-use buildings during construction, the FRA recommends using the long-term operations vibration criteria for a general assessment. These criteria are discussed in detail in Section 4.2.3.2, Operations.

4.2.3.2 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 4-14. 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 4-15.

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 4-14 and Table 4-15 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.

In most cases, for at-grade or aerial train operations, the 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.

Table 4-14 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
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 will require detailed evaluation to define the acceptable vibration levels. Designing for lower vibration levels in a building often requires special design of the HVAC systems and stiffened or vibration-isolated floors.
[5] Vibration-sensitive equipment is not sensitive to ground-borne noise.

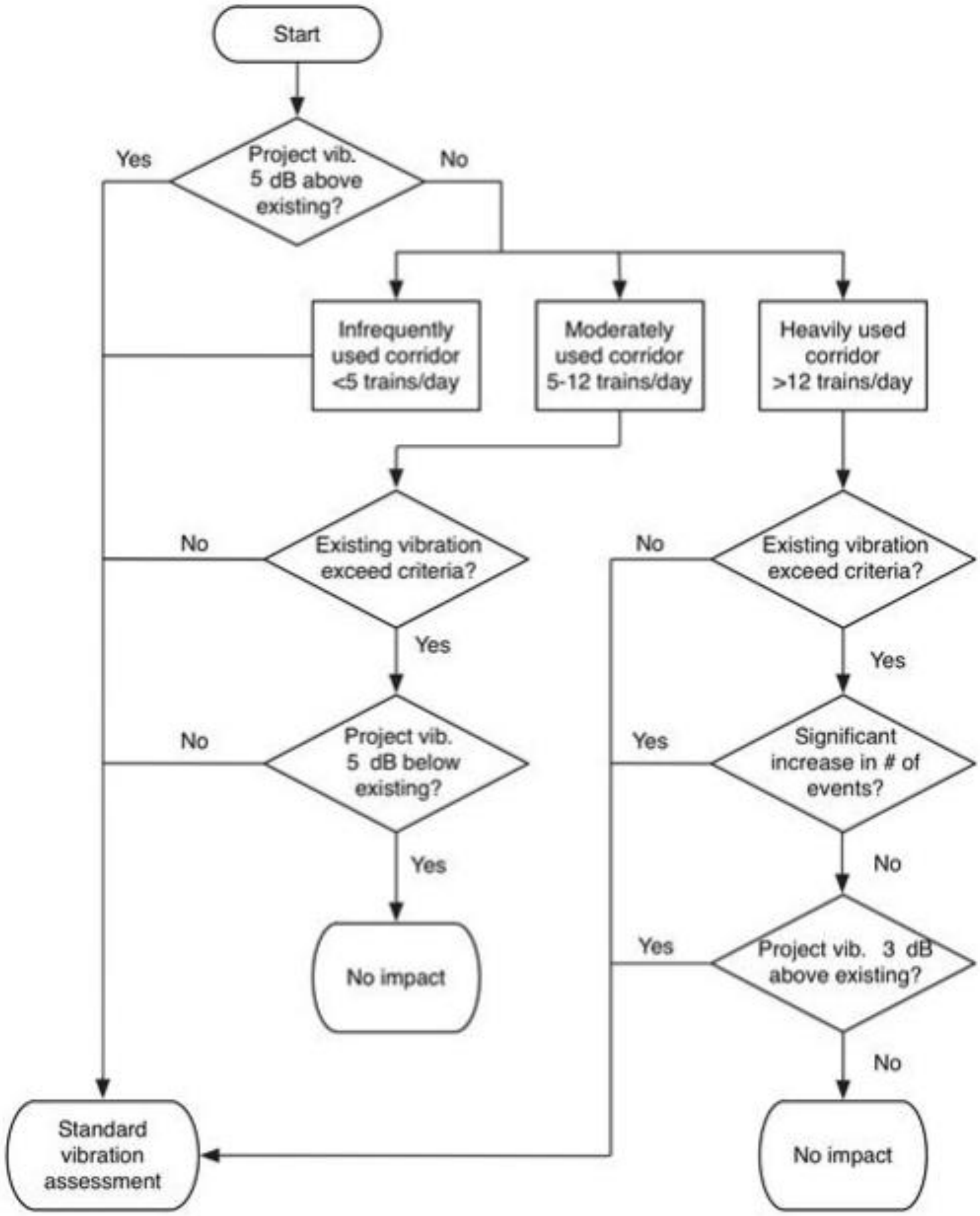
Table 4-15 Ground-Borne Vibration and Ground-Borne Noise Impact Criteria for Special Buildings

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.

Analysts applied additional vibration impact criteria because the project would be located in an existing rail corridor from San Francisco to Santa Clara. When there are existing substantial sources of vibration, such as trains, at locations affected by the project, the existing vibration levels were factored into the assessment. The FRA provides guidance on how to apply the vibration impact criteria based on the existing vibration conditions. The existing rail corridor is first defined by how many trains are on it per day. The following scenarios present the FRA guidance, which is summarized graphically in a flow chart on Figure 4-9:

- **Infrequently used rail corridor** (fewer than five trains per day):
  - Compare the vibration levels from the project to the vibration criteria in Table 4-14 and Table 4-15. If the vibration levels from the project exceed the criteria in Table 4-14 and Table 4-15, the project would have a vibration impact.
- **Moderately used rail corridor** (5 to 12 trains per day):
  - If the existing train vibration levels exceed the criteria in Table 4-14 and Table 4-15 and the project vibration levels are at least 5 VdB lower than the existing levels, the project would not have a vibration impact.
  - If the existing train vibration levels exceed the criteria in Table 4-14 and Table 4-15 and the project vibration levels are not 5 VdB or more below the existing levels, then compare the vibration levels from the project to the vibration criteria in Table 4-14 and Table 4-15.
  - If the existing train vibration levels do not exceed the criteria in Table 4-14 and Table 4-15, then compare the vibration levels from the project to the vibration criteria in Table 4-14 and Table 4-15. If the vibration levels from the project exceed the criteria in Table 4-14 and Table 4-15, the project would have a vibration impact.



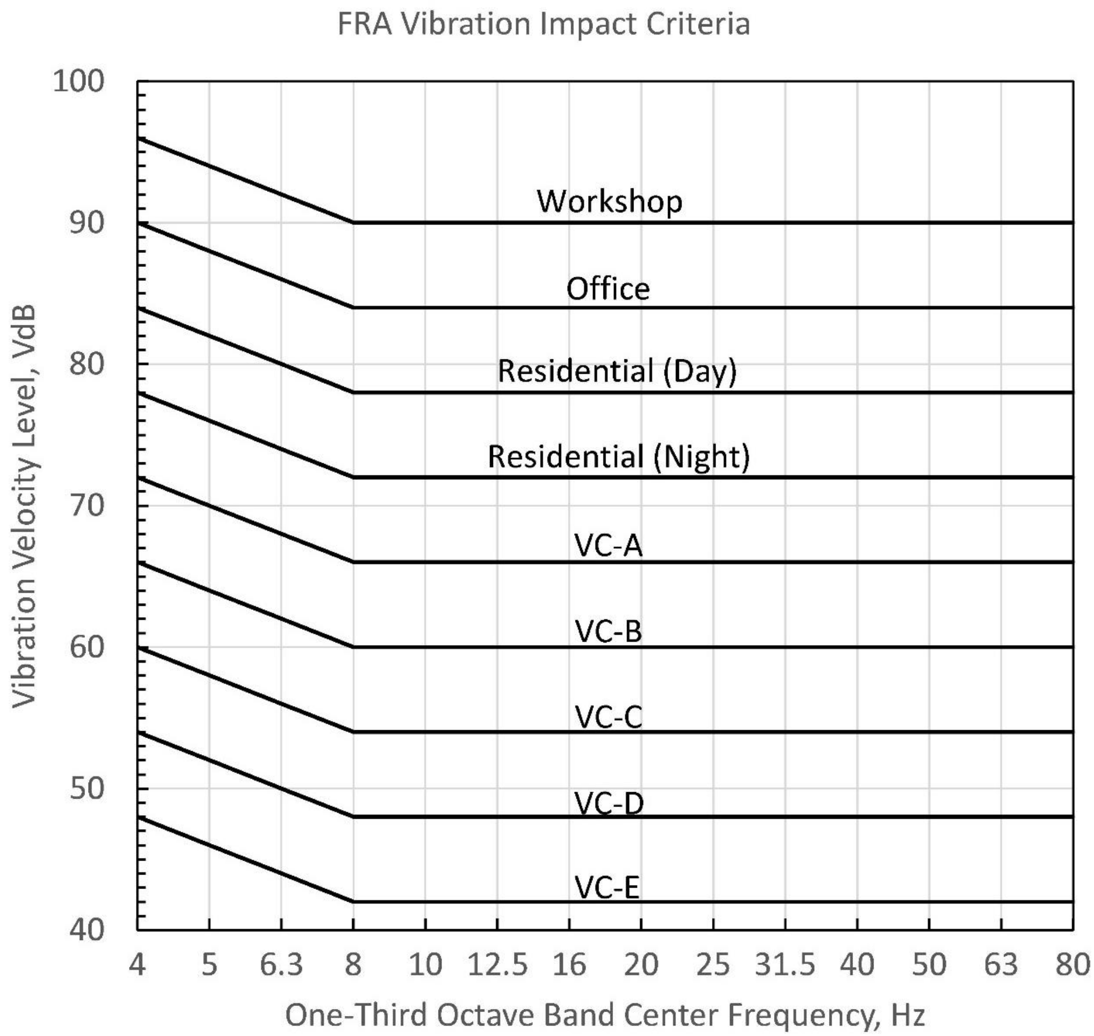
Source: FRA 2012

Figure 4-9 FRA Vibration Impact Criteria Flowchart

- **Heavily used rail corridor** (more than 12 trains per day):
  - If the existing train vibration levels exceed the criteria in Table 4-14 and Table 4-15 and the project would cause a substantial increase in the total number of trains per day (defined as doubling the total trains per day), then compare the vibration levels from the project to the vibration criteria in Table 4-14 and Table 4-15. If the vibration levels from the project exceed the criteria in Table 4-14 and Table 4-15, the project would have a vibration impact.
  - If there is not a substantial increase in the number of vibration events per day, the existing train vibration levels exceed the criteria in Table 4-14 and Table 4-15, and the project vibration levels are 3 VdB greater than the existing levels, the project would have a vibration impact.
  - If the vibration levels from the project are 5 VdB greater than the existing levels, then the existing source can be ignored, and the vibration levels from the project should be compared to the criteria in Table 4-14 and Table 4-15. If the vibration levels from the project exceed the criteria in Table 4-14 and Table 4-15, the project would have a vibration impact.
- **Moving existing tracks:**
  - Existing vibration can be substantial when an HSR project would share an existing rail right-of-way and shift the location of existing tracks. The relocated track can result in lower vibration levels from the existing trains at some locations and higher vibration levels at other locations.
  - If the vibration levels from the relocated existing trains would create higher levels, then the vibration levels from the relocated existing trains and from the project must be compared to the criteria in Table 4-14 and Table 4-15.
  - If the existing vibration levels prior to relocating the track did not exceed the criteria in Table 4-14 and Table 4-15, then the vibration levels from the relocated track must be compared to the criteria. If the vibration levels from either the relocated existing trains or from the project exceed the criteria in Table 4-14 and Table 4-15, the project would have a vibration impact.
  - If the existing vibration levels prior to shifting the track exceeded the criteria in Table 4-14 and Table 4-15 and the vibration levels from the relocated track would increase by more than 3 VdB, then the project would have a vibration impact.

The vibration levels from the new project vibration source must also be compared separately to the criteria in Table 4-14 and Table 4-15. Locations where new four-track passing tracks would be added, or where the project would cause existing tracks to be shifted must be assessed as project vibration sources. The entire project is categorized as a heavily used rail corridor due to the number of Caltrain and freight trains that travel the existing corridor daily.

In addition to the criteria provided for general assessment purposes, FRA has established criteria in terms of 1/3-octave band frequency spectra for use in detailed vibration analyses. Figure 4-10 illustrates the application of these criteria and Table 4-16 shows descriptions of the criteria. The VC-A through VC-E curves are used for special equipment that is very sensitive to vibration.



Source: FRA 2012

Figure 4-10 FRA Criteria for Detailed Vibration Analysis

Table 4-16 Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve	Maximum Vibration Level (VdB re: 1 µin/sec)[1]	Description of Use
Workshop	90	Distinctly perceptible vibration. Appropriate to workshops and non-sensitive areas.
Office	84	Perceptible vibration. Appropriate to offices and non-sensitive areas.
Residential day	78	Barely perceptible vibration. Adequate for computer equipment and low-power optical microscopes (up to ×20).
Residential night, operating rooms	72	Vibration not perceptible, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (×100) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (×400), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (×1,000), inspection and lithography equipment to 3-micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1-micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

Source: FRA 2012
µin/sec = microinch per second
VC = vibration criteria
VdB = vibration decibels
[1] As measured in 1/3-octave bands over the frequency range of 8–100 Hz.

4.2.4 Methods for Establishing Existing Vibration Levels

Locations for measuring the existing ground vibration levels in the RSA encompass the variable conditions along the alignment. The primary source of existing ground vibration in the RSA is Caltrain operations and to a lesser degree infrequent freight trains. Analysts selected measurement sites to measure the overall ground vibration level due to train passbys as well as the 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. The selection of the vibration measurement sites was also based on a preliminary, unpublished vibration analysis conducted for the project in 2010. The selection of measurement sites for this more recent work prioritized those areas with higher potential for vibration impact.

Because Caltrain train vibration is the dominant source of ground vibration in most areas, the vibration survey focused on obtaining ground vibration measurements during Caltrain passbys. Vibration was measured for sensitive receptors at typical setback distances from the nearest track. For each site, train vibration was typically measured at a minimum of two distances from the rail alignment simultaneously.

The ambient vibration survey establishes the existing overall vibration levels throughout the corridor. The variation in measured vibration levels from Caltrain trains in the RSA is due to the varying speed and the variability in the soil vibration attenuation characteristics. These factors were used in the selection of field vibration propagation testing locations for the detailed analysis.

Section 4.2.5.2, Operations Vibration, provides details about the vibration propagation measurement procedure.

4.2.5 Prediction Methods

4.2.5.1 Construction Vibration

Analysts assessed construction vibration impacts in accordance with the method described in 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 amplitudes 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 4-14 and 4-15) and damage (Table 4-13) were applied to determine impacts from construction vibration. Analysts used the following information to assess the construction vibration:

- 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 operations to nearby vibration-sensitive receptors

4.2.5.2 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. For this analysis, analysts evaluated residential and institutional locations within 220 feet of the alternatives' centerlines.

The FRA criteria for assessing ground-borne vibration from shared corridors require that the levels resulting from the relocated existing tracks be compared to the existing vibration levels. Thus, analysts prepared separate analyses to predict ground-borne vibration from HSR operations and from existing and future Caltrain operations.

The FRA prediction method is based on an empirical modeling approach. The basis of the empirical model is the assumption that vibration generated by a train rolling on steel rail and its propagation through the surrounding geologic strata (soil and rock) and into buildings can be separated into independent elements. Each of the vibration elements can be quantified separately by measurements conducted in the field. The individual elements are combined to predict ground-borne noise and vibration inside occupied buildings, which are vibration-sensitive and adjacent to the rail alignment. Adjustments are made to the prediction model to account for other factors such as train speed and track and superstructure effects.

The prediction model for ground-borne vibration employs the following equation:

$$\mathrm{Lv} = \mathrm{FDL} + \mathrm{LSR} + \mathrm{AF}$$

where:

L_v	=	projected vibration velocity level in a specific building: VdB
FDL	=	force density level: dB re: 1 lb/ft$^{1/2}$
LSR	=	line source response: dB re: 10^{-6} (inch/sec)/(lb/ft$^{1/2}$)
AF	=	adjustment factor for track and structure: dB (relative level)

All of the model parameters are determined in terms of their 1/3-octave band frequency content. The overall vibration level at a specific building is the combination of the individual 1/3-octave band levels determined by an "energy sum" over all the bands. The energy sum, calculated by summing the energy in all 1/3-octave bands, results in a single-number level (also in dBs: VdB) accounting for the vibration energy in all of the 1/3-octave bands within the overall frequency range of interest. The FRA general assessment vibration criteria are based on the overall vibration level. The FRA detailed assessment criteria are based on the individual 1/3-octave band levels.

Each projection of ground-borne vibration begins with the force density level (FDL), which represents an excitation force caused by the wheels of a train rolling on the rail. As each train has several wheels rolling simultaneously, the prediction model incorporates this input as an incoherent line of vibration forces generated by the dynamic interaction of the rail vehicle and the rail and the track support system. This analysis uses the FDL indicated for the Pendolino train as the most representative FDL for the technology envisioned for the statewide HSR system because it is also a high-speed EMU vehicle.

The FDLs used in the vibration analyses are illustrated on Figure 4-11. The Pendolino FDL used to predict HSR vibration levels is shown at a reference speed of 150 mph. The FDL of Caltrain locomotives is also illustrated on Figure 4-11 at a reference speed of 50 mph. The Caltrain FDL was calculated from field measurements of existing trains in the Project Section and in the San Jose to Merced Project Section. The figure shows that even at very different speeds, the HSR and Caltrain FDLs are similar below 31.5 Hz. The Caltrain FDL shows a peak at 100 Hz that is more than 10 dB greater than the HSR FDL, which would result in higher vibration levels in the 100 Hz 1/3-octave band.

The reference HSR Pendolino FDL is from a system where high-speed passenger trains were operating on their own dedicated tracks, with smooth rail in good condition. The HSR trains in the Project Section would operate on tracks that are shared with both Caltrain and freight trains, which increases the likelihood that the acoustic rail roughness could increase with time and potentially lead to increased vibration levels. Additionally, the blended service tracks would not necessarily be designed specifically with a wheel profile matching the HSR train wheels and the tracks would not be designed with the same tolerances and stiffness of a dedicated HSR section of track (such as the track on which the HSR Pendolino FDL data was measured). To account for this, an added engineering factor of 5 VdB has been added to the HSR vibration predictions where blended service with Caltrain and freight occur.

The FDL of the Caltrain system (locomotives and coaches) was empirically derived from train passby measurements and the impact testing performed at multiple sites throughout the Project Section and the San Jose to Merced Project Section. The future Caltrain rolling stock will be EMU vehicles (no locomotive). The FTA guidelines provide an FDL for commuter rail; however, this assumes the use of a locomotive. Consideration was given to other previously measured FDLs that might approximate an FDL for an EMU, including FDL for heavy rail transit vehicles. However, none was found to be completely satisfactory. The *Caltrain Peninsula Corridor Electrification Project Noise and Vibration Technical Report* (PCJPB 2014) conservatively assumed that the future EMUs would generate the same vibration as the existing diesel trains. Consistent with that assumption, the FDL for Caltrain was selected with the assumption that the future EMU's FDL would be no greater than the existing diesel FDL.

Figure 4-11 illustrates the FDL spectra used in the vibration prediction model for HSR and Caltrain. The FDLs for HSR and Caltrain were adjusted for speed using the following formula.

$$20 * \mathrm{Log}(^{S}/_{S_{ref}})$$

where:

S	=	operations speed (mph)
S_{ref}	=	speed reference (mph)

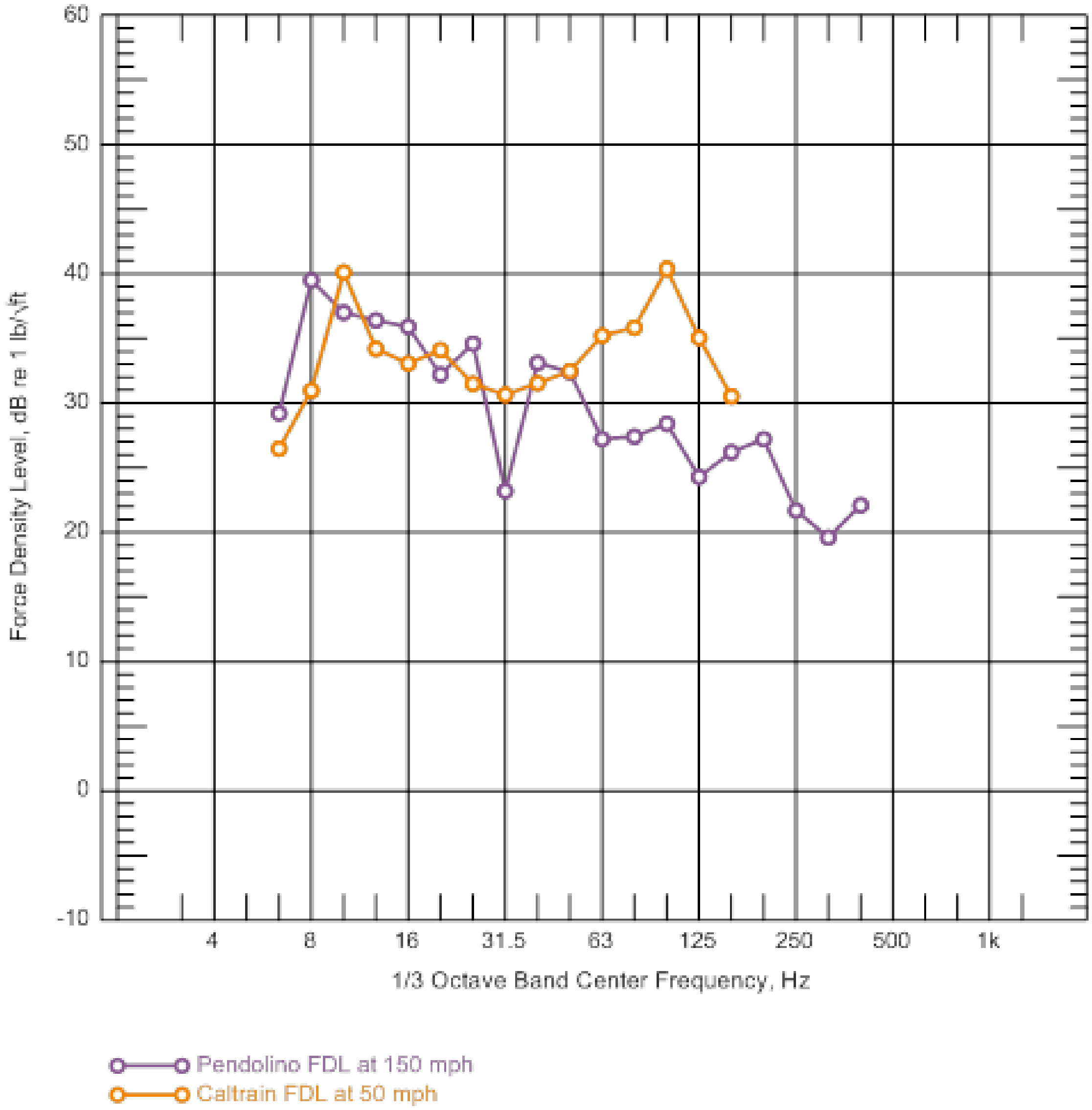


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Figure 4-11 Force Density Level Spectra Used in the Vibration Analysis

The second element in the FRA model is the line source response (LSR). The LSR quantifies the effect of soil conditions at a receptor location relative to the FDL. The LSR represents the response of the local soil strata to vibration and the attenuation of vibration energy due to its propagation through the surrounding soil. The LSR characterizes the vibration velocity response at a single location on the surface of the ground due to incoherent forces distributed over the length of a train (i.e., a finite line source). LSR as used in this analysis refers to the response of a free ground surface and not to the response of a built structure, such as a floor in a building. However, the response of an individual building can be measured if there are only a limited number of buildings potentially affected. This analysis addresses impacts on hundreds of buildings, making that approach impractical.

The LSR for a soil region is found by imparting a vertical force on the ground surface or bottom of a borehole for a subsurface alignment, measuring that force with a load cell or strain gage and simultaneously measuring the vertical vibration velocity of the ground surface at several distances from the impact location. This procedure, described in the FRA guidance manual, provides a set of point source responses (also referred to as transfer mobility), from which an LSR can be calculated.

The LSR is added to the FDL to obtain the ground surface vibration L_v in the absence of buildings. Analysts obtained the various LSRs used in the vibration analyses from numerous site measurements conducted in the field using the procedure described in the FRA guidance manual.

The normal procedure for obtaining transfer mobility data is to impact the ground at several locations and measure the ground surface velocity at various distances from the point of impact. For surface alignments, analysts used a pneumatic, force-instrumented hammer to generate impact forces. The pneumatic hammer consists of a 27-pound cylindrical mass guided by a 4-inch diameter tube with pneumatic assist to both raise the hammer and drive the hammer downward onto a load cell. Approximately 20 to 30 impacts are recorded at each surface position.

For subway alignments, boreholes were drilled, and a force-instrumented transducer was attached to the end of a drill string. The impacts delivered to the bottom of the borehole were obtained with a standard, 130-pound driller's slide hammer. Force input from the hammer and geophone responses are recorded simultaneously for 40 to 50 impacts at each testing depth. A graphic representation of the surface test is illustrated on Figure 4-12 and the borehole test is illustrated on Figure 4-13.

Transfer mobility data collected by the vibration testing were then fit with polynomial functions of distance using least squares regression. The point source responses that are derived from the curve fitting were then numerically integrated over a length of 600 feet (to approximate the train length) to obtain the following mathematical function for the line source response with distance:

$$\mathrm{LSR(d)} = \mathrm{A} + \mathrm{B} * \mathrm{Log(d)} + \mathrm{C} * \mathrm{Log^2(d)}$$

where:

A, B, C	=	polynomial coefficients
d	=	perpendicular and horizontal distance from track centerline (feet)

Because ground-borne noise and vibration are typically not substantial at distances of more than 250 feet from the tracks, a 600-foot train length provides a reasonable approximation to the length of train that would affect ground-borne vibration.

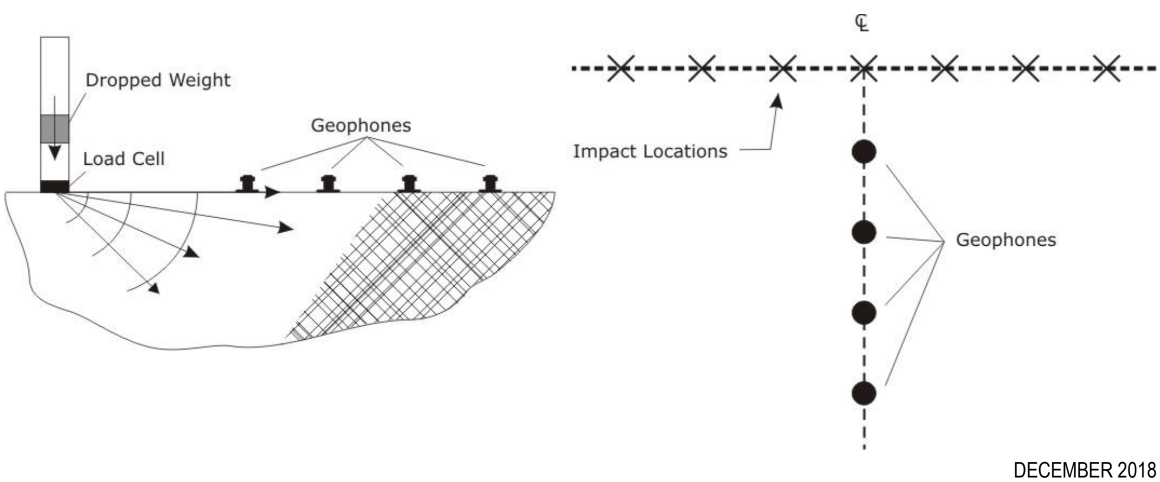

Figure 4-12 Surface Vibration Propagation Test (cross section)

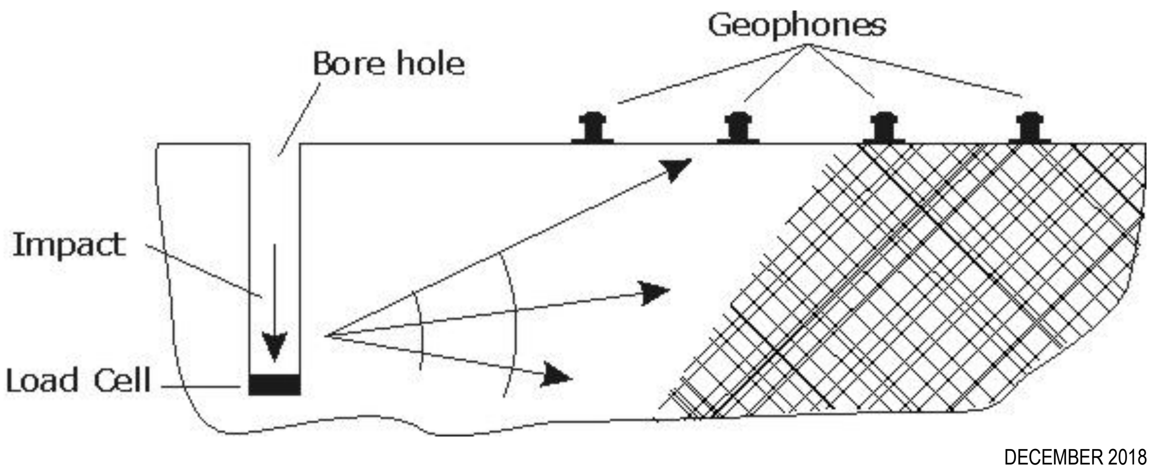

Figure 4-13 Borehole Vibration Propagation Test (cross section)

To predict levels of ground-borne noise and vibration for project conditions different from those on which the FDL is based, analysts applied the adjustment factors specified in the FRA guidance manual to account for the effects of train speed and the specific alignment structures (e.g., at grade, embankment, aerial, and tunnel geometry). Vibration levels from HSR on an aerial structure are assumed 10 VdB less than vibration from at-grade or embankment sections of track based on Table 8-2 of the FRA guidance manual.

Ground-borne noise is generated when the surfaces of interior building elements 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 final step in the ground-borne noise and vibration prediction procedure is the prediction of interior noise levels in occupied building spaces due to acoustic radiation caused by the room's vibrating elements. The following equation from Section 9.3.2 of the FRA guidance manual shows the relationship between ground-borne vibration and ground-borne noise:

$$L_A = L_v + K_{rad} + K_{A-wt}$$

where:

L_A	=	A-weighted sound level in 1/3-octave band (dBA re: 20 μPa)
L_v	=	RMS vibration velocity level in 1/3-octave band (VdB re: 1 μin/sec)
K_{rad}	=	adjustment to convert from vibration to sound pressure level and account for average acoustical absorption inside room (typically -5 dB for residential rooms)
K_{A-wt}	=	A-weighting adjustment in each 1/3-octave band

Ground-borne noise is computed on a 1/3-octave-band basis. The 1/3-octave-band noise levels are A-weighted and combined to obtain an overall A-weighted noise level. The A-weighted ground-borne noise level is evaluated with respect to the FRA ground-borne noise criteria.

Where trains change tracks or cross over other tracks, wheel impacts at regular crossovers (conventional rail-bound manganese frogs) or special trackwork produce an increase in vibration relative to standard track and thus would require an adjustment factor to account for the ground vibration levels in the immediate vicinity of a track crossover or turnout. Adjustments were made to predicted vibration levels to account for increases in localized vibration 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 for both alternatives are assumed to be standard frogs. Wheel impacts at turnouts and crossovers with standard frogs were assumed to cause localized increases in vibration of up to 10 VdB within 50 feet, decreasing with distance from the frogs.

5 EXISTING CONDITIONS AND EFFECTS ANALYSIS

This chapter presents the existing noise and vibration environment and existing measurement results. This chapter also provides the results of the noise and vibration impact assessments for operations and construction.

5.1 Noise

5.1.1 Existing Noise Environment

This section summarizes the noise measurement results and describes the noise-sensitive land uses in the RSA. Section 5.1.1.2, Noise Measurement and Modeling Discussion, summarizes the existing noise model used to identify the existing ambient noise conditions at all noise-sensitive receptors in the RSA.

5.1.1.1 Noise Measurement Results

A total of 75 measurements of ambient noise were conducted within the noise RSA. Measurements of ambient noise were conducted 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, and 11 locations in the Mountain View to Santa Clara Subsection between San Antonio Road and Scott Boulevard. The noise measurement locations are illustrated on Figures 5-1 through 5-4. Photographs of the noise measurement sites are provided in Appendix A.

The noise monitors were located at or near noise-sensitive locations. At some sites the noise measurement microphones were located in the back, front, or side yards of residences. At other sites, the microphones were mounted to utility poles near noise-sensitive locations. At all sites, the microphones were positioned in accordance with FRA guidance relative to both the dominant ambient noise sources and the noise-sensitive locations.

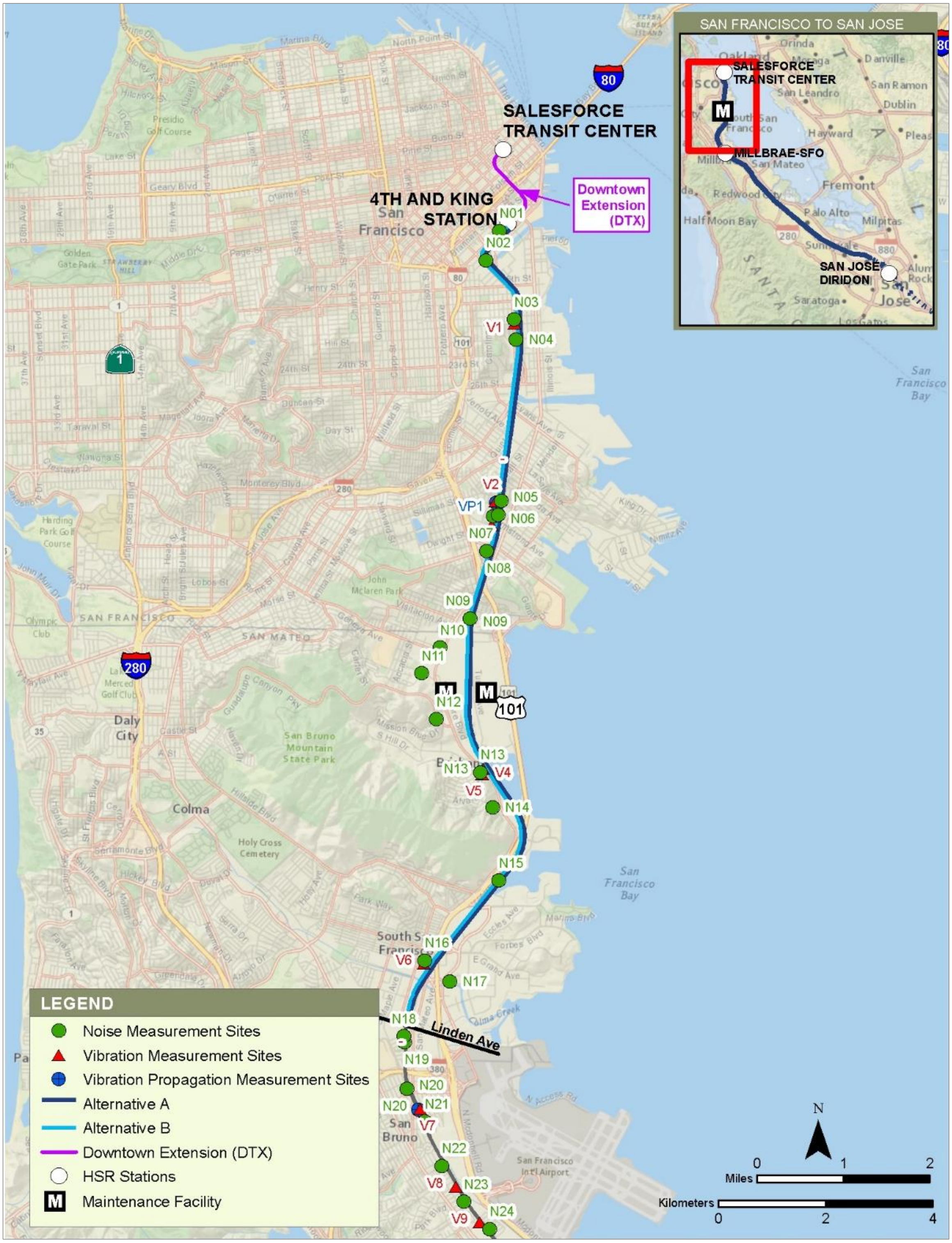

Figure 5-1 Noise and Vibration Measurement Locations (San Francisco to South San Francisco Subsection)

DECEMBER 2018

Figure 5-2 Noise and Vibration Measurement Locations (San Bruno to San Mateo Subsection)

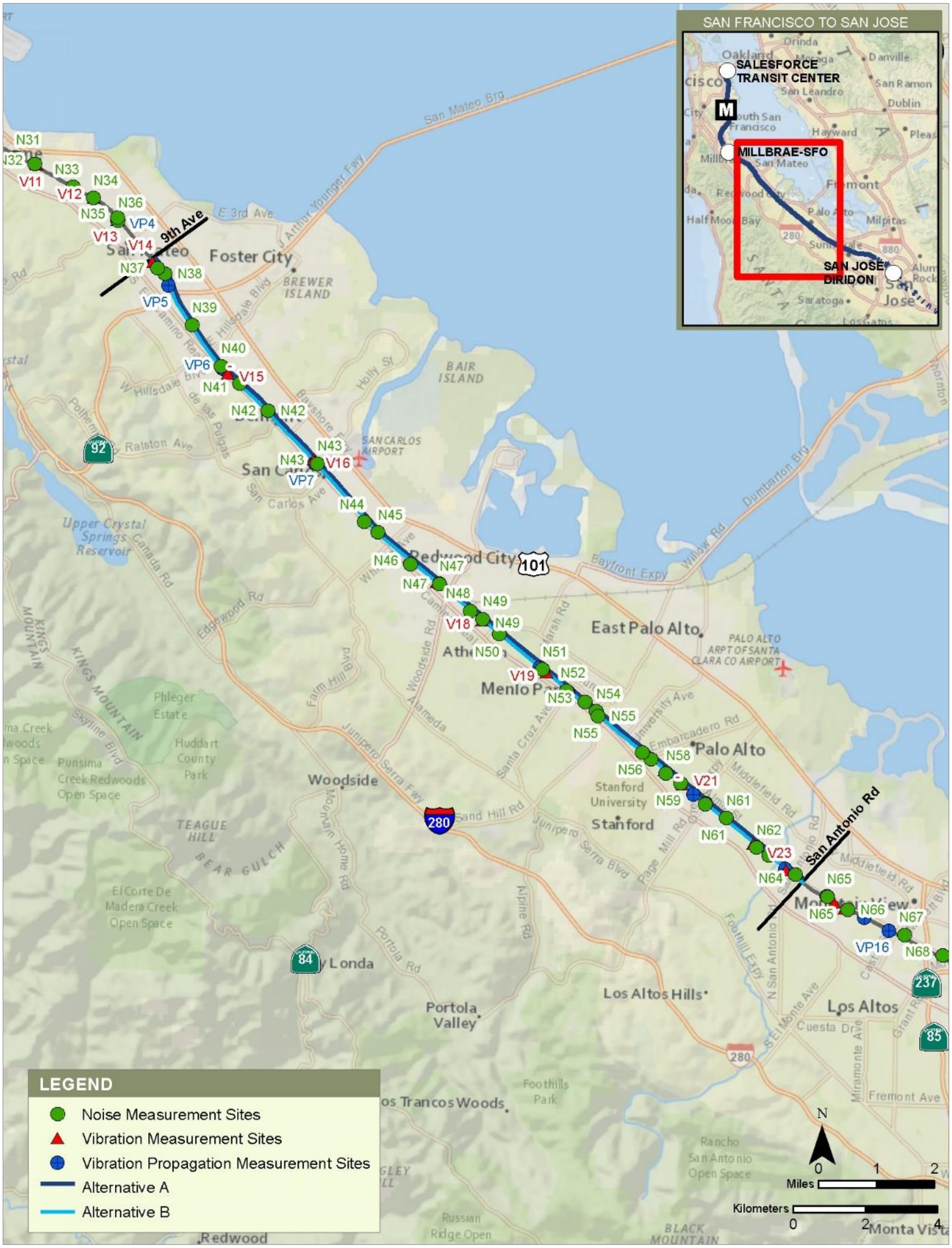

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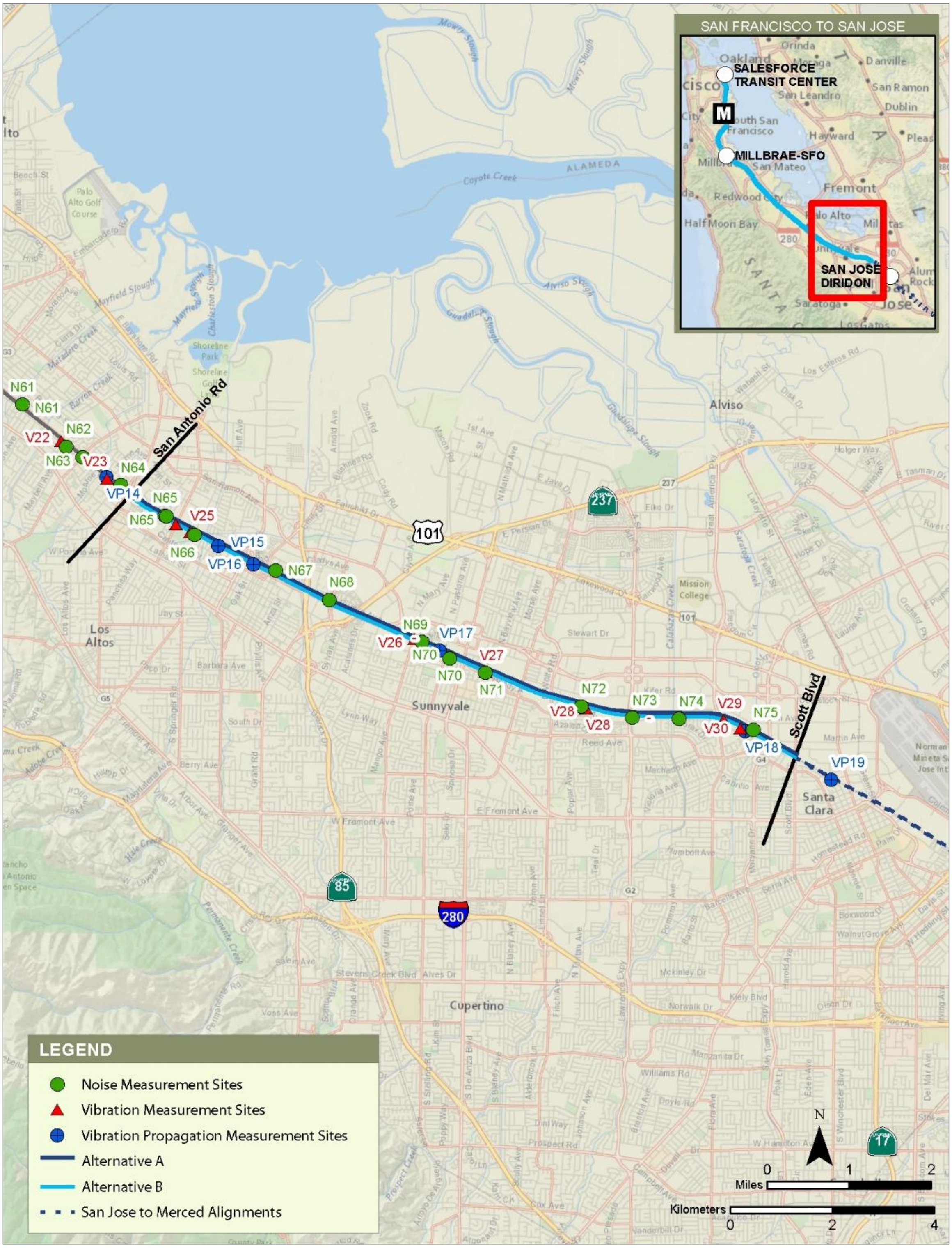
Figure 5-3 Noise and Vibration Measurement Locations (San Mateo to Palo Alto Subsection)



JUNE 2019

Figure 5-4 Noise and Vibration Measurement Locations (Mountain View to Santa Clara Subsection)

The major noise sources for much of the Project Section are trains presently operating in the existing rail corridor. Noise monitors were located near noise-sensitive receptors and near existing major noise sources, such as roadways or rail lines. The noise measurement results shown in Table 5-1 represent the actual measured sound levels at the noise monitor locations. The results of the existing noise measurement program were used to validate the existing noise spreadsheet model to better predict existing noise levels at all noise-sensitive locations throughout the RSA; the existing noise spreadsheet model was used to identify the ambient existing noise levels at the exterior façade of building locations for residential land uses and at the nearest point of use for nonresidential noise-sensitive sites.

In the San Francisco to South San Francisco Subsection, the adjacent land use includes a mix of residential and industrial neighborhoods. The southern part of the San Francisco to South San Francisco 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. South of Interstate (I-) 380, sensitive receptors are on both sides of the alignment. The San Bruno to San Mateo Subsection includes the southern portion of South San Francisco, San Bruno, Millbrae, and Burlingame. The adjacent land uses include a mix of residential, industrial, and commercial uses in the central business districts. The southern portion of the San Bruno to San Mateo Subsection is primarily residential land use. The San Mateo to Palo Alto Subsection covers the area between Ninth Avenue in San Mateo and San Antonio Road in Palo Alto. This part of the project has primarily residential land use adjacent to it, much of which is abutting backyards, and includes the southern portion of San Mateo, Belmont, San Carlos, Redwood City, North Fair Oaks, Atherton, Menlo Park and Palo Alto. The Mountain View to Santa Clara Subsection covers the area between San Antonio Road in Palo Alto to Scott Boulevard in Santa Clara. The project abuts residential and commercial areas, and the alignment also runs parallel to an arterial road.

The noise measurement results are organized by subsection in Table 5-1. Table 5-1 shows the results of the ambient noise measurements Wilson Ihrig conducted in 2009, 2010, 2013, 2016, and 2017. Wilson Ihrig conducted unpublished noise measurements in 2009 and 2010. Noise measurements conducted by Wilson Ihrig in 2013 are included in the *Caltrain Peninsula Corridor Electrification Project Noise and Vibration Technical Report* (PCJPB 2014). Noise measurements conducted by Wilson Ihrig in 2016 and 2017 are included in this assessment. Appendix B provides plots of the ambient noise measurement results.

Table 5-1 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, CA	Residential	2/13/2017	79	69
N02	469 Berry Street, San Francisco, CA	Residential	2/13/2017	73	67
N03	431 Pennsylvania Avenue, San Francisco, CA	Residential	11/6/2009	65	68
N04	1174 22nd Street, San Francisco, CA	Residential	11/30/2009	74	64
N05	48 Reddy Street, San Francisco, CA	Residential	11/6/2009	64	64
N06	2403 Mendell Street, San Francisco, CA	Residential	5/26/2016	69	72
N07	88 Kalmanovitz, San Francisco, CA	Residential	6/14/2010	64	75
N08	48 Gould Street, San Francisco, CA	Residential	6/14/2010	68	76
N09	327 Tunnel Avenue, San Francisco, CA	Residential/ Church	5/26/2016	73	67

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
N10	18 McDonald Avenue, Daly City, CA	Residential	5/26/2016	67	69
N11	104 Main Street, Daly City, CA	Residential	5/26/2016	65	67
N12	163 Mission Blue Drive, Brisbane, CA	Residential	5/26/2016	65	68
N13	42 San Francisco Avenue, Brisbane, CA	Residential	5/31/2016	65	64
N14	50 Joy Avenue, Brisbane, CA	Residential	11/3/2009	76	64
N15	1300 Veterans Boulevard, South San Francisco, CA	Hotel	3/9/2010	77	72
N16	242 Village Way, South San Francisco, CA	Residential	11/3/2009	77	75
N17	111 Mitchell Avenue, South San Francisco, CA	Hotel	5/31/2016	69	76
San Bruno to San Mateo Subsection					
N18	1289 Herman Street, San Bruno, CA	Residential	5/17/2013	78	76
N19	1209 Herman Street, San Bruno, CA	Residential	11/3/2009	76	75
N20	847 Huntington Avenue, San Bruno, CA	Residential	5/31/2016	75	77
N21	576 First Avenue, San Bruno, CA	Residential	3/9/2010	75	75
N22	265 San Luis Avenue, San Bruno, CA	Residential	5/31/2016	66	67
N23	1036 San Antonio Avenue, Millbrae, CA	School	3/9/2010	70	68
N24	254 Monterey Street, Millbrae, CA	Residential	11/3/2009	71	70
N25	20 Hillcrest Boulevard, Millbrae, CA	Residential	5/17/2013	63	62
N26	267 Aviador Avenue, Millbrae, CA	Residential	6/1/2016	65	63
N27	150 Serra Avenue, Millbrae, CA	Hospital	3/9/2010	73	72
N28	1710 California Drive, Burlingame, CA	Hospital / Residential	3/9/2010	68	66
N29	1457 California Drive, Burlingame, CA	Residential	5/17/2013	71	73
N30	1279 California Drive, Burlingame, CA	Residential	6/1/2016	73	77
N31	966 California Drive, Burlingame, CA	School	3/9/2010	74	76
N32	815 Carolan Avenue, Burlingame, CA	Residential	10/30/2009	71	70
N33	112 Myrtle Road, Burlingame, CA	Residential	2/13/2017	79	81
N34	362 Villa Terrace, San Mateo, CA	Residential	2/13/2017	79	80
N35	142 North Railroad Avenue, San Mateo, CA	Residential	5/17/2013	74	72
N36	396 Catalpa Street, San Mateo, CA	Residential	10/30/2009	69	68
San Mateo to Palo Alto Subsection					
N37	200 12th Avenue, San Mateo, CA	Residential	6/1/2016	65	66
N38	1416 South Railroad Avenue, San Mateo, CA	Residential	10/30/2009	67	67

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
N39	2600 South Delaware Street, San Mateo, CA	Residential	6/1/2016	73	71
N40	8 Antioch Drive, San Mateo, CA	Residential	10/28/2009	73	71
N41	102 Blossom Circle, San Mateo, CA	Residential	5/17/2013	70	70
N42	792 Old County Road, Belmont, CA	Residential	6/2/2016	70	68
N43	1088 Sylvan Drive, San Carlos, CA	Residential	6/2/2016	71	69
N44	1552 West El Camino Real, San Carlos, CA	Hotel	3/9/2010	73	73
N45	1840 Stafford Street, San Carlos, CA	Residential	10/28/2009	73	74
N46	100-198 Winklebleck Street, Redwood City, CA	Commercial	10/28/2009	69	71
N47	300 Cedar Street, Redwood City, CA	Residential	6/2/2016	78	80
N48	198 Buckingham Avenue, Redwood City, CA	Residential	5/17/2013	71	67
N49	200 Berkshire Avenue, North Fair Oaks, CA	Residential	6/2/2016	69	69
N50	3390 Glendale Avenue, North Fair Oaks, CA	Residential	6/3/2016	71	67
N51	1601 Stone Pine Lane, Menlo Park, CA	Residential	10/23/2009	70	74
N52	1128 Merrill Street, Menlo Park, CA	Commercial	3/9/2010	72	68
N53	638 Alma Street, Menlo Park, CA	Park	3/9/2010	68	68
N54	248 Alma Street, Menlo Park, CA	Residential	10/23/2009	66	67
N55	118 West El Camino Real, Menlo Park, CA	Residential	6/3/2016	65	69
N56	Lucas Lane and Encina Avenue, Palo Alto, CA	Hospital	3/5/2010	72	70
N57	Lucas Lane and Embarcadero Road, Palo Alto, CA	School	3/5/2010	74	72
N58	1528 Mariposa Avenue, Palo Alto, CA	Residential	10/23/2009	61	59
N59	Peers Park, Palo Alto, CA	Residential	5/17/2013	71	71
N60	195 Page Mill Road, Palo Alto, CA	Residential	6/3/2016	67	68
N61	3040 Alma Street, Palo Alto, CA	Residential	6/3/2016	74	73
N62	4116 Park Boulevard, Palo Alto, CA	Residential	3/5/2010	62	61
N63	4201 Park Boulevard, Palo Alto, CA	Residential	5/17/2013	80	79
N64	4243 Alma Street, Palo Alto, CA	Church	3/9/2010	75	75
Mountain View to Santa Clara Subsection					
N65	2358 Central Expressway, Mountain View, CA	Residential	6/6/2016	76	77
N66	1929 Crisanto Avenue, Mountain View, CA	Residential	6/6/2016	70	69
N67	112 Horizon Avenue, Mountain View, CA	Residential	10/20/2009	71	70
N68	Central Expressway and Whisman Station Drive, Mountain View, CA	Residential	3/5/2010	71	73

Site	Location	Land Use	Date Deployed	Average L_{dn}[1] (dBA)	Loudest Hour L_{eq} (dBA)
N69	981 Asilomar Terrace, Sunnyvale, CA	Residential	10/20/2009	66	69
N70	110 Waverly Street, Sunnyvale, CA	Residential	6/6/2016	66	66
N71	111 West Evelyn Avenue, Sunnyvale, CA	Commercial	3/5/2010	76	73
N72	Evelyn Terrace, Santa Clara, CA	Residential	10/16/2009	72	69
N73	3585 Agate Street, Santa Clara, CA	Residential	5/17/2013	69	67
N74	2790 Agate Drive, Santa Clara, CA	Residential	10/16/2009	63	61
N75	2400 Walsh Avenue, Santa Clara, CA	School	3/5/2010	64	65

Source: PCJPB 2014
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.

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 subsection 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 under construction, is located 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 on the alignment (Table 4-7). 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 south of the Quint Street lead from the Port of San Francisco to South San Francisco. The ambient noise setting corresponds to that of a typical dense urban land use setting. Additional sources of ambient noise are vehicles on I-280 and US 101 and local motor-vehicle traffic. Near the southern end of this subsection, the ambient noise setting is influenced by aircraft activities associated with SFO.

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. Per local planning documents, noise above 70 L_{dn} *requires noise insulation analysis and design* for residential land use in San Francisco (City and County of San Francisco 2004) and is *normally unacceptable* for residential land use in Daly City (City of Daly City 2013), and *development should not be undertaken* for residential land use in South San Francisco (City of South San Francisco 1999).

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 area of the alignment in the southern portion of South San Francisco, San Bruno, Millbrae, Burlingame, and the northern portion of San Mateo. The adjacent land use also includes a mix of residential and industrial use, with some commercial use in the central business districts. The southern portion of this subsection is primarily residential land use. The ambient noise setting of the northern portion of this subsection is urban, while the southern portion is primarily residential land use.

The existing noise in this subsection is dominated by the daily rail operations on the alignment (Table 4-7). 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 setting 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. 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. Per local planning documents, noise above 70 L_{dn} (CNEL) is considered *Incompatible* for residential land use in San Bruno (City of San Bruno 2009) and *conditionally compatible* for residential land use in Millbrae (City of Millbrae 1998); in Burlingame noise above 65 L_{dn} is *normally unacceptable*, while noise above 75 L_{dn} is *clearly unacceptable* for residential land use (City of Burlingame 2019).

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 portion of the alignment in 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 on the alignment (Table 4-7). 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 (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 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 at quiet urban areas to 80 dBA at active urban areas, depending on the location. Per local planning documents, noise above 70 L_{dn} (CNEL) is considered *normally unacceptable* for residential land use in San Mateo, Atherton, Menlo Park, and Redwood City (City of San Mateo 2015; City of Redwood City 2010; Town of Atherton 2002; City of Menlo Park 2013) and *conditionally acceptable* for all noise-sensitive land use in Palo Alto and San Carlos (City of San Carlos 2009; City of Palo Alto 2017).

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 includes the portion of the alignment within Mountain View, Sunnyvale, and the northern portion of Santa Clara. The project abuts residential, 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 on the alignment (Table 4-7). 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 corresponds to an urban setting 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. Per local planning documents, noise above 70 L_{dn} is considered *normally unacceptable* for residential land use in Mountain View (City of Mountain View 2012) and *conditionally acceptable* for residential land use in Sunnyvale (City of Sunnyvale 2011).

5.1.1.2 Noise Measurement and Modeling Discussion

To validate the existing noise model, the existing noise spreadsheet model results were calculated at the exact locations of the noise monitors. In some instances, the noise monitors were closer to existing noise sources such as roadways and rail lines than the noise-sensitive buildings themselves. Once the existing noise model was validated for existing conditions by showing close agreement with the measurement results (as shown in Table 5-2), the existing noise model was then used to predict ambient noise levels at all sensitive receptors, typically building façades, in the RSA.

Table 5-2 shows the results of the comparison of the existing noise model and the measured noise levels at the measurement locations. The comparison indicates that the existing noise model is in close agreement with the field noise measurement data. The deviation at all measurement locations near the existing rail corridor was no more than 3 dBA, and it was better at most locations.

Sites N10, N11, and N12 were located near the Brisbane LMF sites, away from the existing rail alignment. At these three sites, the measured ambient noise data were used to establish existing noise levels at the nearby noise-sensitive receptor locations using the methods in Appendix E of the FTA guidance manual.

Table 5-2 Comparison of Existing Noise Model Results to Existing Measurement Results

Site	Measured Average L_{dn}[1] (dBA)	Modeled L_{dn} (dBA)	Difference[2]
San Francisco to South San Francisco Subsection			
N01	79	79	0
N02	73	73	0
N03	65	65	0
N04	74	74	0
N05	64	63	1
N06	69	66	3
N07	64	61	3
N08	68	68	-1
N09	73	73	0
N10	67	N/A[3]	N/A[3]
N11	65	N/A[3]	N/A[3]
N12	65	N/A[3]	N/A[3]
N13	65	65	0
N14	76	76	0
N15	77	77	0
N16	77	77	0
N17	69	67	-2

Site	Measured Average L_{dn}[1] (dBA)	Modeled L_{dn} (dBA)	Difference[2]
San Bruno to San Mateo Subsection			
N18	78	76	1
N19	76	77	-1
N20	74	76	-2
N21	75	75	0
N22	66	65	1
N23	70	71	-1
N24	71	71	-1
N25	63	64	-2
N26	65	64	0
N27	73	73	0
N28	68	69	-1
N29	71	71	0
N30	73	73	0
N31	74	74	0
N32	71	71	-1
N33	79	79	0
N34	79	78	1
N35	74	71	1
N36	69	72	-2
San Mateo to Palo Alto Subsection			
N37	65	67	-2
N38	67	68	-1
N39	73	73	0
N40	73	73	0
N41	70	68	3
N42	70	70	0
N43	71	71	0
N44	73	73	0
N45	73	73	0
N46	69	66	2
N47	78	77	0
N48	71	68	3
N49	69	70	-1

Site	Measured Average L_{dn}[1] (dBA)	Modeled L_{dn} (dBA)	Difference[2]
N50	71	71	0
N51	70	70	-2
N52	72	73	-1
N53	68	68	-1
N54	66	66	0
N55	70	71	-2
N56	72	72	0
N57	74	74	0
N58	61	62	-1
N59	71	71	0
N60	67	67	-2
N61	74	74	0
N62	62	64	-3
N63	80	79	2
N64	75	75	0
N65	76	76	0
Mountain View to Santa Clara Subsection			
N66	70	71	-1
N67	71	70	0
N68	71	71	0
N69	66	68	-3
N70	66	66	0
N71	76	76	0
N72	72	70	2
N73	69	69	0
N74	63	62	1
N75	64	64	0

dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
LMF = light maintenance facility
N/A = not applicable
[1] The L_{dn} was calculated from the average hourly L_{eq} values collected over the entire measurement period.
[2] The difference is the measured level minus the modeled level at each location.
[3] Sites N10, N11, and N12 were located near the Brisbane LMF, away from the existing rail corridor. The existing rail noise model was not used for these sites.

5.1.2 Noise Impact Assessment

Noise impacts were assessed according to the criteria described in Section 4.1.3 and the method, data, and assumptions described in Section 4.1.4, Methods for Establishing Existing Noise Levels, and Section 4.1.5, Prediction Methods.

5.1.2.1 Construction Noise Effects

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 passing tracks (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. Impacts would occur in residential areas and at other noise-sensitive land uses within several hundred feet of the alignment. 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.

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 and Atherton 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 and Millbrae Stations would take 2 years; building the Brisbane LMF would take 2 to 3 years; and building the passing track under Alternative B would take 4.5 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 OCS pole relocation and some roadway realignments would require weekend and nighttime construction work. Track realignments of less than 10 feet would be done 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 tracks.

Table 5-3 shows data on noise emissions of construction equipment. It includes average values of the L_{max} for various pieces of typical construction equipment at a distance of 50 feet. The data are from Table 10-1 of the FRA guidance manual.

Table 5-3 Construction Equipment Noise Emission Levels

Equipment	Typical Noise Level at 50 feet from Source (dBA)
Auger drill rig[1]	85
Backhoe	80
Ballast tamper	83
Compactor	82
Concrete mixer	85
Crane, mobile	83
Dozer	85

Equipment	Typical Noise Level at 50 feet from Source (dBA)
Drill rig truck[1]	84
Drum mixer[1]	80
Excavator[1]	85
Man lift[1]	85
Generator	82
Grader	85
Loader	80
Paver[1]	85
Pickup truck[1]	55
Pile driver (impact)	101
Pile driver (vibratory)	95
Pump	77
Roller	85
Scraper	85
Truck	84
Vacuum street sweeper[1]	80
Vacuum excavator (vac-truck)[1]	85

Sources: FRA 2012; FHWA 2006
dBA = A-weighted decibel
[1] Reference level from FHWA Roadway Construction Noise Model (FHWA 2006).

Predicting construction noise requires a construction scenario of the equipment that would likely be used and average utilization factors. Utilization factors represent the percentage of time the equipment would be expected to be operating during each phase. Analysts used the typical noise levels for various pieces of equipment to calculate the L_{eq} at various distances from a construction site. Additional noise level data and utilization factor data were obtained from the FHWA *Roadway Construction Noise Model* (FHWA 2006).

Analysts identified five different typical types of construction activities that would be used for project construction for analysis. Table 5-4 shows the results of the analysis. For each typical planned construction activity, the expected noisiest pieces of equipment are listed. For this level of detail, analysts assumed that all pieces of equipment would be located at the center of the construction site. The L_{eq} was calculated by incorporating the typical L_{max} of each piece of equipment and the utilization factor. The total 8-hour L_{eq} was calculated by combining total equipment quantities and their respective hours of operation over an 8-hour work period. For each construction activity type, the projections were adjusted to calculate the distance at which the L_{eq} would reach the criteria shown in Table 5-4.

The criteria are based on land use, with the most stringent category being for residential locations. For typical 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. These distances would be applicable to both project alternatives because the same construction scenarios would apply to both alternatives. 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. These distances would be applicable to both project alternatives because the same construction scenarios apply to both alternatives.

Table 5-4 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						
Excavation (track relocation/roadway realignment)	Bulldozers, loaders, cranes, dump trucks, water trucks	90	500	158	89	50
Earthwork and retaining walls (track relocation/roadway realignment)	Scrapers, graders, compactors, dump trucks, water trucks	94	792	251	141	79
Track construction (relocation)	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. Noise levels for the loudest subtask are 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.

The potential for noise impacts would be greatest where noise-sensitive land uses are in close proximity to major construction activities with a long duration (e.g., LMF, passing tracks, station modifications) and nighttime construction activities (e.g., passing tracks, parallel tracks and roadway realignment). Analysts 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 (shown in Table 5-4). 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 within this subsection would be required to build the Tunnel Avenue overpass and realign tracks. 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 would be affected by nighttime construction noise. Construction activities for the East Brisbane LMF would occur approximately 1,900 feet from the nearest residences which is far enough away 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. Residences within 500 feet of nighttime track realignment in San Bruno, Millbrae, Burlingame, and San Mateo, would be temporarily affected by construction noise.
- **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 residences within 500 feet of nighttime construction in San Mateo, Belmont, San Carlos, Atherton, Menlo Park, and Palo Alto would be temporarily affected by construction noise.
- **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 residences within 500 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara would be temporarily affected by construction noise.

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 construct the West Brisbane LMF approximately 1,500 feet from residences which is far enough away that they 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. Residences within 500 feet of nighttime track realignment in San Bruno, Millbrae, Burlingame, and San Mateo would be temporarily affected by construction noise.
- **San Mateo to Palo Alto Subsection**—Alternative B would construct 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 residences within 500 feet of nighttime construction in San Mateo, Belmont, San Carlos, and Redwood City would be temporarily affected by construction noise.

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 residences within 500 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara would be temporarily affected by construction noise.

The project alternatives incorporate project features (IAMF) to avoid or minimize potential effects from construction and operations. 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 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. Typical construction practices in the FTA and FRA guidance manuals 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 they occur in the same period.
- Phase demolition, earthmoving, and ground-impacting operations so they do not occur in the same period.
- Avoid impact pile driving where possible in noise- and vibration-sensitive areas.

Application of the FRA guidelines would minimize temporary construction effects on sensitive receptors. However, based on the analysis in this section, there is still the potential for adverse effects 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 5.1.1, Existing Noise Environment, sensitive receptors are in proximity to the project in all four subsections. Numerous residential sensitive receptors would be 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 5-4 would experience temporary increases in noise levels in exceedance of the FRA noise impact criteria.

5.1.2.2 Operations Noise Effects

This section describes the projected noise impacts related to HSR train operations for the 2029 and 2040 conditions[10]; impacts associated with the onset of passing HSR trains; and noise impacts of stations, the Brisbane LMF, vehicular traffic, and traction power facilities. As discussed in Section 4.1.3, the FRA noise impact criteria are based on a comparison of future projected noise levels to existing noise levels. Where the project alternatives would cause existing noise sources to change, such as by shifting an existing rail alignment, those changes become part of the projected noise levels. Additionally, when a noise source in the RSA is known to be changing either with or without the project alternatives, that change in future noise is included in the future projections as well. The assumption for this project is that the Caltrain PCEP will happen regardless of the HSR project. Therefore, either with or without the project alternatives, the future noise levels within the RSA will change. To quantify the effect of the project alternatives, the

[10] The 2029 analysis was conducted for the 4th and King Street Station only, from just south of Mission Bay Drive to the 4th and King Street Station. The 2040 analysis was conducted for the rest of the alignment, from just 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 it is an interim station only, providing service until completion of the Transbay Joint Powers Authority's DTX project, which has undergone separate environmental clearance.

future noise levels at all noise-sensitive receptors were calculated both with and without the project alternatives and compared to the existing levels.

Train Operations

This analysis evaluates the No Project Alternative and the project alternatives in 2029 and 2040. 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 implementation of the Caltrain PCEP and the project. Meanwhile, the 2029 and 2040 Plus Project cumulative conditions evaluate changes in noise levels associated with operation of the project, in addition to implementation of the Caltrain PCEP and increased operation of freight railroads in the corridor. Table 5-5 lists key assumptions for the operations noise and vibration analyses.

Table 5-5 Key Assumptions for the Operational Noise and Vibration Analysis

Component	Operational Conditions			
	Existing (2017)	2029 No Project	2029 Plus Project	2040 Plus Project
Caltrain	92 trains per day[1] 79 mph maximum 100% diesel	92 trains per day[1] 79 mph maximum 25% diesel, 75% EMU	114 trains per day[1] 79 mph maximum 100% EMU	114 trains per day[1] 110 mph maximum 100% EMU
HSR (project)	Not applicable	Not applicable	48 to 59 EMU trains per day[2] 79 mph maximum 4th and King Street Interim Station	134 to 144 EMU trains per day[2] 110 mph maximum Downtown station at Salesforce Transit Center
Existing freight	2–4 diesel trains per day	2–4 diesel trains per day	2–4 diesel trains per day	2–4 diesel trains per day
Cumulative freight	Not applicable	3–7 trains per day	3–7 trains per day	7–10 trains per day

EMU = electric multiple unit
HSR = high-speed rail
mph = miles per hour
[1] 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.
[2] Peak hour operations do not directly affect the noise analysis; for the Year 2029 HSR includes 2 trains per peak hour per direction and 4 trains per peak hour per direction for Year 2040.

Table 5-6 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 operational noise impacts between the two alternatives in this subsection. The 2029 Plus Project Cumulative conditions were not evaluated for the 4th and King Street Station and approach because there are no other passenger rail services that will use the station other than Caltrain and HSR and because freight service does not use the station or the immediate approaches.

Table 5-7 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, Caltrain and HSR would be operating in the corridor at up to 110 mph. Noise generated by the total number of trains under Alternative A would result in 1,634 severe impacts and 4,074 moderate impacts and Alternative B would result in 1,628 severe impacts and 4,068 moderate impacts. The results between alternatives differ in the San Francisco to South San Francisco and San Mateo to Palo Alto Subsections. The passing tracks 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.

Table 5-6 Summary of 2029 No Project[1] and 2029 Plus Project[2] Noise Impacts

Subsection	Land Use Category[1]	No Project[3]		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**

N/A = not applicable
[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 HSR project and planned changes in Caltrain operations as part of PCEP.
[3] Federal Railroad Administration Land Use Categories are summarized in Table 4-3. 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 5-7 Summary of 2040 No Project[1] and 2040 Plus Project[2] Noise Impacts

Subsection	Land Use Category[3]	No Project		Alternative A		Alternative B	
		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
Subtotal	**2**	**35**	**9**	**4,036**	**1,631**	**4,031**	**1,626**
	1, 3	**7**	**0**	**38**	**3**	**37**	**2**
Total	**1, 2, 3**	**42**	**9**	**4,074**	**1,634**	**4,068**	**1,628**

[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 4-3. 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.

The projected 2040 Plus Project noise impact locations for each project alternative are illustrated on Figures 5-5 through 5-12, with impacts for Alternative A shown on Figures 5-5 through 5-8 and impacts for Alternative B shown on Figures 5-9 through 5-12. 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 noise impact assessment.

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Figure 5-5 2040 Plus Project Noise Impacts—Alternative A (San Francisco to South San Francisco Subsection)

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Figure 5-6 2040 Plus Project Noise Impacts—Alternative A (San Bruno to San Mateo Subsection)

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Figure 5-7 2040 Plus Project Noise Impacts—Alternative A (San Mateo to Palo Alto Subsection)

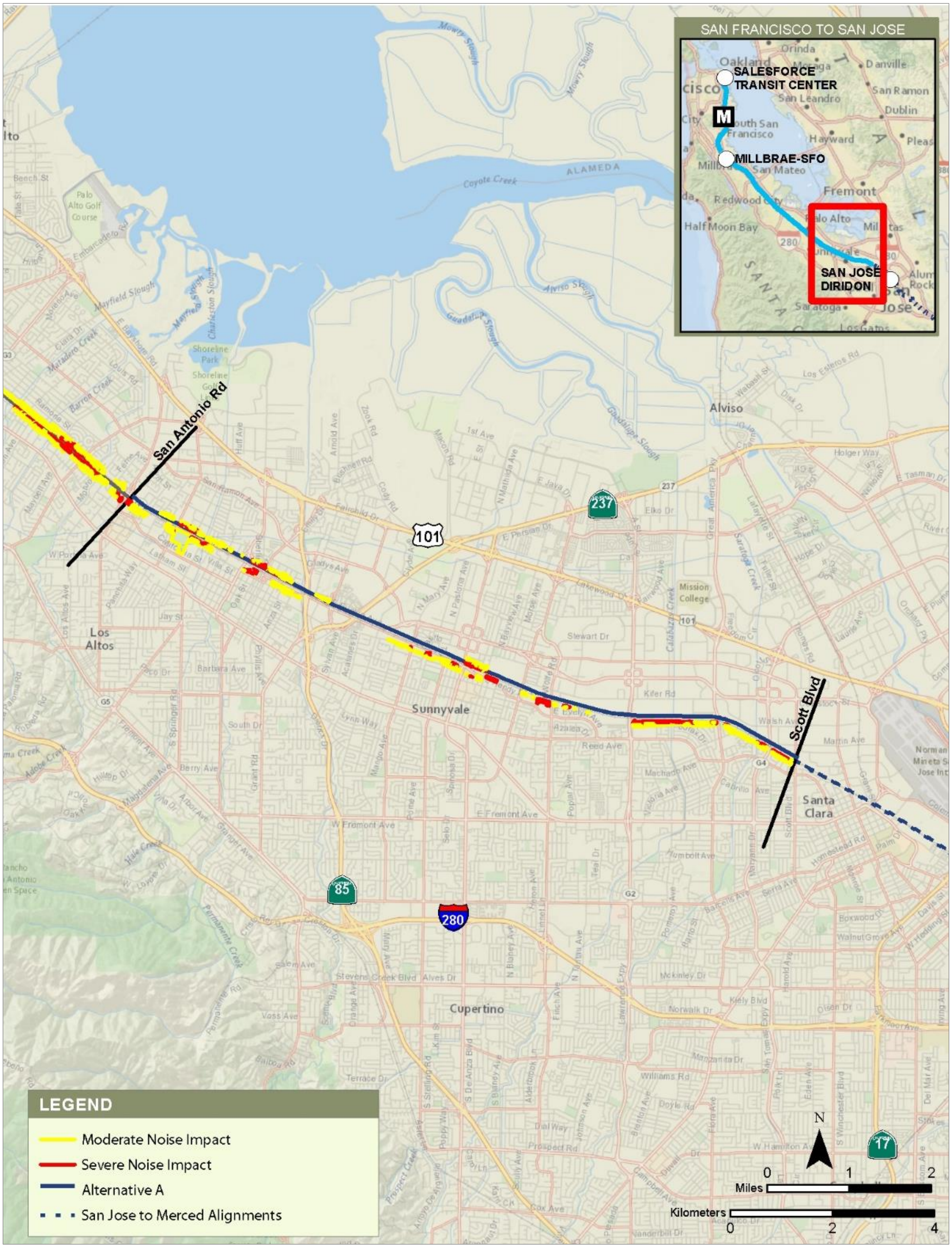

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Figure 5-8 2040 Plus Project Noise Impacts—Alternative A (Mountain View to Santa Clara Subsection)

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Figure 5-9 2040 Plus Project Noise Impacts—Alternative B (San Francisco to South San Francisco Subsection)

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Figure 5-10 2040 Plus Project Noise Impacts—Alternative B (San Bruno to San Mateo Subsection)

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Figure 5-11 2040 Plus Project Noise Impacts—Alternative B (San Mateo to Palo Alto Subsection)

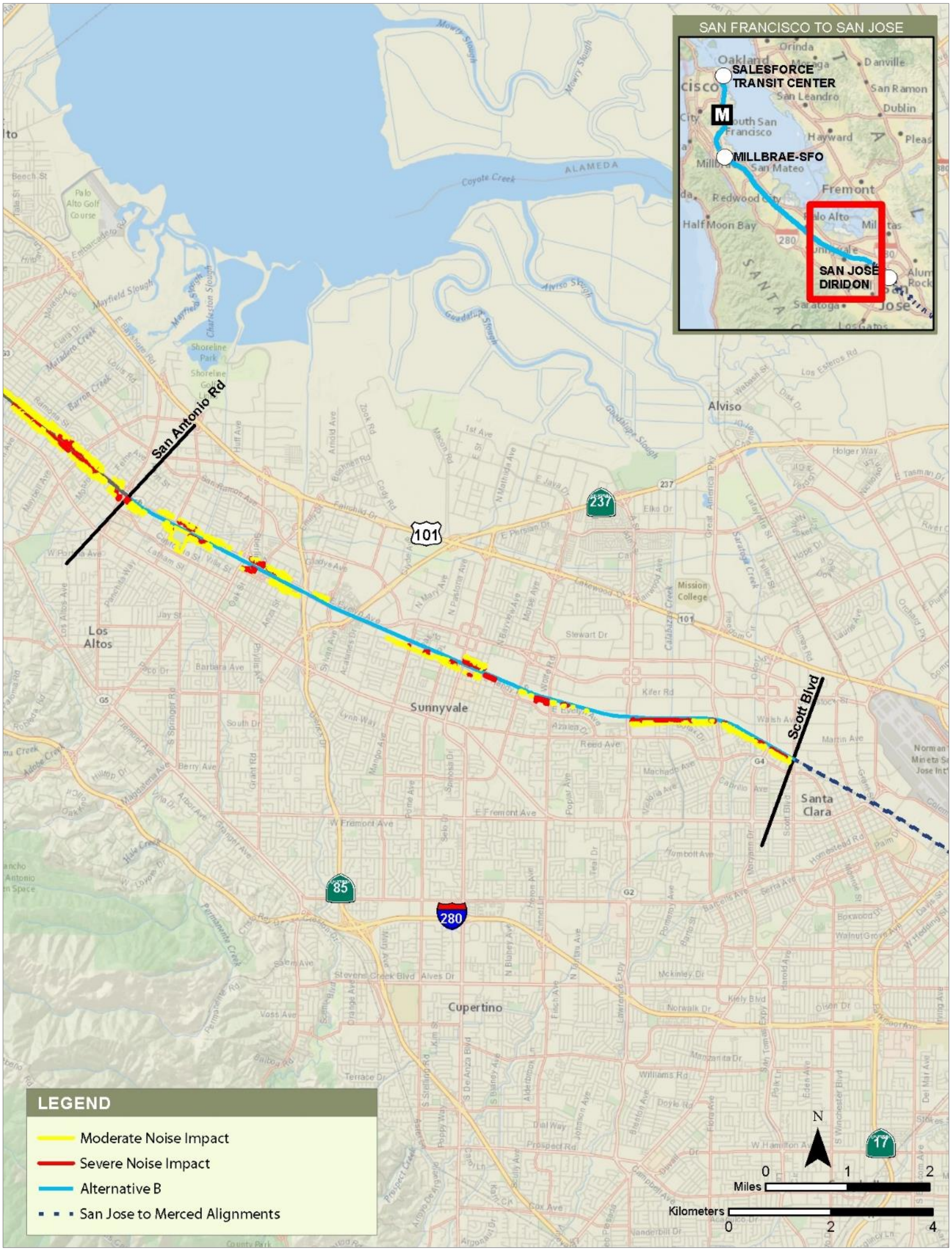

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Figure 5-12 2040 Plus Project Noise Impacts—Alternative B (Mountain View to Santa Clara Subsection)

Analysts also conducted a cumulative noise impact assessment for both the 2040 No Project and 2040 Plus Project conditions (results shown in Table 5-8). The cumulative analysis assumes that the Caltrain PCEP will be implemented and that the increase in 2040 freight operations (shown in Table 4-9) would occur. Under the 2040 No Project cumulative condition there would be 33 severe noise impacts and 331 moderate noise impacts caused by increases in PCEP and other, non-HSR train operations. Under the 2040 Plus Project cumulative condition there would be 2,134 severe noise impacts and 3,785 moderate impacts under Alternative A; and 2,132 severe impacts and 3,779 moderate impacts under Alternative B. The results between alternatives differ in the San Francisco to South San Francisco and San Mateo to Palo Alto Subsections. The passing tracks 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.

Table 5-8 Summary of 2040 No Project[1] and Plus Project[2] Cumulative Noise Impacts

Subsection	Land Use Category[1]	No Project Cumulative[2]		Plus Project Cumulative			
				Alternative A		Alternative B	
		Moderate	Severe	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco	2	2	0	179	176	178	173
	1, 3	0	0	6	0	6	0
San Bruno to San Mateo	2	153	19	944	683	944	683
	1, 3	10	1	20	1	20	1
San Mateo to Palo Alto	2	130	4	1,822	997	1,817	1,000
	1, 3	14	1	28	6	28	4
Mountain View to Santa Clara	2	21	8	783	271	783	271
	1, 3	1	0	3	0	3	0
Subtotal	**2**	**306**	**31**	**3,728**	**2,127**	**3,722**	**2,127**
	1, 3	**25**	**2**	**57**	**7**	**57**	**5**
Total	**1, 2, 3**	**331**	**33**	**3,785**	**2,134**	**3,779**	**2,132**

[1] The 2040 No Project cumulative condition reflects planned changes in Caltrain operations as part of PCEP for all locations other than the 4th and King Street Station area, as well as anticipated increases in freight operation. 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, as well as anticipated increases in freight operation.
[3] Federal Railroad Administration Land Use Categories are summarized in Table 4-3. 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.

Implementation of the project alternatives would not change the current practices regarding the sounding of train horns and crossing bells within 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 located at grade at the same locations as the existing Caltrain railway. As a result, HSR trains would regularly sound warning horns at all at-grade crossings and Caltrain passenger stations.

Tables 5-9 and 5-10 show a detailed breakdown of the 2040 Plus Project noise impact assessment results for each subsection. The subsections are divided into smaller areas by city or other geographic extents. In each location, ranges of distance to the nearest HSR track and maximum HSR speed are shown. The ranges represent a composite of many receptors and provide the upper and lower limits of these values for each geographic location. In locations with noise impacts, the data represent the range for those affected receptors; in locations without noise impacts, the data are representative of the receptor with the largest projected noise level increase. The detailed impact tables provide ranges of existing noise levels, predicted future noise levels, and predicted increase in noise levels. The numbers of moderate and severe noise impacts in each location are provided. In each area, the specific land uses of the projected noise impacts are included. Most of the noise impacts would occur at single-family residences; several multifamily residential buildings would also be affected.

Table 5-9 Detailed 2040 Plus Project Noise Impacts—Alternative A

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco Subsection										
4th & King Street Station[6]	—	—	—	—	—	—	—	—	—	—
Design District	2	81–403	45–110	57–79	61–80	0.9–4.6	0.2–2.6	1.4–6.2	3 SF; 5 MF	2 SF; 5 MF
	1, 3	152–326	110	77–82	79–83	0.9–2.6	0.3–0.9	2.1–4.7	2 Medical	0
SF Tunnels No. 1 and 2[7]	—	—	—	—	—	—	—	—	—	—
Islais Creek	2	49–381	100–110	57–72	61–76	2.6–4.5	0.8–2.6	2.5–6.1	17 SF; 3 MF	43 SF; 3 MF
	1, 3	71	110	70	73	2.9	2.7	5.8	1 Studio	0
SF Tunnel No. 3[7]	—	—	—	—	—	—	—	—	—	—
Portola Place	2	66–408	110	56–70	60–72	1.1–4.4	1–2.9	2.7–6.6	110 SF; 2 MF	102 SF; 7 MF
	1, 3	368	110	58	60	2.3	5.4	10.1	0	0
SF Tunnel No. 4[7]	—	—	—	—	—	—	—	—	—	—
Bayshore	2	38–194	75–110	60–72	65–79	3.9–6.8	0.8–2	2.5–5	1 SF; 1 MF	2 SF; 4 MF
	1, 3	129	75	73	75	2.5	1.9	5.3	1 Church	0
Brisbane	2	87–1921	85–110	54–77	58–77	0.3–6.5	0.3–3.5	2–7.6	19 SF; 1 Hotel	5 SF
	1, 3	—	—	—	—	—	—	—	—	—
South San Francisco	2	91–455	100–110	75–86	76–86	0–1.1	0–0.4	0.3–2.2	14 SF; 2 MF; 4 Hotel	0
	1, 3	298	110	68	71	2.5	2.9	6.2	0	0
San Bruno to San Mateo Subsection										
San Bruno	2	56–476	100–110	60–77	63–80	0.9–4.8	0.3–2	2–5	211 SF; 66 MF	41 SF; 2 MF
	1, 3	292	100	70	72	2.0	2.7	5.7	-	0
Millbrae	2	78–471	100–110	60–73	62–78	2.1–8.3	0.6–2	2.4–5	109 SF; 5 MF	115 SF; 6 MF; 1 Hotel
	1, 3	274	110	74	77	2.5	1.4	5.0	1 School	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
Burlingame	2	98–491	105–110	57–75	60–79	1–5.7	0.5–2.8	2.2–6.4	288 SF; 77 MF	109 SF; 46 MF; 1 Fire Dep
	1, 3	53–355	110	73–82	76–85	2.3–2.5	0.2–1.7	2–5.2	1 Medical; 1 Park, 3 School	1 Museum
San Mateo North	2	28–490	79–110	54–82	58–84	1.4–4.2	0.1–3.5	0.8–7.6	240 SF; 73 MF	120 SF; 54 MF; 1 Hospital
	1, 3	154–266	110	72–75	74–76	1.7–2.5	1.3–2.2	5–5.4	3 Medical, 1 Church	0
San Mateo to Palo Alto Subsection										
San Mateo South	2	52–493	110	54–74	58–77	1.1–6	0.5–3.5	2.3–7.6	479 SF; 86 MF	41 SF; 23 MF
	1, 3	50–70	110	75–77	79–81	3.8–4.8	0.8–1.2	4.7–4.9	2 School	1 School
Belmont	2	65–471	110	56–72	59–74	1.1–4.6	0.8–2.9	2.5–6.6	19 SF; 76 MF; 4 Hotel	3 SF; 4 MF
	1, 3	79	110	74	75	0.8	1.5	5.1	0	0
San Carlos	2	52–476	110	55–74	58–77	1.2–4	0.5–3.3	2.3–7.4	94 SF; 7 MF; 1 Fire Dep; 3 Hotel	17 SF; 1 MF
	1, 3	454	110	65	67	2.1	3.4	7.1	0	0
Redwood City	2	30–548	110	55–78	59–82	1–4.3	0.2–3.2	1.8–7.2	144 SF; 37 MF; 2 Hotel	48 SF; 46 MF; 3 Hotel
	1, 3	39–291	110	72–82	74–85	1.7–2.6	0.3–2.3	2.1–5.5	1 Theater; 3 Medical; 1 Park, 1 Library	1 Medical
North Fair Oaks	2	26–311	110	54–77	58–81	0.4–4.5	0.3–3.4	2.1–7.5	126 SF; 33 MF	101 SF; 8 MF
	1, 3	332	110	58	60	2.1	5.3	9.9	0	0
Atherton	2	56–435	110	54–71	58–75	2.4–4.4	1–3.5	2.6–7.6	56 SF	39 SF
	1, 3	90–178	110	73–78	75–81	2.2–2.4	0.6–1.8	3.9–5.2	1 Park, 1 Library	0
Menlo Park	2	32–462	110	54–79	57–83	2.5–5.3	0.2–3.5	1.4–7.6	105 SF; 56 MF; 3 Hotel	54 SF; 88 MF; 2 Hotel
	1, 3	112–214	110	73–78	75–80	2.4–2.7	0.7–1.8	4.4–5.2	1 Medical; 1 Park, 1 Library; 1 Institutional	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
Palo Alto	2	38–481	110	56–75	59–79	1.1–4.3	0.4–2.9	2.2–6.6	514 SF; 117 MF; 1 Hospital; 1 Hotel	248 SF; 38 MF; 1 Fire Dep; 2 Hospital; 2 Hotel
	1, 3	70–163	110	74–78	76–80	1.3–2.5	0.7–1.6	4.4–5.1	3 Medical; 1 Park, 3 School	0
Mountain View to Santa Clara Subsection										
Mountain View	2	27–552	90–110	56–74	59–76	1.1–4.1	0.6–2.9	2.3–6.6	328 SF; 87 MF	21 SF; 22 MF; 1 Fire Dep
	1, 3	274–311	110	76–76	78–79	2.4–2.4	1–1.1	4.7–4.8	2 Institutional	0
Sunnyvale	2	45–482	110	55–72	58–76	1.7–6.9	0.8–3.3	2.5–7.4	131 SF; 42 MF	41 SF; 16 MF
	1, 3	117	110	75	77	2.5	1.2	4.9	1 Medical	0
Santa Clara	2	59–385	110	55–70	59–75	1.5–7.1	1–3.2	2.7–7.2	140 SF; 93 MF	44 SF; 48 MF
	1, 3	91	110	69	71	2.1	2.9	6.2	0	0
Subtotal	**2**								**4,036**	**1,631**
	1, 3								**38**	**3**
Total	**1, 2, 3**								**4,074**	**1,634**

dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
MF = multi-family residential building
mph = miles per hour
SF = single-family residential building
[1] Federal Railroad Administration Land Use Categories are summarized in Table 4-3. 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.
[2] The ranges shown for the distances, speeds, and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location. In locations with noise impacts, the data represent the range for those affected receptors. In locations without noise impacts, the data are representative of the receptor with the highest projected noise level increase (typically the receptor located closest to the alignment.)
[3] Noise levels for Land Use Category 2 are based on L_{dn} and measured in dBA. Noise levels for Land Use Categories 1 and 3 are based on L_{eq} and measured in dBA.
[4] Predicted future noise levels represent the total future predicted noise levels with the project alternatives.
[5] Increases in noise level represent the predicted increase in future noise levels with the project alternatives over the existing noise levels.
[6] This portion of the alignment was not assessed for the 2040 Plus Project condition.
[7] Airborne noise was not assessed in this portion of the alignment where the alternative is in a tunnel.

Table 5-10 Detailed 2040 Plus Project Noise Impacts—Alternative B

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
San Francisco to South San Francisco Subsection										
4th and King Street Station[6]	—	—	—	—	—	—	—	—	—	—
Design District	2	81–403	45–110	57–79	61–80	0.9–4.6	0.2–2.6	1.4–6.2	3 SF; 5 MF	2 SF; 5 MF
	1, 3	152–326	110	77–82	79–83	0.9–2.6	0.3–0.9	2.1–4.7	2 Medical	0
SF Tunnels No. 1 and 2[7]	—	—	—	—	—	—	—	—	—	—
Islais Creek	2	49–381	100–110	57–72	61–76	2.6–4.5	0.8–2.6	2.5–6.1	17 SF; 3 MF	43 SF; 3 MF
	1, 3	71	110	70	73	2.9	2.7	5.8	1 Studio	0
SF Tunnel No. 3[7]	—	—	—	—	—	—	—	—	—	—
Portola Place	2	66–408	110	56–70	60–72	1.1–4.4	1–2.9	2.7–6.6	110 SF; 2 MF	102 SF; 7 MF
	1, 3	368	110	58	60	2.3	5.4	10.1	0	0
SF Tunnel No. 4[7]	—	—	—	—	—	—	—	—	—	—
Bayshore[8]	2	38–194	75–110	60–72	64–77	3.3–5.4	0.8–2	2.5–5	2 SF; 1 MF	1 SF; 4 MF
	1, 3	129	75	73	75	2.4	1.9	5.3	1 Church	0
Brisbane[8]	2	87–1728	85–110	54–77	58–77	0.3–6.5	0.3–3.5	2–7.6	19 SF; 1 Hotel	1 SF
	1, 3	—	—	—	—	—	—	—	—	—
South San Francisco[8]	2	91–455	100–110	75–86	76–86	0–1.1	0–0.4	0.3–2.2	14 SF; 2 MF; 4 Hotel	0
	1, 3	298	110	68	71	2.5	2.9	6.2	0	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
San Bruno to San Mateo Subsection										
San Bruno	2	56–476	100–110	60–77	63–80	0.9–4.8	0.3–2	2–5	211 SF; 66 MF	41 SF; 2 MF
	1, 3	292	110	70	72	2.0	2.7	5.7	0	0
Millbrae	2	78–471	100–110	60–73	62–78	2.1–8.3	0.6–2	2.4–5	109 SF; 5 MF	115 SF; 6 MF; 1 Hotel
	1, 3	274	110	74	77	2.5	1.4	5.0	1 School	0
Burlingame	2	98–491	105–110	57–75	60–79	1–5.7	0.5–2.8	2.2–6.4	288 SF; 77 MF	109 SF; 46 MF; 1 Fire Dep
	1, 3	53–355	110	73–82	76–85	2.3–2.5	0.2–1.7	2–5.2	1 Medical; 1 Park, 3 School	1 Museum
San Mateo North	2	28–490	79–110	54–82	58–84	1.4–4.2	0.1–3.5	0.8–7.6	240 SF; 73 MF	120 SF; 54 MF; 1 Hospital
	1, 3	154–266	110	72–75	74–76	1.7–2.5	1.3–2.2	5–5.4	3 Medical, 1 Church	0
San Mateo to Palo Alto Subsection										
San Mateo South[8]	2	59–493	110	54–74	58–77	1–5.8	0.5–3.5	2.3–7.6	471 SF; 87 MF	43 SF; 22 MF
	1, 3	70	110	75	79	4.0	1.2	4.9	1 School	0
Belmont[8]	2	65–471	110	56–72	60–74	1–4.5	0.8–2.9	2.5–6.6	19 SF; 79 MF; 4 Hotel	3 SF; 1 MF
	1, 3	79	110	74	74	0.7	1.5	5.1	0	0
San Carlos[8]	2	52–476	110	55–74	58–76	1.3–4.1	0.5–3.3	2.3–7.4	92 SF; 7 MF; 1 Fire Dep; 3 Hotel	19 SF; 1 MF
	1, 3	454	110	65	67	2.1	3.4	7.1	0	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
Redwood City[8]	2	30–548	110	55–78	59–82	1–4.3	0.2–3.2	1.8–7.2	144 SF; 37 MF; 2 Hotel	48 SF; 46 MF; 3 Hotel
	1, 3	39–291	110	72–82	74–85	1.7–2.6	0.3–2.3	2.1–5.5	1 Theater; 3 Medical; 1 Park, 1 Library	1 Medical
North Fair Oaks	2	26–311	110	54–77	58–81	0.4–4.5	0.3–3.4	2.1–7.5	126 SF; 33 MF	101 SF; 8 MF
	1, 3	332	110	58	60	2.1	5.3	9.9	0	0
Atherton	2	56–435	110	54–71	58–75	2.4–4.4	1–3.5	2.6–7.6	56 SF	39 SF
	1, 3	90–178	110	73–78	75–81	2.2–2.4	0.6–1.8	3.9–5.2	1 Park, 1 Library	0
Menlo Park	2	32–462	110	54–79	57–83	2.5–5.3	0.2–3.5	1.4–7.6	105 SF; 56 MF; 3 Hotel	54 SF; 88 MF; 2 Hotel
	1, 3	112–214	110	73–78	75–80	2.4–2.7	0.7–1.8	4.4–5.2	1 Medical; 1 Park, 1 Library; 1 Institutional	0
Palo Alto	2	38–481	110	56–75	59–79	1.1–4.3	0.4–2.9	2.2–6.6	514 SF; 117 MF; 1 Hospital; 1 Hotel	248 SF; 38 MF; 1 Fire Dep; 2 Hospital; 2 Hotel
	1, 3	70–163	110	74–78	76–80	1.3–2.5	0.7–1.6	4.4–5.1	3 Medical; 1 Park, 3 School	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)[2]	Maximum HSR Speed (mph)	Existing Noise Level (dBA)	Future Noise Level[3]		Noise Impact Criteria		Number of Impacts	
					Predicted[4]	Increase[5]	Moderate	Severe	Moderate	Severe
Mountain View to Santa Clara Subsection										
Mountain View	2	27–552	90–110	56–74	59–76	1.1–4.1	0.6–2.9	2.3–6.6	328 SF; 87 MF	21 SF; 22 MF; 1 Fire Dep
	1, 3	274–311	110	76–76	78–79	2.4–2.4	1–1.1	4.7–4.8	2 Institutional	0
Sunnyvale	2	45–482	110	55–72	58–76	1.7–6.9	0.8–3.3	2.5–7.4	131 SF; 42 MF	41 SF; 16 MF
	1, 3	117	110	75	77	2.5	1.2	4.9	1 Medical	0
Santa Clara	2	59–385	110	55–70	59–75	1.5–7.1	1–3.2	2.7–7.2	140 SF; 93 MF	44 SF; 48 MF
	1, 3	91	110	69	71	2.1	2.9	6.2	0	0
Subtotal	**2**								**4,031**	**1,626**
	1, 3								**37**	**2**
Total	**1, 2, 3**								**4,068**	**1,628**

dBA = A-weighted decibel
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
MF = multi-family residential building
mph = miles per hour
SF = single-family residential building
[1] Federal Railroad Administration Land Use Categories are summarized in Table 4-3. 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.
[2] The ranges shown for the distances, speeds, and noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location. In locations with noise impacts, the data represent the range for those affected receptors. In locations without noise impacts, the data are representative of the receptor with the highest projected noise level increase (typically the receptor located closest to the alignment.)
[3] Noise levels for Land Use Category 2 are based on L_{dn} and measured in dBA. Noise levels for Land Use Categories 1 and 3 are based on L_{eq} and measured in dBA.
[4] Predicted future noise levels represent the total future predicted noise levels with the project alternatives.
[5] Increases in noise level represent the predicted increase in future noise levels with the project alternatives over the existing noise levels.
[6] This portion of the alignment was not assessed for the 2040 Plus Project case.
[7] Airborne noise was not assessed in this portion of the alignment where the alternative is in a tunnel.
[8] This location includes passing tracks where Alternative B differs from Alternative A.

Annoyance from Onset of HSR Passbys

Onset rate is the average rate of change of increasing sound pressure level measured in dB/sec during a single noise event. The rapid approach of an HSR train is accompanied by a sudden increase in noise for a receiver near the tracks. As described in Section 4.1.3.2, Operations, startle effects are likely to occur in humans as onset rates approach 30 dB/sec when there is no advance warning of train approach.

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). 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. As illustrated on Figure 4-5, once the HSR train reaches 110 mph, the onset rate is 30 dB/second when the noise-sensitive receptor is within 23 feet from the train. To avoid startle effects at human noise-sensitive receptors due to onset rates, noise-sensitive receivers 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 effects 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 Santa Clara 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 effects would occur. The Authority identified a few noise-sensitive receptors 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 startle effect 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 startle effect is expected to occur due to operations.

Operation of either project alternative would also result in wayside noise near the four short existing tunnel portals in the San Francisco to South San Francisco Subsection, which could startle nearby wayside receptors. Wayside noise near the tunnel portals is not expected to cause an adverse effect on sensitive receptors due to the train speed and track configuration, because configurations with train speeds less than 155 mph and ballasted track do not generate problematic portal booms (Tunnel Magazine 2011).

Station Noise

The project includes the modification of two existing stations to serve as HSR stations—in downtown San Francisco at the existing Fourth and King Street Station, and in Millbrae at the exist intermodal station. The stations would be the same under both project alternatives.

The method used to assess noise impact from HSR stations is summarized in Section 4.1.5.2, Operations Noise. The dominant noise source at receptors near the HSR stations would be assumed to be HSR train movements. This analysis also assessed additional noise from station parking facilities. Preliminary layouts of the parking facilities at the HSR stations were used to identify the location and total number of parking spaces at each station location. No additional parking facilities are associated with the 4th and King Street Station; the Millbrae Station site plan includes at-grade parking areas.

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 all the parking spaces would be filled once and then vacated once. During the non-peak mid-day and evening hours, the analysis assumed that a percentage of the parking spaces corresponding to the ridership peaking factors (Authority 2008) would be filled and then vacated each hour.

A noise assessment following Section 4.4 of the FTA guidance manual was conducted using these inputs and the method described in Section 4.1.5.2 of this report to calculate the total noise contribution from the parking facilities at the noise-sensitive receptors near the Millbrae Station. Near the Millbrae Station, the largest L_{dn} contribution from the parking facilities at the nearby noise receptors would be 37 dBA. The results of the station noise assessment indicate that the additional noise from parking facilities would be substantially lower than the projected L_{dn} from HSR operations. At all nearby receptors, the L_{dn} contribution from the parking facilities at Millbrae Station would be at least 24 dB less than HSR operations.

Light Maintenance Facility Noise

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.

Analysts used the methods to assess noise impacts from the proposed Brisbane LMF that were summarized in Section 4.1.5.2. 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 LMFs. The HSR operations schedule of train movements into and out of the LMFs 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 away from the East Brisbane LMF and approximately 1,500 feet away 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.

Vehicle Traffic Noise

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

Noise from changes in traffic volume due to the project was assessed following the method summarized in Section 4.1.5.2. The traffic noise analysis focused on roadway segments near the HSR stations and the Brisbane LMFs. Daily traffic volumes for these select roadway segments were used to calculate traffic growth factors to assess the potential change in noise levels for each project alternative. Changes in noise levels for 2029 were assessed at the 4th and King Street Station, while changes in noise levels for 2040 were assessed at Millbrae Station and the Brisbane LMFs.

Table 5-11 identifies the roadway segments assessed for the 4th and King Street Station in 2029. It includes the existing total ADT volumes for each roadway segment, the 2029 No Project ADT, and the 2029 Plus Project ADT. The potential noise increases over existing noise conditions are calculated to determine impacts, and for context, compared with the No Project Alternative. This assessment identifies that two roadway segments near the 4th and King Street Station have the potential for noise level increases greater than 3 dB compared to existing noise conditions. However, none of the segments would have an increase greater than 1 dB compared to the No Project Alternative. All comparisons to the No Project Alternative are for informational purposes only, and not a determinant of impact.

Table 5-11 Change in 2029 Traffic Noise Levels Due to Project—4th and King Street Station

Segment	Roadway Segment Description	Existing ADT	No Project ADT	Plus Project ADT	Noise Increase Over Existing (dBA)	Noise Increase Over No Project (dBA)[1]
1	4th Street between Bluxome Street and Brannan Street	5,467	10,817	11,217	3	0
2	4th Street between Townsend Street and Bluxome Street	5,694	10,783	11,094	3	0
3	Townsend Street between 5th Street and 4th Street	10,403	13,806	15,139	2	0
4	4th Street between King Street and Townsend Street	8,300	13,667	13,833	2	0
5	King Street between 5th Street and 4th Street	26,072	32,556	32,744	1	0
6	4th Street between Berry Street and King Street	6,589	11,389	11,467	2	0
7	7th Street between 16th Street and Mission Bay Drive	9,208	13,278	13,461	2	0
8	16th Street between 7th Street/ Mississippi Street and Owens Street	15,483	19,278	19,411	1	0

ADT = average daily traffic
dBA = A-weighted decibel
LMF = light maintenance facility
[1] The noise increase over No Project data are presented only for reference purposes. The noise increase over existing is what determines impact.

Table 5-12 shows the roadway segments assessed for Alternative A in 2040. It includes the existing ADT volumes for each roadway segment, the 2040 No Project ADT, and the 2040 Plus Project ADT for Alternative A. This assessment indicates that for Alternative A in 2040, none of the roadway segments near the Brisbane LMF or the Millbrae Station would have a noise level increase greater than 2 dB compared to existing noise conditions or greater than 1 dB compared to the No Project Alternative.

Table 5-12 Change in 2040 Traffic Noise Levels Due to Project—Alternative A

Segment	Roadway Segment Description	Existing ADT	No Project ADT	Plus Project ADT	Noise Increase Over Existing (dBA)	Noise Increase Over No Project (dBA)[1]
San Francisco to South San Francisco Subsection						
Brisbane Light Maintenance Facility						
1	Bayshore Boulevard between Tunnel Avenue and Hester Avenue/US 101 Southbound Off-Ramp	24,786	32,833	32,981	1	0
2	Bayshore Boulevard between Blanken Avenue and Tunnel Avenue	21,367	28,056	28,056	1	0
3	Bayshore Boulevard between Visitacion Avenue and Blanken Avenue	22,975	33,139	33,139	2	0
4	Bayshore Boulevard between Geneva Avenue and Visitacion Avenue	17,722	26,833	26,833	2	0
5	Bayshore Boulevard between Industrial Way and Geneva Avenue	17,394	25,889	25,900	2	0
6	Bayshore Boulevard between Guadalupe Canyon Parkway and Industrial Way	17,786	25,611	25,622	2	0
7	Bayshore Boulevard between Valley Drive and Guadalupe Canyon Parkway	19,822	27,444	27,511	1	0
8	Bayshore Boulevard between Old County Road and Valley Drive	23,014	30,167	32,061	1	0
9	Tunnel Avenue between Bayshore Boulevard and Lagoon Road	4,997	7,111	7,283	2	0
10	Tunnel Avenue between Blanken Avenue and Bayshore Boulevard	3,911	5,111	5,256	1	0
San Bruno to San Mateo Subsection						
Millbrae Station						
1	El Camino Real (SR 82) between Victoria Avenue and Hillcrest Boulevard	34,697	46,583	47,161	1	0
2	El Camino Real (SR 82) between Chadbourne Avenue and Victoria Avenue	35,633	46,722	47,156	1	0

Segment	Roadway Segment Description	Existing ADT	No Project ADT	Plus Project ADT	Noise Increase Over Existing (dBA)	Noise Increase Over No Project (dBA)[1]
3	El Camino Real (SR 82) between Linden Avenue and Chadbourne Avenue	35,756	46,667	47,183	1	0
4	El Camino Real (SR 82) between Millbrae Avenue and Linden Avenue	34,178	44,778	45,472	1	0
5	Millbrae Avenue between El Camino Real (SR 82) and Rollins Road	38,108	45,056	45,322	1	0
6	El Camino Real (SR 82) between Murchison Drive and Millbrae Avenue	29,533	44,194	44,642	2	0
7	El Camino Real (SR 82) between Trousdale Drive and Murchison Drive	21,092	34,889	35,406	2	0

ADT = average daily traffic
dBA = A-weighted decibel
SR = State Route
US = U.S. Highway
[1] The noise increase over No Project data are presented only for reference purposes. The noise increase over existing is what determines impact.

Table 5-13 shows the roadway segments assessed for Alternative B in 2040 near the Brisbane LMF. Traffic volumes at Millbrae Station are the same for Alternatives A and B and therefore are not repeated. Near the Brisbane LMF, none of the roadway segments have the potential for noise level increases greater than 2 dB compared to existing noise conditions or greater than 1 dB compared to the No Project Alternative.

Table 5-13 Change in 2040 Traffic Noise Levels Due to Project—Alternative B

Segment	Roadway Segment Description	Existing ADT	No Project ADT	Plus Project ADT	Noise Increase Over Existing (dBA)	Noise Increase Over No Project (dBA)[1]
San Francisco to South San Francisco Subsection						
Brisbane Light Maintenance Facility						
1	Bayshore Boulevard between Tunnel Avenue and Hester Avenue/US 101 Southbound Off-Ramp	24,786	32,833	33,003	1	0
2	Bayshore Boulevard between Blanken Avenue and Tunnel Avenue	21,367	28,056	28,278	1	0
3	Bayshore Boulevard between Visitacion Avenue and Blanken Avenue	22,975	33,139	33,361	2	0
4	Bayshore Boulevard between Geneva Avenue and Visitacion Avenue	17,722	26,833	27,056	2	0
5	Bayshore Boulevard between Industrial Way and Geneva Avenue	17,394	25,889	26,425	2	0

Segment	Roadway Segment Description	Existing ADT	No Project ADT	Plus Project ADT	Noise Increase Over Existing (dBA)	Noise Increase Over No Project (dBA) [1]
6	Bayshore Boulevard between Guadalupe Canyon Parkway and Industrial Way	17,786	25,611	25,772	2	0
7	Bayshore Boulevard between Valley Drive and Guadalupe Canyon Parkway	19,822	27,444	27,589	1	0
8	Bayshore Boulevard between Old County Road and Valley Drive	23,014	30,167	32,106	1	0
9	Tunnel Avenue between Bayshore Boulevard and Lagoon Road	4,997	7,111	7,194	2	0
10	Tunnel Avenue between Blanken Avenue and Bayshore Boulevard	3,911	5,111	5,111	1	0

ADT = average daily traffic
dBA = A-weighted decibel
US = U.S. Highway
[1] The noise increase over No Project data are presented only for reference purposes. The noise increase over existing is what determines impact.

Overall, there are no roadway segments where the increases in traffic associated with the project alternatives under the 2040 Plus Project condition are anticipated to be greater than or equal to 3 dB. The only segments where increases greater than or equal to 3 dB are projected are near the 4th and King Street Station for the 2029 Plus Project condition.

The traffic noise predictions have been made by comparing the existing traffic volumes to 2040 Plus Project volumes and by comparing the 2040 No Project volumes to the 2040 Plus Project volumes. The traffic volume predictions include growth factors unrelated to the project alternatives. As would be expected, the analysis shows greater potential increases in traffic noise compared to the existing noise conditions than when compared to the No Project condition.

Traction Power Facility Noise

Any new equipment required to handle HSR electrical load in the Project Section 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 the PCEP analysis (PCJPB 2014), analysts identified potentially affected noise-sensitive receptors near TPFs using the screening distance of 250 feet for receptors. FTA reference levels were used to calculate the total project noise level at the receptors identified within the screening distance, within which 15 noise-sensitive receptors were identified for PCEP. Of these receptors, only one severe impact (Paralleling Station [PS] 5 Option 2, Palo Alto) and one moderate impact (PS 1, San Francisco) were identified in the PCEP analysis.

The list of 15 noise-sensitive receptors from the PCEP analysis was reviewed to determine which would warrant analysis update for the present study. The TPFs considered are as follows:

- PS 1 (San Francisco)
- PS 2, Variant A (San Francisco)
- PS 3, Option 3 (Burlingame)
- PS 4, Option 3 (San Mateo)
- PS 5, modified Option 2 (Palo Alto)
- PS 6, Option 2 (Sunnyvale)
- PS 7, Variant C (San Jose)

- Switching Station 1, Option 2 (Redwood City)
- TPSS 1, Option 4 (South San Francisco)
- TPSS 2, Option 2 (San Jose)

In most cases, the receptors would be located over 100 feet from the TPF, resulting in TPF noise levels of 64 L_{dn} and lower, which, when combined with the HSR train noise, would generate no new impacts compared to the HSR train operation impacts. Only two receptors were identified at a distance of 100 feet or less from the TPF, and those are presented in Table 5-14. In addition, there are three new TPF options that have been considered for PCEP since the original analysis (PCJPB 2015b, 2018a, 2018b). Of the new TPF options, PS 2, Variant A and PS 7, Variant C have no sensitive receptors within the 250-foot screening distance; PS 3, Option 3 would be within the screening distance of residences, but at 190 feet distance, no further analysis is provided for that location.

HSR train operational noise levels were calculated using the methods described in Section 4.1.5.2 to assess the total project noise levels considering ambient noise at the receptors and accounting for both changes from project operations and the new noise source associated with additional equipment at the PCEP TPFs. Analysts estimated that the highest noise levels from additional equipment at these TPFs would be as high as 86 L_{dn} dBA at 5 feet, generating a TPF-generated noise increase of 18.2 dBA. This increase would exceed the 3.1 dBA severe impact threshold and generate a severe noise impact near PS 5, Option 2 due to the additional equipment alone under both project alternatives in the San Mateo to Palo Alto Subsection; the total project noise with HSR train operations would increase 18.2 dBA. Additional equipment at the TPFs may also increase noise in excess of the 1.1-dBA moderate impact threshold at two residences in the Mountain View to Santa Clara Subsection near PS 6, Option 2; the total project noise with HSR train operations would increase 4.7 dBA. In all cases, in combination with HSR train operations, the noise associated with additional equipment at PCEP TPFs would not affect any new receptors not already affected by the train operation impacts shown previously in Table 5-7. Furthermore, this analysis is conservative because distances were based on the outer boundary of the facility footprint, which would be greater than the actual distance to the noise source in most cases.

Table 5-14 Transfer Power Facility Noise Analysis Results

City	Facility[1]	Near Receptor Address	Land Use Category[2]	Land Use	Receptor Distance to Ancillary Facility (feet)	Ambient L_{dn}	Substation Noise, L_{dn} (dBA)	Project with TPF	Number of Receivers	Noise Increase Impact Thresholds		Noise Increase with Project and TPF
								Alternatives A and B		Moderate	Severe	Alternatives A and B
Palo Alto	PCEP PS5, Option 2	195 Page Mill Rd	2	MFR	5	68	86	86.2	1	1.2	3.1	18.2[3]
Sunnyvale	PCEP PS6, Option 2	105 N Taaffe St	2	SFR	100	69	64	73.7	2	1.1	2.9	4.7[4]

Source: PCJPB 2014
dBA = A-weighted decibel
L_{dn} = day-night sound level
MFR = multifamily residence
PS = paralleling station
SFR = single-family residence
TPF = traction power facility
[1] Facilities not listed have no noise sensitive receivers within 100 feet of the facility.
[2] Federal Railroad Administration land use categories are summarized in Table 4-3. 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.

5.2 Vibration

5.2.1 Existing Vibration Environment

This section summarizes the locations of existing vibration measurement sites and the results of vibration measurement. This section also describes the vibration-sensitive land uses and sources of existing vibration in the RSA.

5.2.1.1 Vibration Measurement Results and Discussion

Measurements of the existing vibration levels were conducted at 30 sites in the RSA. The locations of the vibration measurement sites are illustrated on Figures 5-1 through 5-4, and photographs of these sites are provided in Appendix A.

The existing vibration measurement results are shown in Table 5-15. At each site, ground-borne vibration levels were recorded at multiple distances, and the range of distances from the track centerline from where the vibration levels were measured are included in Table 5-15. The results include the range of maximum overall ground-borne vibration levels for each type of train passby based on the distance from the track. The range in measured vibration levels corresponds directly to the accelerometer or geophone distance from the track. Higher vibration levels occur closer to the existing tracks and the vibration levels decrease with distance from the track.

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 close to roadways. The vibration-sensitive land uses in the RSA are generally located where the vibration RSA is adjacent to existing rail rights-of-way and therefore, where existing ambient vibration measurements were conducted.

Table 5-15 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
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

Site	Location	Date	Distance from Track (feet)	Overall Vibration Level (VdB)	Source
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

VdB = vibration decibels

Figure 5-13 illustrates results of the existing vibration measurements. The overall ground-borne vibration L_v at each site at each measurement distance from the tracks are included. The various symbols in the figure identify the site and each type of train passby. For reference, the FRA residential vibration criterion of 72 VdB is also included, showing the range of distances at which existing train vibration currently exceeds the criterion. The measurements show that the vibration levels decrease with distance, varying 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, which is less than would typically be expected.

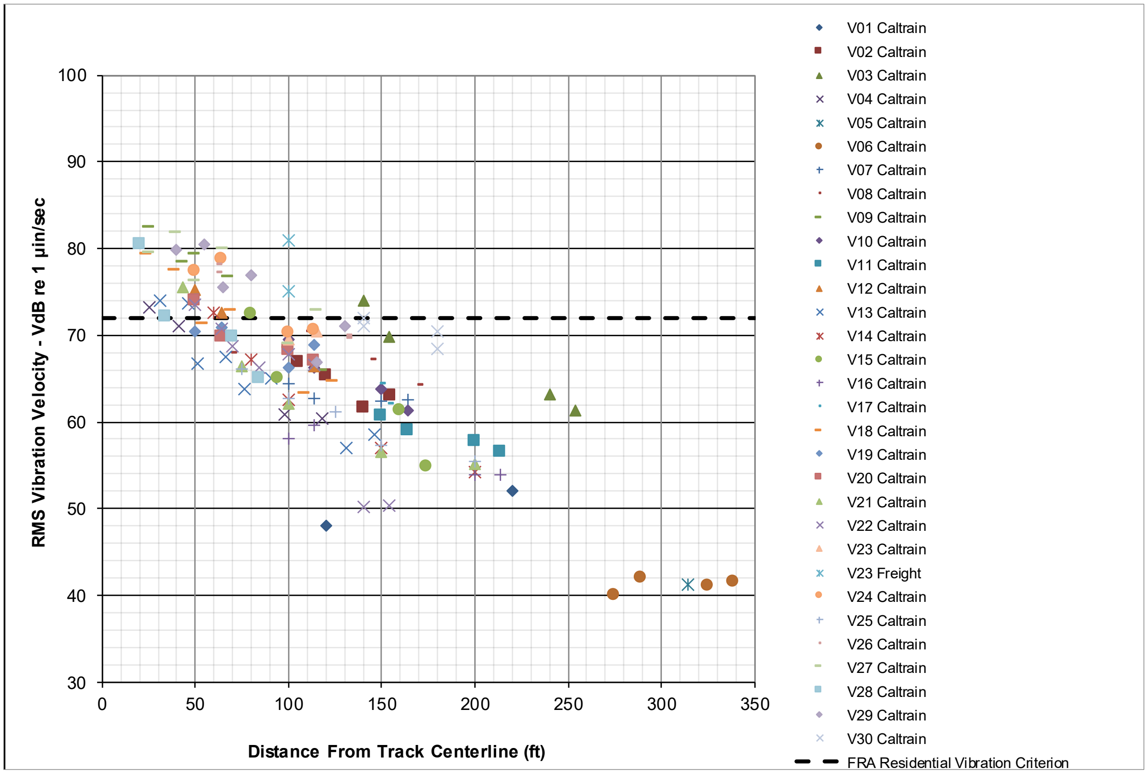

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Figure 5-13 Existing Vibration Measurement Levels

As discussed in Section 4.2.4, Methods for Establishing Existing Vibration Levels, vibration propagation measurements were conducted at 18 locations in the RSA to assist in the prediction of ground-borne vibration levels from HSR operations. The vibration propagation measurements shown in Table 5-16 are site-specific tests that quantify the efficiency of vibration propagation through the soil at specific locations. The results are used to conduct a detailed vibration analysis and predict future ground-borne vibration levels from HSR operations.

Surface vibration propagation tests were conducted at 12 locations in the RSA. Six borehole vibration propagation tests were also conducted in the RSA during previous work in 2010. The LSR data from each propagation measurement site are plotted in Appendix C, which also provides LSR coefficients for each site. Two additional vibration propagation test sites located in the San Jose to Merced Project Section are also included in Table 5-16 because they were used for predictions at some nearby receptor locations.

Table 5-16 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

Site	Location	Date	Test Type	Depth (feet)[1]
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	W 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 (San Jose to Merced Project Section)				
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

[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 both San Francisco and South San Francisco, the alignment runs 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 the BART subway trains. 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 was between 82 VdB (at 25 feet) and 57 VdB (at 200 feet).

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 10 locations: V14 through V23. Ambient vibration from Caltrain trains obtained along this subsection ranged between 79 VdB (at 24 feet) and 54 VdB (at 214 feet). Freight train passby vibration was measured at one site in this subsection, with measured vibration levels between 75 VdB and 81 VdB (at 100 feet).

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).

5.2.2 Vibration Impact Assessment

Vibration impacts were assessed according to the criteria described in Section 4.2.3 and the method, data, and assumptions described in Section 4.2.4 and Section 4.2.5, Prediction Methods.

5.2.2.1 Construction Vibration Effects

Construction of project alternatives would require the use of equipment that would generate temporary ground-borne vibration during the construction period which would last approximately 4.5 years. The effects from construction-related vibration would be similar under both project alternatives, however 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, the construction of Alternative B would expose a greater number of receptors to construction vibration.

The potential for vibration impacts would be greatest where vibration-sensitive land uses are in close proximity to major construction activities with a long duration (e.g., LMF, passing tracks, 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 effects and would have fewer effects 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. Residences within

140 feet of nighttime construction in the Little Hollywood neighborhood of San Francisco would be affected by nighttime construction vibration. 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. Residences within 140 feet of nighttime construction in San Bruno, Millbrae, Burlingame, and San Mateo would be temporarily affected by construction vibration.
- **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 residences within 140 feet of nighttime construction in San Mateo, Belmont, San Carlos, Atherton, Menlo Park, and Palo Alto would be temporarily affected by construction vibration.
- **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 residences within 140 feet of residences in Mountain View, Sunnyvale, and Santa Clara would be temporarily affected by construction vibration.

Alternative B would include the following locations of potential construction vibration impacts and would have greater effects 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 140 feet of nighttime construction in the Little Hollywood neighborhood of San Francisco would be temporarily affected by construction vibration.
- **San Bruno to San Mateo Subsection**—There are no differences between Alternative B and Alternative A in this subsection. Residences within 140 feet of nighttime construction work in San Bruno, Millbrae, Burlingame, and San Mateo would be temporarily affected by construction vibration.
- **San Mateo to Palo Alto Subsection**—Alternative B would construct 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 residences within 140 feet of nighttime construction in San Mateo, Belmont, San Carlos, and Redwood City would be temporarily affected by construction vibration. 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 residences within 140 feet of nighttime construction in Mountain View, Sunnyvale, and Santa Clara would be temporarily affected by construction vibration.

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 jack hammers or hoe-rams, the frequent event criterion of 72 VdB is more appropriate. Nighttime annoyance would potentially occur as far 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 waves in the ground that are strong enough to potentially cause cosmetic or structural damage. Of the vibration-sensitive buildings along the project corridor that have been considered, the most sensitive are lightweight (wood-framed) buildings with plaster interior wall finishes, as shown in Table 4-13 for Type III structures. The potential for vibration impact would occur near pile driving, vibratory compaction, demolition, or excavation activities near vibration-sensitive structures (building damage) or vibration-sensitive use (annoyance). Pile driving very close to buildings (within 50 feet) would be anticipated to exceed the threshold of 0.2 in/sec PPV and cause building damage at Type III, as shown in Table 5-17. Pile-driving activities would only occur at limited worksites, such as the LMF building foundations and new columns for bridge expansions.

Table 5-17 Construction Equipment Vibration Impact Distances (feet)

Construction Equipment	Source Vibration at 25 feet		Buffer Distances[1] and Thresholds (feet)				
	Peak Particle Velocity (PPV in/sec)	Vibration Level (Lv)	Bldg. Damage (Type I)[2]	Bldg. Damage (Type II)[3]	Bldg. Damage (Type III)[4]	Annoyance (Infrequent Events)[5]	Annoyance (Frequent Events)[6]
			0.5 in/sec PPV	0.3 in/sec PPV	0.2 in/sec PPV	80 VdB	72 VdB
Impact pile driver	0.644	104	30	42	55	159	296
Vibratory pile driver	0.17	93	12	17	22	66	122
Vibratory compactor	0.21	94	14	20	26	76	140
Loaded trucks	0.076	86	7	10	13	38	71
Jackhammer	0.035	79	4	6	8	23	42
Small bulldozer	0.003	58	1	1	2	4	8

Source: FRA 2012
in/sec = inches per second
L_v = velocity level
PPV = peak particle velocity
VdB = vibration decibels
[1] Buffer distances calculated to the ground at the edge of structures.
[2] Type I = Reinforced-concrete, no plaster
[3] Type II = Engineered concrete and masonry, no plaster
[4] Type III = nonengineered timber and masonry
[5] Infrequent = less than 30 vibration events per day
[6] Frequent = more than 70 vibration events per day

5.2.2.2 Operations Vibration Effects

This section describes the predicted vibration impacts related to HSR operations, which are due to annoyance. The vibration propagation measurement results were combined with the FDL data illustrated on Figure 4-11 for HSR trains and Caltrain trains, as described in Section 4.2.5.2. Figure 5-14 illustrates the projections of maximum overall ground-borne vibration levels from HSR operations for each of the at-grade vibration propagation measurement sites. These sample projections assume HSR would operate on at-grade track at 110 mph. The figure also includes the FRA residential vibration criterion of 72 VdB as a reference.

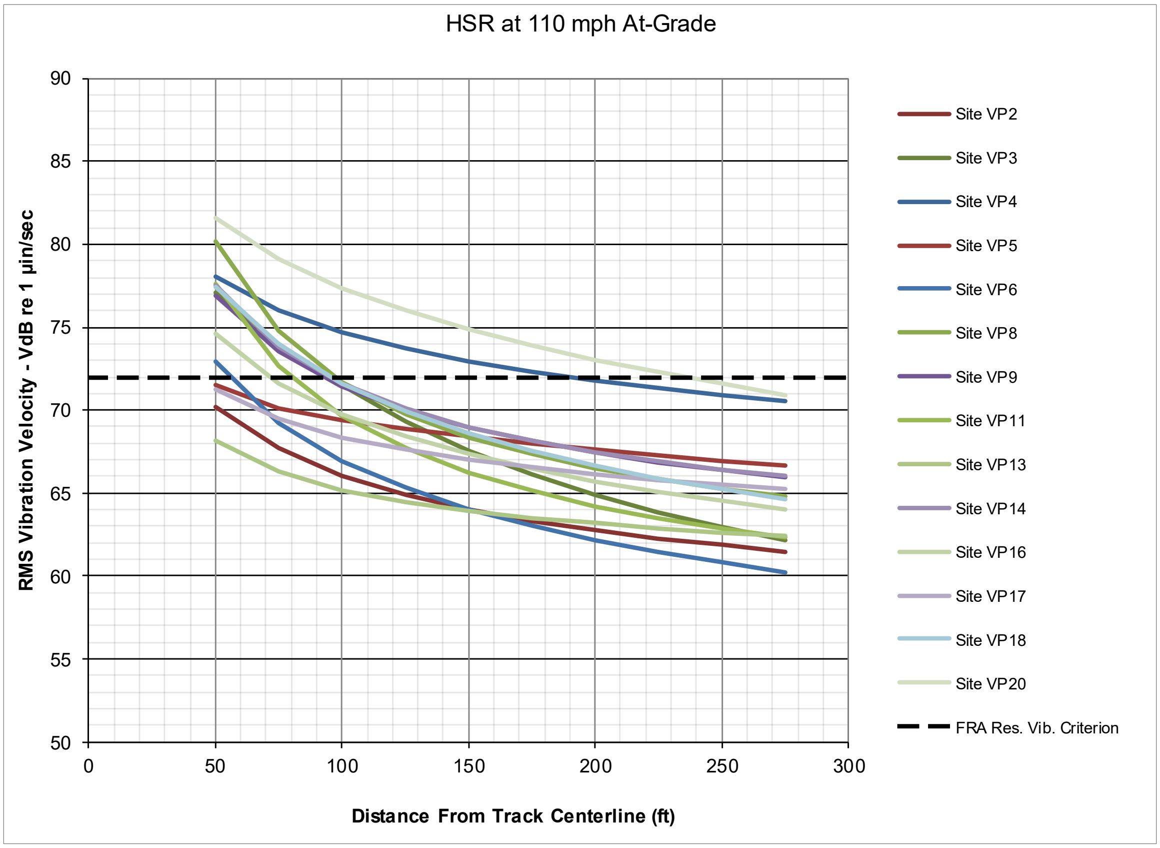

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Figure 5-14 Projected HSR Vibration Levels

The plot shows the variation in vibration propagation throughout the RSA. The projections at the lower curves indicate much greater attenuation of vibration levels with distance compared to the higher curves. The most efficient propagation occurs near Catalpa (Site VP4) in San Mateo. Locations in the RSA would experience different vibration levels for a train moving at the same speed because the ground conditions affect the vibration levels. At Site VP4 the projections for a 110-mph HSR train at grade are above the impact criterion within approximately 200 feet of the track.

Figure 5-15 illustrates predicted HSR vibration levels at site VP14 for comparison with Caltrain vibration levels. The plot shows the vibration projections at this sample site for HSR at grade at 110 mph in addition to projections of a Caltrain train at 79 mph (the current maximum speed of Caltrain trains in the RSA). As described in Section 4.2.5.2, vibration levels typically increase with increasing speed. However, even at 79 mph, the overall vibration level from a Caltrain passby is expected to be higher than from an HSR train traveling at 110 mph.

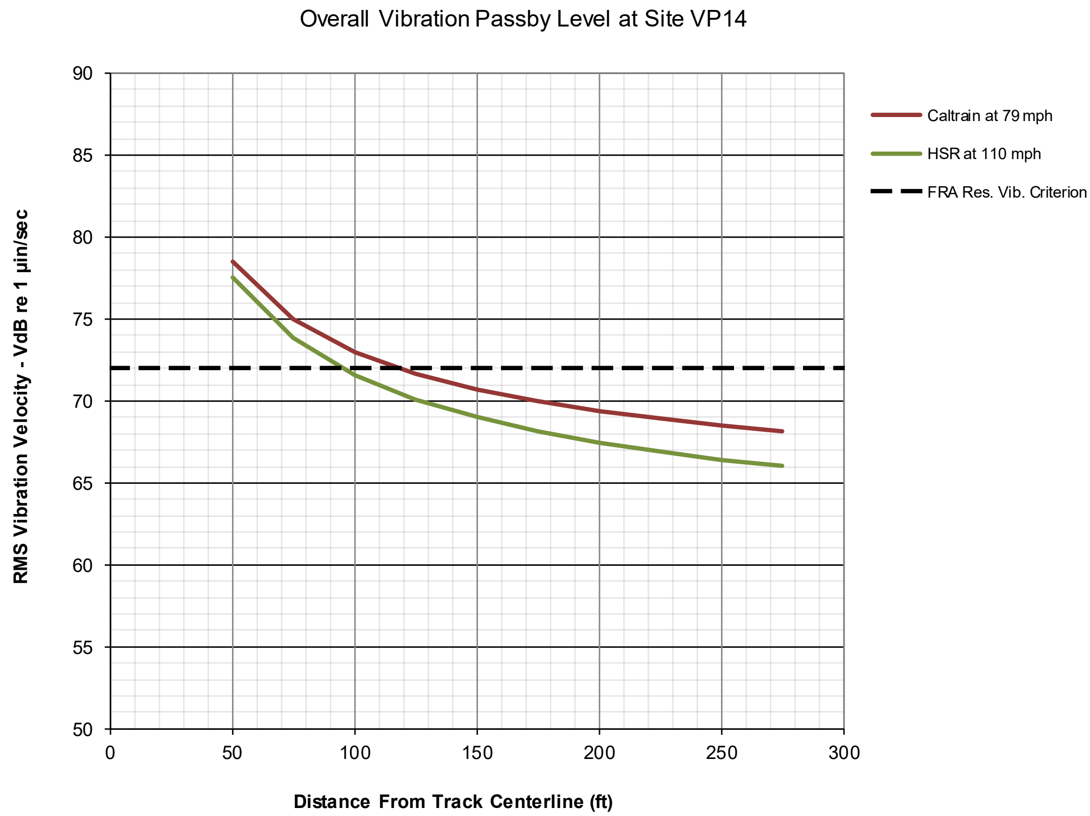

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Figure 5-15 Comparison of Projected HSR and Caltrain Vibration Levels

Potential vibration impacts from HSR operations were assessed according to the criteria described in Section 4.2.3.2. In the subsections of the vibration RSA with existing rail operations, analysts calculated the existing vibration levels and future project levels at vibration receptors. The modeled vibration levels for existing sources and shifted existing sources due to HSR operations were calculated based on the measurement data and method discussed previously in Section 4.2.5.2. HSR vibration levels were predicted at each vibration-sensitive receptor or cluster of receptors for the project alternatives. In areas with existing train operations, the modeled existing vibration levels were compared to the modeled future project vibration levels from HSR operations and shifted existing operations (where applicable).

The vibration impact criteria summarized in Section 4.2.3.2 are based on a maximum level of vibration from a train passby. This differs from the noise impact criteria, which are based on time-weighted metrics that account for the level of an event as well as the number of events in a specific period. Because the vibration impact criteria are based on single train passby events, a cumulative analysis was not necessary.

The vibration impact assessment was conducted for 2029 for the 4th and King Street Station only, and for 2040 for the alignment south of the 4th and King Street Station. Under the No Project condition, the Caltrain PCEP is assumed to use EMU vehicles in place of the current diesel locomotive–hauled coaches. The vibration analysis for the Caltrain PCEP assumed that the EMU vehicle would generate vibration similar to the existing vehicle (PCJPB 2014). 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 do not exceed applicable criteria. Table 5-18 summarizes the results of the 2040 vibration impact assessment with the project alternatives. The vibration impacts are included for both alternatives and 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 San Francisco. Alternative A would result in 2,290 ground-borne vibration impacts and 18 ground-borne noise impacts. Alternative B would result in 2,288 ground-borne vibration impacts and 18 ground-borne noise impacts. The vibration impacts would occur in all four subsections.

These vibration impacts would result from both HSR train operations and also in some cases by Caltrain operations. Where the HSR project would shift Caltrain and freight tracks closer to vibration-sensitive buildings, the train operations on those modified tracks are treated as project vibration sources and compared to the impact criteria. Under both alternatives, the project would cause Caltrain trains would operate at increased speeds of up to 110 mph to accommodate blended service. Accordingly, Caltrain operations at higher speeds are treated as project vibration sources and compared to impact criteria.

Table 5-18 Summary of 2040 No Project and 2040 Plus Project Vibration Impacts

Subsection	Land Use Category	Number of Vibration Impacts					
		No Project[1]		Alternative A		Alternative B	
		GBV	GBN	GBV	GBN	GBV	GBN
San Francisco to South San Francisco	2	0	0	68	17	67	17
	1, 3	0	0	8	1	8	1
San Bruno to San Mateo	2	0	0	647	0	647	0
	1, 3	0	0	5	0	5	0
San Mateo to Palo Alto	2	0	0	1,137	0	1,137	0
	1, 3	0	0	13	0	12	0
Mountain View to Santa Clara	2	0	0	409	0	409	0
	1, 3	0	0	3	0	3	0
Subtotal	**2**	**0**	**0**	**2,261**	**17**	**2,260**	**17**
	1, 3	**0**	**0**	**29**	**1**	**28**	**1**
Total	**1, 2, 3**	**0**	**0**	**2,290**	**18**	**2,288**	**18**

GBN = ground-borne noise
GBV = ground-borne vibration
[1] No Project impacts are provided for comparison purposes and are not used to determine project impacts.

The potential vibration impact locations for each project alternative are illustrated on Figures 5-16 through 5-23. Figures 5-16 through 5-19 show the Alternative A vibration impact locations, and Figures 5-20 through 5-23 show the Alternative B vibration impact locations. Each red area indicates a cluster of receptors predicted to have a potential ground-borne vibration impact. Each yellow area indicates a cluster of receptors predicted to have a potential ground-borne noise impact.

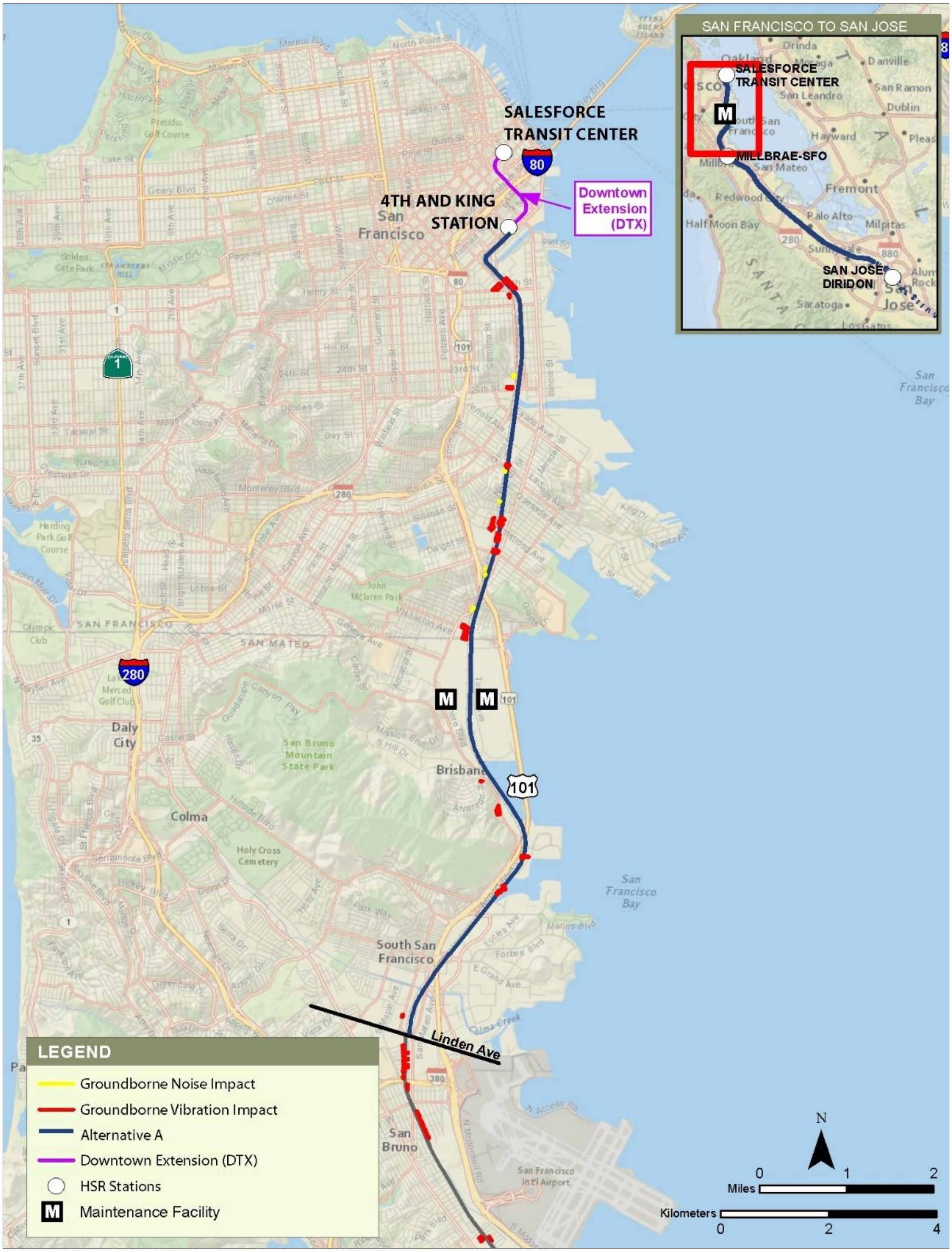

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Figure 5-16 2040 Plus Project Vibration Impacts—Alternative A (San Francisco to South San Francisco Subsection)

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Figure 5-17 2040 Plus Project Vibration Impacts—Alternative A (San Bruno to San Mateo Subsection)

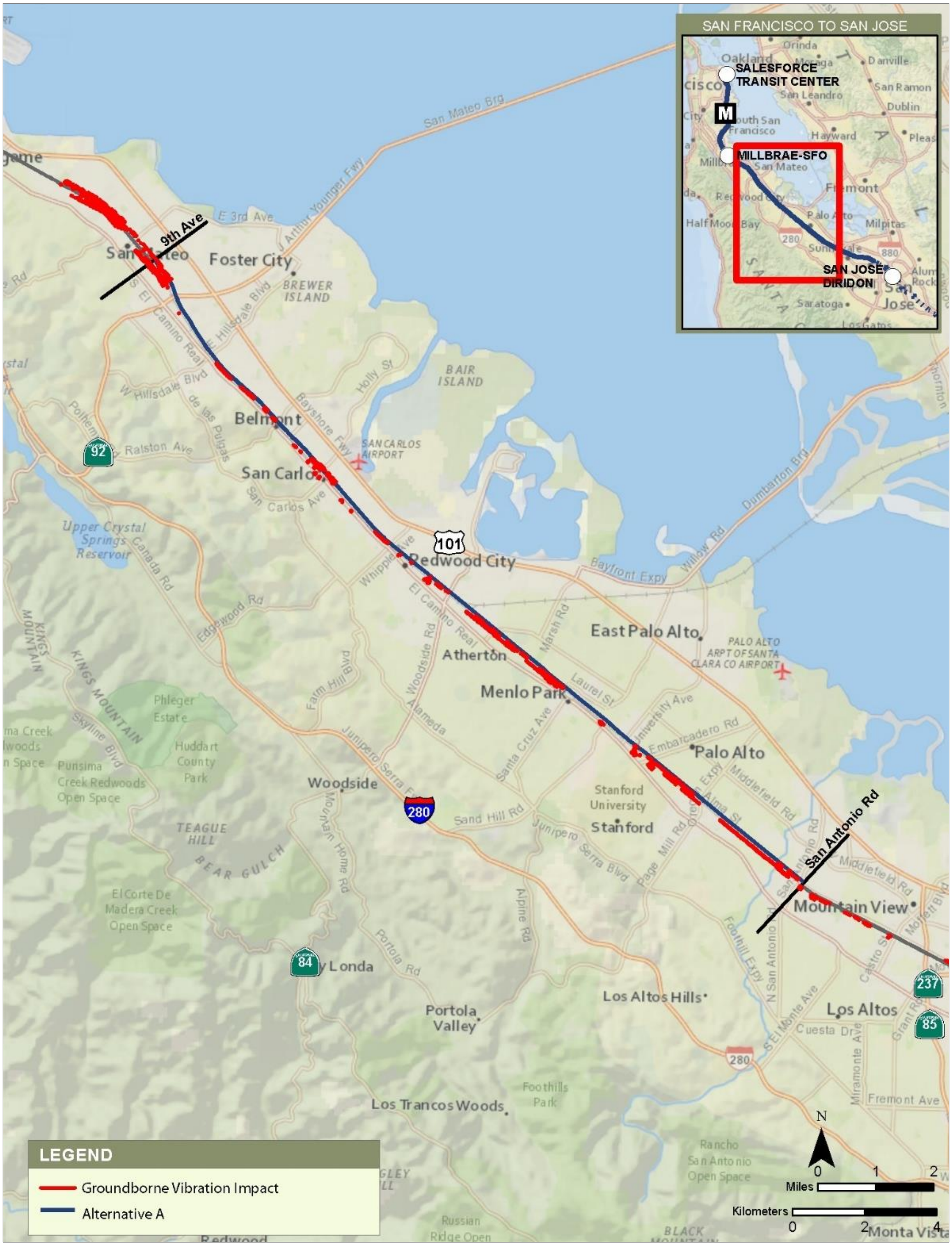

Figure 5-18 2040 Plus Project Vibration Impacts—Alternative A (San Mateo to Palo Alto Subsection)

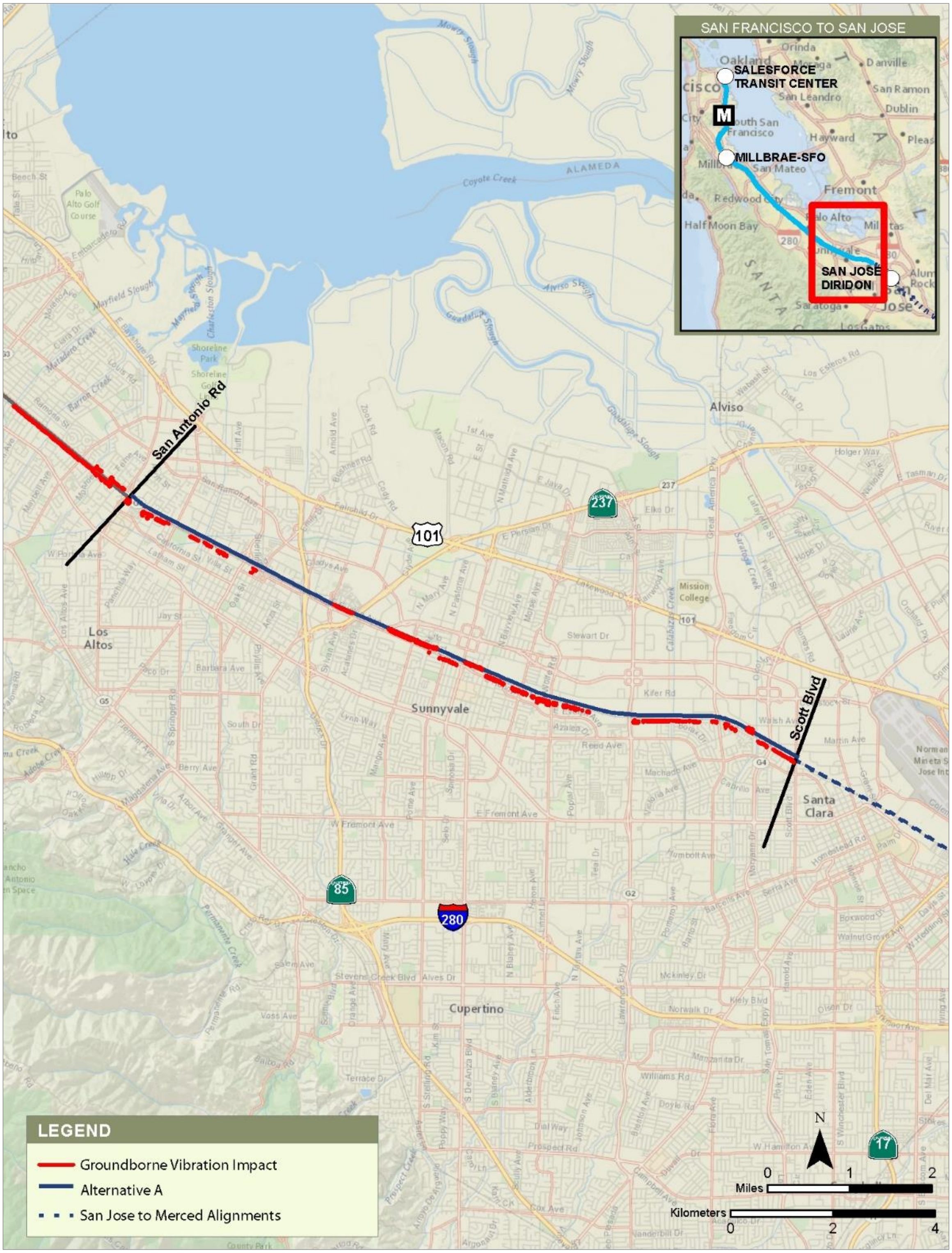

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Figure 5-19 2040 Plus Project Vibration Impacts—Alternative A (Mountain View to Santa Clara Subsection)

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Figure 5-20 2040 Plus Project Vibration Impacts—Alternative B (San Francisco to South San Francisco Subsection)

Figure 5-21 2040 Plus Project Vibration Impacts—Alternative B (San Bruno to San Mateo Subsection)

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Figure 5-22 2040 Plus Project Vibration Impacts—Alternative B (San Mateo to Palo Alto Subsection)

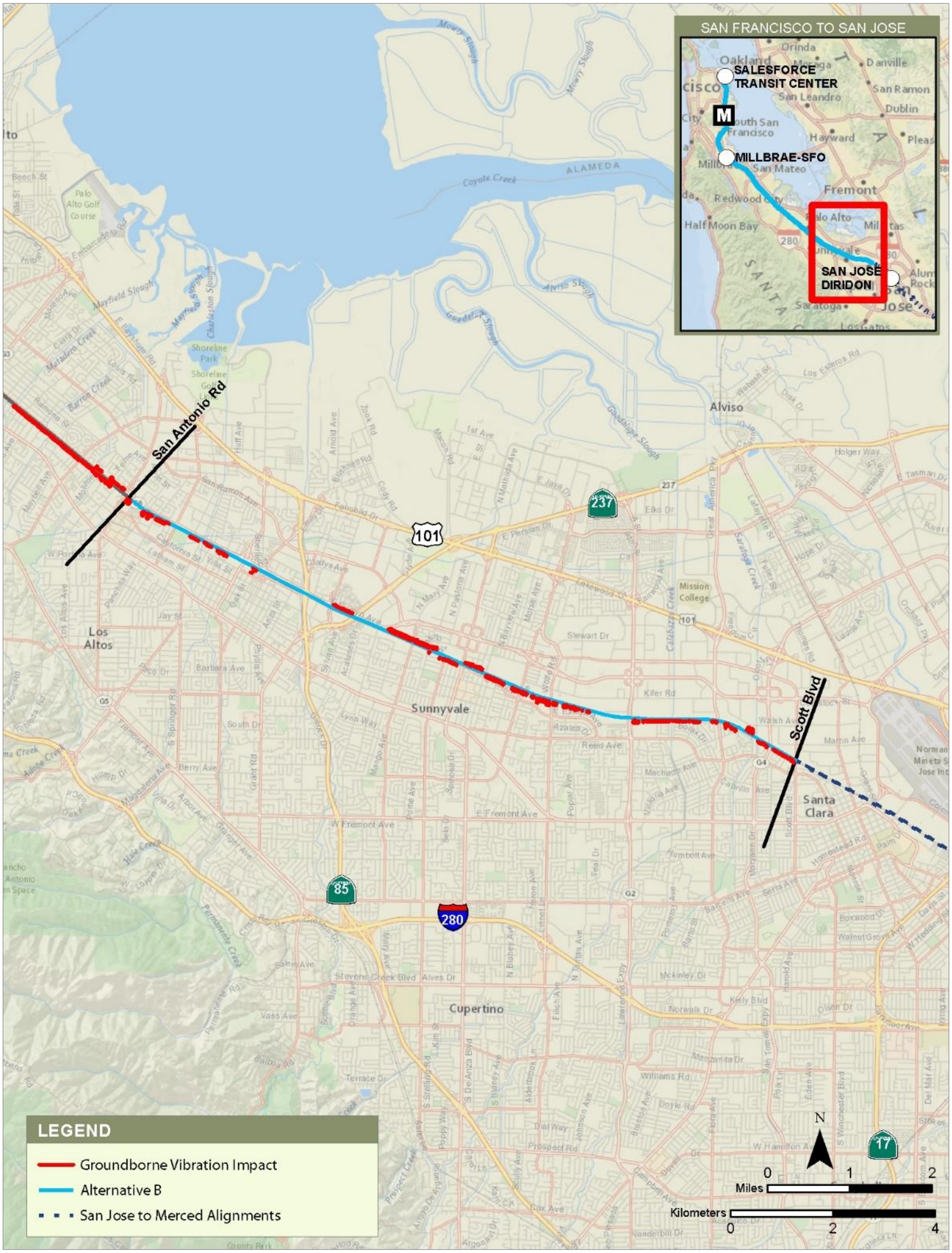

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Figure 5-23 2040 Plus Project Vibration Impacts—Alternative B (Mountain View to Santa Clara Subsection)

Tables 5-19 through 5-21 show the vibration impact assessment results by project alternative, subsection, and segments within each subsection. The distance to the nearest vibration-sensitive receptor is shown, along with the maximum speed of HSR trains in the area. Table 5-19 presents a detailed breakdown of the ground-borne vibration impact assessment results for Alternative A. Table 5-20 presents a detailed breakdown of the ground-borne vibration impact assessment results for Alternative B. Table 5-21 is a detailed breakdown of the ground-borne noise impact assessment results for both alternatives, because both project alternatives are the same in the San Francisco to South San Francisco Subsection areas with existing short tunnels.

The entire RSA is categorized as a heavily used rail corridor, and many receptors in the RSA currently experience high vibration levels. The project alternatives would more than double the number of train passby events per day, causing vibration impacts from the project alternatives.

The detailed vibration impact assessment results tables include the range of maximum existing vibration L_v that the vibration receptors are currently exposed to in each location. In the each of the four subsections, there are many vibration-sensitive locations where the existing levels exceed the residential criterion of 72 VdB. Caltrain trains create similar ground-borne vibration levels to those from HSR trains in the RSA, even though the maximum speeds are generally slower. The tables also include the range of maximum future Caltrain vibration levels. In some areas, the project would cause the existing tracks to be shifted, and for new tracks to be added. The analysis accounts for where the existing vibration rail sources would be shifted closer to sensitive locations with the project.

The range of maximum vibration levels from HSR trains is provided for each location. Throughout most of the RSA the projected vibration levels from HSR trains would exceed the impact criterion at some nearby locations. Even though the HSR train speeds are slightly higher than conventional-speed commuter rail such as Caltrain in the RSA, the ground-borne vibration levels are often comparable or lower. This is likely due to the relatively low input forces from the HSR trains (the FDL). 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.

Tables 5-19 and 5-20 also show the number of ground-borne vibration impacts in each segment of each subsection. Under Alternative A, 1,682 single-family residences, 568 multifamily residential buildings,[11] 4 hospitals, 9 hotels, 1 fire department building, 3 churches, 7 schools, 10 medical buildings, 2 institutional buildings, 2 studios, 1 laboratory, and 1 museum have the potential for ground-borne vibration impacts. Alternative B is similar to Alternative A throughout much of the RSA. Under Alternative B, 1,680 single-family residences, 569 multifamily residential buildings, 4 hospitals, 9 hotels, 1 fire department building, 3 churches, 5 schools, 11 medical buildings, 2 institutional buildings, 2 studios, 1 laboratory, and 1 museum have the potential for ground-borne vibration impacts.

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, where airborne noise would not provide masking. The results are presented in Table 5-21. Under both project alternatives, 1 studio building, 16 single-family residences, and 1 multifamily residential building have the potential for ground-borne noise impacts.

Operation of the project alternatives does not have the potential to cause building damage because the vibration levels do not approach damage thresholds. See Section 4.2.1, Descriptors, for additional discussion.

[11] The number of dwelling units in each potentially affected multifamily residential building is not specified.

Table 5-19 Detailed 2029 and 2040 Plus Project Ground-Borne Vibration Impacts—Alternative A

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
San Francisco to South San Francisco Subsection								
4th and King Street Station[3]	1	661	25	55	57	54	65	0
	2	87	25	73	69	65	72	0
Design District	2	81–87	45–110	45–78	74–87	71–84	72	2 MF
	3	152–205	110	65–72	76–81	73–77	75	2 Medical
SF Tunnels No. 1 and 2	2	97	110	61	65	61	72	0
Islais Creek	1	71	110	63	69	64	65	1 Studio
	2	125	110	65	68	65	72	0
	3	93–103	110	63–82	76–86	73–82	75	1 School; 1 Institutional
SF Tunnel No. 3	2	14	110	37	73	69	72	1 SF
	3	235	110	58	61	60	75	0
Portola Place	2	66–389	110	57–82	73–85	70–82	72	47 SF; 8 MF
	3	58–155	110	70–81	81–84	77–80	75	1 Church; 1 Institutional
SF Tunnel No. 4	2	76	110	67	70	67	72	0
	3	17	110	71	74	70	75	0
Bayshore	2	36–193	75	44–83	73–89	70–85	72	4 MF
	3	130	75	63	68	61	75	0
Brisbane	2	87–408	85–110	59–78	73–79	69–76	72	2 SF; 1 MF; 1 Hotel
South San Francisco	1	298	110	65	67	64	65	1 Studio
	2	91–109	110	62–77	73–80	69–76	72	2 Hotel
	3	127	110	69	72	68	75	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
San Bruno to San Mateo Subsection								
San Bruno	2	32–143	100–110	60–77	73–82	69–78	72	78 SF; 2 MF
	3	176	100	67	69	66	75	0
Millbrae	2	42–154	110	53–74	73–92	68–83	72	40 SF; 1 Hotel
	3	278	110	65	68	64	75	0
Burlingame	1	411	110	56	59	59	65	0
	2	96–473	105–110	53–76	73–79	68–75	72	52 SF; 40 MF
	3	53	110	57	82	78	75	1 Museum
San Mateo North	2	28–473	79–110	70–83	73–86	68–82	72	319 SF; 114 MF; 1 Hospital
	3	154–189	110	70–74	76–80	72–75	75	1 Church; 3 Medical
San Mateo to Palo Alto Subsection								
San Mateo South	2	32–472	110	65–79	73–85	68–81	72	415 SF; 61 MF
	3	29–51	110	66–79	82–86	78–81	75	3 School
Belmont	2	65–147	110	65–78	73–78	69–75	72	3 SF; 17 MF
	3	78	110	67	77	73	75	1 Medical
San Carlos	1	114	110	75	78	74	65	1 Laboratory
	2	51–466	110	65–79	73–82	69–78	72	116 SF; 5 MF; 1 Fire Department; 2 Hotel
	3	177	110	64	76	72	75	1 Medical
Redwood City	2	30–146	110	62–90	73–93	70–89	72	20 SF; 10 MF; 2 Hotel
	3	39	110	62	81	77	75	1 Medical
Fair Oaks	2	26–147	110	64–87	73–90	69–85	72	102 SF; 13 MF
	3	171	110	68	70	67	75	0
Atherton	2	54–108	110	62–76	73–78	69–74	72	38 SF
	3	180	110	67	70	66	75	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
Menlo Park	2	32–118	110	59–80	73–83	69–79	72	32 SF; 37 MF; 1 Hotel
	3	136	110	69	72	68	75	0
Palo Alto	1	62–197	110	68–76	71–79	68–75	65	3 Hospital
	2	38–166	110	59–84	73–87	68–83	72	214 SF; 48 MF
	3	70–154	110	65–75	76–78	72–74	75	1 Church; 1 School; 1 Medical
Mountain View to Santa Clara Subsection								
Mountain View	2	27–195	110	62–82	73–85	69–80	72	39 SF; 46 MF
	3	222	110	66	69	65	75	0
Sunnyvale	2	45–203	110	64–84	73–89	67–85	72	111 SF; 109 MF
	3	116	110	74	77	74	75	1 Medical
Santa Clara	2	59–171	110	65–77	73–80	67–76	72	53 SF; 51 MF
	3	91	110	73	76	72	75	2 School
TOTAL	**1**							**2 Studio; 1 Laboratory; 3 Hospital**
	2							**1,682 SF; 568 MF; 1 Fire Department; 1 Hospital; 9 Hotel**
	3							**3 Church; 7 School; 10 Medical; 2 Institutional; 1 Museum**

HSR = high-speed rail
MF = multifamily
SF = single family
VdB = vibration decibels
µin/sec = microinches per second
[1] Federal Railroad Administration Land Use Categories are summarized in Table 4-13. Land Use Category 1 = Areas where vibration would interfere with operations; Category 2 = Residential; Category 3 = Institutional use.
[2] Maximum overall vibration velocity levels (VdB re: 1 µin/sec). The ranges shown for the vibration levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location. The data represent the range for vibration-sensitive receptors.
[3] Analyzed for 2029 only.

Table 5-20 Detailed 2029 and 2040 Plus Project Ground-Borne Vibration Impacts—Alternative B

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
San Francisco to South San Francisco Subsection								
4th and King Street Station[3]	1	661	25	55	57	54	65	0
	2	87	25	73	69	65	72	0
Design District	2	81–87	45–110	45–78	74–87	71–84	72	2 MF
	3	152–205	110	65–72	76–81	73–77	75	2 Medical
SF Tunnels No. 1 and 2	2	97	110	61	65	61	72	0
Islais Creek	1	71	110	63	69	64	65	1 Studio
	2	125	110	65	68	65	72	0
	3	93–103	110	63–82	76–86	73–82	75	1 School; 1 Institutional
SF Tunnel No. 3	2	14	110	37	73	69	72	1 SF
	3	235	110	58	61	60	75	0
Portola Place	2	66–389	110	57–82	73–85	70–82	72	47 SF; 8 MF
	3	58–155	110	70–81	81–84	77–80	75	1 Church; 1 Institutional
SF Tunnel No. 4	2	76	110	67	70	67	72	0
	3	17	110	71	74	70	75	0
Bayshore	2	53–207	70	44–83	73–88	69–77	72	4 MF
	3	130	70	63	68	61	75	0
Brisbane[4]	2	87–354	85–110	59–78	73–79	70–76	72	1 SF; 1 MF; 1 Hotel
South San Francisco	1	298	110	65	67	64	65	1 Studio
	2	91–109	110	62–77	73–80	69–76	72	2 Hotel
	3	127	110	69	72	68	75	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
San Bruno to San Mateo Subsection								
San Bruno	2	32–143	100–110	60–77	73–82	69–78	72	78 SF; 2 MF
	3	176	100	67	69	66	75	0
Millbrae	2	42–154	110	53–74	73–92	68–83	72	40 SF; 1 Hotel
	3	278	110	65	68	64	75	0
Burlingame	1	411	110	56	59	59	65	0
	2	96–473	105–110	53–76	73–79	68–75	72	52 SF; 40 MF
	3	53	110	57	82	78	75	1 Museum
San Mateo North	2	28–473	79–110	70–83	73–86	68–82	72	319 SF; 114 MF; 1 Hospital
	3	154–189	110	70–74	76–80	72–75	75	1 Church; 3 Medical
San Mateo to Palo Alto Subsection								
San Mateo South[4]	2	45–489	110	65–79	73–85	68–80	72	413 SF; 62 MF
	3	45	110	66	85	79	75	1 School
Belmont[3]	2	67–148	110	65–78	73–81	69–76	72	3 SF; 17 MF
	3	94	110	67	77	72	75	1 Medical
San Carlos[4]	1	116	110	75	79	74	65	1 Laboratory
	2	58–476	110	65–79	73–83	68–77	72	117 SF; 5 MF; 1 Fire Department; 2 Hotel
	3	154–214	110	64–74	76–77	71–73	75	2 Medical
Redwood City[4]	2	30–146	110	62–90	73–93	70–89	72	20 SF; 10 MF; 2 Hotel
	3	39	110	62	81	77	75	1 Medical
Fair Oaks	2	26–147	110	64–87	73–90	69–85	72	102 SF; 13 MF
	3	171	110	68	70	67	75	0
Atherton	2	54–108	110	62–76	73–78	69–74	72	38 SF
	3	180	110	67	70	66	75	0

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Overall Vibration Velocity Level (VdB)[2]				Number of Impacts
				Maximum Existing Vibration Level	Maximum Future Caltrain Vibration Level	Maximum HSR Project Vibration Level	Vibration Impact Criteria	
Menlo Park	2	32–118	110	59–80	73–83	69–79	72	32 SF; 37 MF; 1 Hotel
	3	136	110	69	72	68	75	0
Palo Alto	1	62–197	110	68–76	71–79	68–75	65	3 Hospital
	2	38–166	110	59–84	73–87	68–83	72	214 SF; 48 MF
	3	70–154	110	65–75	76–78	72–74	75	1 Church; 1 School; 1 Medical
Mountain View to Santa Clara Subsection								
Mountain View	2	27–195	110	62–82	73–85	69–80	72	39 SF; 46 MF
	3	222	110	66	69	65	75	0
Sunnyvale	2	45–203	110	64–84	73–89	67–85	72	111 SF; 109 MF
	3	116	110	74	77	74	75	1 Medical
Santa Clara	2	59–171	110	65–77	73–80	67–76	72	53 SF; 51 MF
	3	91	110	73	76	72	75	2 School
Total	**1**							**2 Studio; 1 Laboratory; 3 Hospital**
	2							**1,680 SF; 569 MF; 1 Fire Department; 1 Hospital; 9 Hotel**
	3							**3 Church; 5 School; 11 Medical; 2 Institutional; 1 Museum**

HSR = high-speed rail
MF = multifamily
SF = single family
VdB = vibration decibels
µin/sec = microinches per second
[1] Federal Railroad Administration Land Use Categories are summarized in Table 4-13. Land Use Category 1 = Areas where vibration would interfere with operations; Category 2 = Residential; Category 3 = Institutional use.
[2] Maximum overall vibration velocity levels (VdB re: 1 µin/sec). The ranges shown for the vibration levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location. The data represent the range for vibration-sensitive receptors.
[3] Analyzed for 2029 only.
[4] This location includes passing tracks where Alternative B differs from Alternative A.

Table 5-21 Detailed 2040 Plus Project Ground-Borne Noise Impacts—Alternatives A and B

Location	Land Use Category[1]	Distance to Near HSR Track (feet)	Maximum HSR Speed (mph)	Ground-Borne Noise Level (dBA)[2]				Number of Impacts
				Maximum Existing Ground-Borne Noise Level	Maximum Future Caltrain Ground-Borne Noise Level	Maximum HSR Project Ground-Borne Noise Level	Ground-Borne Noise Impact Criteria	
San Francisco to South San Francisco Subsection								
Design District	2	246	110	3	18	8	35	0
SF Tunnels No. 1 and 2	2	80	100	18	30	23	35	0
Islais Creek	1	71	110	18	35	23	25	1 Studio
	2	49	110	18	34	23	35	0
	3	93	110	23	35	28	40	0
SF Tunnel No. 3	2	0–24	110	19–25	37	24–30	35	5 SF
	3	235	110	3	18	8	40	0
Portola Place	2	93	110	18	30	23	35	0
SF Tunnel No. 4	2	0–36	110	19–21	36–39	24–26	35	11 SF; 1 MF
	3	17	110	27	39	32	40	0
Bayshore	2	121	65	15	27	20	35	0
Total	**1**							**1 Studio**
	2							**16 SF; 1 MF**
	3							**0**

dBA = A-weighted decibel
HSR = high-speed rail
MF = multifamily
SF = single family
VdB = vibration decibels
[1] Federal Railroad Administration Land Use Categories are summarized in Table 4-13. Land Use Category 1 = Areas where vibration would interfere with operations; Category 2 = Residential; Category 3 = Institutional use.
[2] Maximum overall ground-borne noise levels (dBA). The ranges shown for the ground-borne noise levels in this table are a composite of many receptors and are meant to provide the limits of these values for each geographic location. The data represent the range for ground-borne noise-sensitive receptors.

5.3 Summary of Effects

The noise and vibration effects for both project alternatives are summarized in Table 5-22 for both construction and operations and described below the table.

Table 5-22 Summary of Effects

Effect	Alternative A	Alternative B
Construction-Related Noise		
Construction noise impacts	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 the excavation work activity, 792 feet from the earthwork and retaining wall work, and as far as 706 feet from track construction activity. For stations and ancillary structures, excavation and foundation work would generate temporary nighttime impacts at residential areas up to 446 feet from 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 greater amounts and longer durations of nighttime construction activity near noise-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City.
Operations-Related Noise		
2029 Plus Project operational noise impacts at 4th and King Street and approach	▪ 0 noise impacts	▪ 0 noise impacts
2040 Plus Project operational noise impacts	▪ 4,074 moderate impacts ▪ 1,634 severe impacts	▪ 4,068 moderate impacts ▪ 1,628 severe impacts
2040 Plus Project cumulative operational noise impacts	▪ 3,785 moderate impacts ▪ 2,134 severe impacts	▪ 3,779 moderate impacts ▪ 2,132 severe impacts
Annoyance from onset of HSR passby	At stations and at-grade crossings where receptors may be within the distance where rapid onset noise exposure would exceed the FTA threshold, but advance warnings would be provided at these locations 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.	
HSR station noise	Noise contribution from parking facilities: ▪ No new parking at the 4th and King Street Station ▪ 37 dBA L_{dn} at the Millbrae Caltrain Station This additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.	Noise contribution from parking facilities: ▪ No new parking at the 4th and King Street Station ▪ 37 dBA L_{dn} at the Millbrae Caltrain Station This additional noise would be substantially lower than noise from HSR trains. No additional impact is projected.

Effect	Alternative A	Alternative B
Maintenance facility noise	36 dBA L_{dn} contribution from train movements at the East Brisbane LMF, which is substantially lower than the noise from operating HSR trains. No additional impact is projected.	40 dBA L_{dn} contribution from train movements at the West Brisbane LMF, which is substantially lower than the noise from operating HSR trains. No additional impact is projected.
2029 Plus Project traffic-related noise increases at streets near 4th and King Street Station	Roadway segments with an anticipated increase in traffic noise of 3 dB or greater: ▪ 2 roadway segments near the 4th and King Street Station	
2040 Plus Project traffic-related noise increases	No roadway segments with an anticipated increase in traffic noise of 3 dB or greater.	
Traction power facility noise	The installation of additional equipment at PCEP TPFs would generate one severe impact at PCEP PS 5, Option 2 and two moderate impacts at PS 6, Option 2 under both alternatives, but would not affect new receptors beyond those already affected by operational noise from trains and horns.	
Construction-Related Vibration		
Construction vibration impacts	During nighttime work, potential building damage from impact pile driving to structures within 55 feet. 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 on-going demolition work with jack hammers or hoe-rams.	Temporary vibration impacts at vibration-sensitive locations would be similar to Alternative A with exception of the passing track area, where construction would require greater amounts and longer durations of nighttime construction activity near vibration-sensitive receptors in San Mateo, Belmont, San Carlos, and Redwood City.
Operations-Related Vibration		
Operations vibration impacts	Annoyance: ▪ 2,290 permanent vibration impacts Building damage: ▪ none	Annoyance: ▪ 2,288 permanent vibration impacts Building damage: ▪ none
Operations ground-borne noise impacts	18 permanent ground-borne noise impacts	18 permanent ground-borne noise impacts

dB = decibel
dBA = A-weighted decibel
HSR = high-speed rail
L_{dn} = day-night sound level
L_{eq} = equivalent sound level
LMF = light maintenance facility

5.3.1 Noise

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 the excavation work activity, 792 feet from the earthwork and retaining wall work, and as far as 706 feet from track construction activity. For stations and ancillary structures, excavation and foundation work would generate temporary nighttime impacts at residential areas up to 446 feet from 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. 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. The Authority and its contractors would comply with FTA and FRA guidelines for minimizing noise and vibration impacts at sensitive receptors during project construction (NV-IAMF#1), but construction noise and vibration effects would remain. Distances to potential construction noise impacts for various types of activity would be the same for both alternatives.

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

Operational Noise

Operation of the project would permanently increase noise levels above the FRA's noise impact thresholds at sensitive receptors. Both Alternative A and Alternative B would generate the same or similar number of severe and moderate operation noise impacts. There would be zero impacts under the 2029 Plus Project condition at the 4th and King Street Station and approach. Under the 2040 Plus Project condition, there would be 1,634 severe noise impacts and 4,074 moderate impacts under Alternative A and 1,628 severe noise impacts and 4,068 moderate impacts under Alternative B. Under the 2040 Plus Project cumulative condition, there would be 2,134 severe noise impacts and 3,785 moderate impacts under Alternative A, and 2,132 severe noise impacts and 3,779 moderate impacts under Alternative B.

Operation of the project would generate traffic and associated noise at stations providing HSR service. Near the 4th and King Street Station, there would be no new parking, and no noise from parking facilities would occur. At the Millbrae Station, the largest L_{dn} contribution from the parking facilities at the nearby noise receptors would be 37 dBA. The additional noise from parking facilities would be substantially lower (at least 24 dB less) than the projected L_{dn} from HSR operations.

Operation of the project would also generate additional noise associated with train movements in and out of the LMF near Brisbane. Under Alternative A, the L_{dn} contribution from the East Brisbane LMF at the nearest receptor would be 36 dBA (more than 14 dBA less than HSR operations). For Alternative B, the maximum contribution from the West Brisbane LMF would be 40 dBA (more than 11 dBA less than HSR operations).

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 roadway segments near the 4th and King Street Station for the 2029 Plus Project conditions, and at the Brisbane LMF and Millbrae Station in the 2040 Plus Project conditions. In 2029, two roadway segments under Alternatives A and B would have the potential for noise level increases 3 dB or more compared to existing noise conditions. In 2040, operation of each project alternative would not result in roadway segments with the potential for noise level increases greater than 3 dB.

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 generate one severe impact at PCEP PS 5, Option 2 and two moderate impacts at PS 6, Option 2. However, in combination with HSR train operations, the noise associated with additional equipment at PCEP TPFs would not affect any new receptors not already affected by the train operation impacts.

5.3.2 Vibration

Construction Vibration

Construction of the project alternatives could result in vibration impacts from human annoyance and building damage. Most construction activities would only cause annoyance from vibration within 140 feet of the mechanical equipment. Some equipment, such as pile driving or on-going demolition work would have the potential to cause annoyance from vibration within 300 feet. Buildings close to pile-driving activity (within 55 feet) would have the potential for structural 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. Incorporation of NV-IAMF#1 would minimize construction vibration and the potential for it to cause annoyance or damage to buildings. However, even with NV-IAMF#1, some sensitive receptors would still be exposed to ground-borne vibration that could result in annoyance or building damage.

Operational Vibration

Operation of the project alternatives could cause permanent vibration impacts at sensitive receptors. Alternative A would result in 2,290 ground-borne vibration impacts and 18 ground-borne noise impacts, while Alternative B would result in 2,288 ground-borne vibration impacts and 18 ground-borne noise impacts. The majority of these vibration impacts (approximately 50 percent) would occur in the San Mateo to Palo Alto Subsection, followed by the San Bruno to San Mateo Subsection (29 percent) due to the close proximity of vibration-sensitive buildings to the alignment, with the remaining vibration impacts occurring in the Mountain View to Santa Clara (18 percent) and San Francisco to South San Francisco (3 percent) Subsections.

Operation of the project alternatives does not have the potential to cause building damage because the vibration levels do not approach damage thresholds. See Section 4.2.1 for additional discussion.

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